VOL 5 • NO 1

ePATIENT

NUCLEAR MEDICINE & MOLECULAR IMAGING

THE FREE NUCLEAR MEDICINE & MOLECULAR IMAGING EDUCATIONAL MAGAZINE AVAILABLE WORLDWIDE

NUCLEAR MEDICINE MADE SIMPLE

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MEDICINA NUCLEAR EN PALABRAS SENCILLAS

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THE ROAD TO THE WFNMB 2022 CONGRESS IN KYOTO

PANGEA PROJECT

PANGEA

TECHNEGAS™
FUNCTIONAL LUNG IMAGING

BENEFITS
V/Q SPECT TECHNEGAS™

Proven diagnostic accuracy
with high sensitivity and specificity [1]

Minimally invasive
aiding patients's confort and compliance [2]

Detects subsegmental
Pulmonary Embolism (PE) [3]

Low radiation burden
26-36 times less absorbed dose to breast of females [4]

Technegas™ has minimal exclusion criteria and may be administered to most patients[4-6] including:
Renal impaired | Contrast allergy | Diabetics
Chronic Obstructive Pulmonary Disease (COPD) | Critically ill
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V/Q SPECT TECHNEGAS™
IN NUCLEAR GUIDELINES

The EANM Guidelines[7] strongly recommend ventilation-perfusion single photon emission computed tomography (V/Q SPECT) as it allows the diagnosis of PE with accuracy even in the presence of COPD and pneumonia.

The CANM Guidelines[8] consider Technegas™ as the agent of choice in COPD population because it has less central airway deposition, better peripheral penetration and it does not wash away quickly as traditional aerosols. Only a few breaths are sufficient to achieve an adequate amount of activity in the lungs, reducing time and personnel exposure.

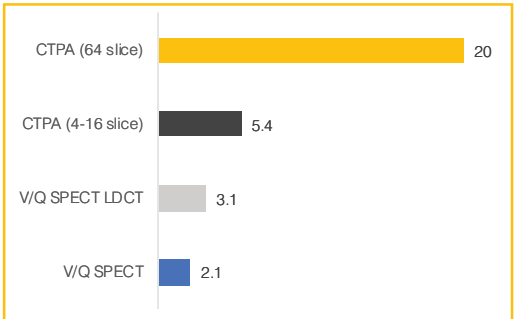

Table 1: Radiation exposure [8] (mSv)
(adapted from CANM guidelines, 2018)

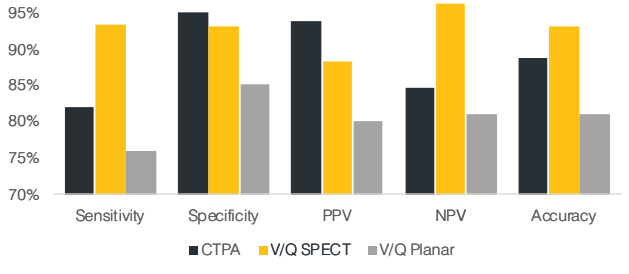

Table 2: Diagnostic ability of CTPA, V/Q SPECT and V/Q Planar to detect PE (adapted from Hess et al, 2016)

All PE's should have a final control 3 months after diagnosis to assess final reperfusion and to benefit from the availability of a baseline exam in case of recurrent symptoms. Low radiation exposure allows repeated studies (*table 1*).

With the uptake in SPECT imaging, V/Q SPECT results are seen as being superior to planar imaging and computed tomography (CTPA) when comparing sensitivity, negative predictive value and accuracy (*table 2*).[1]

Therefore, in situations of acute PE, chronic PE, pregnancy, paediatrics and the COPD population, V/Q SPECT can be considered as a first-line investigation due to its high sensitivity and specificity, low radiation and no adverse reactions.[8]

TO LEARN HOW TO PERFORM A V/Q SPECT STUDY WITH TECHNEGAS™, VISIT: https://bit.ly/2PZDDii

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Last revision (A4): v.2.1 (14/Apr/2021)
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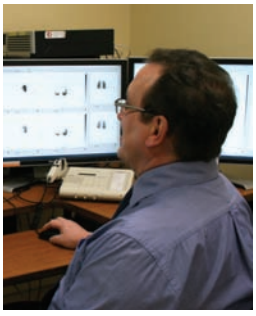

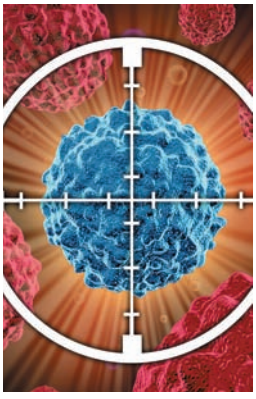

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Don't miss our next issue on Quantification and the second part of Theranostics (neuroendocrine tumors).

EDITORIAL BOARD

Dr. Lamoureux and I are thrilled to introduce our outstanding editorial board members. Through our travel and NM lecturing around the globe, we have met terrific scientists and colleagues. Most, if not all of them, are really passionate about and true advocates for the field of nuclear medicine. They strongly believe in the power, usefulness and safe use of NM diagnostic and therapeutic procedures for the betterment of public healthcare worldwide. We are delighted that the following leaders have embraced the concept of the Pangea-ePatient magazine and accepted to share their invaluable expertise and experience with patients, referring colleagues, health care administrators, government agencies and insurance companies.

Dr. Jean-Luc Urbain

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INTRODUCTION

François Lamoureux
M.D.,M.Sc., FRCPSC
President, CANM

Jean-Luc Urbain
M.D., Ph.D., CPE, FASNC
Past President, CANM

DEAR FRIEND AND COLLEAGUES.

Francois Lamoureux and I are thrilled to introduce to our international readers the new issue of the internationally acclaimed Nuclear Medicine magazine ePatient.

The lack of concerted efforts in research and development of new radiopharmaceuticals in the last part of the 20th century created a climate of uncertainty about the field of nuclear medicine at the beginning of the 21st century. In a very interesting and remarkable turn of events, the development of diagnostic and therapeutic radiopharma-ceuticals based on patients' diseases genotypes and phenotypes and so-called isotopes pairs (Nuclear Theranostics) have triggered a true renaissance of the field of Nuclear Medicine.

Through their exquisite sensitivity and specificity, Nuclear Theranostics, in combination with hybrid imagers (SPECT/CT, PET/CT and PET/MR) will undoubtfully play a major role in precision medicine by significantly improving patient disease management, particularly in oncology.

As exciting as the renaissance of Nuclear Medicine can be, it is also full of challenges. The practice of a fully integrated diagnostic and therapeutic nuclear medicine specialty requires in depth knowledge in many different fields of medicine (e.g. prostate cancer, breast cancer, complex imaging equipment along with an in depth understanding of patient's diseases and management, health care systems and health care economics. This type of complex knowledge, experience and expertise represents both unique opportunities and significant challenges for medical school and nuclear medicine centers across the globe.

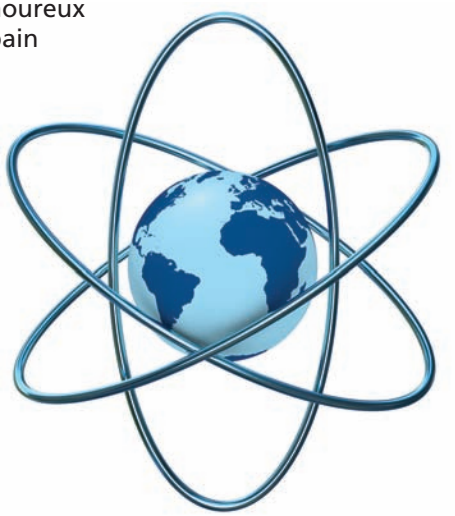
In this new issue of the magazine you will find interviews from various medical and industry leaders in the field sharing their views on the present and future of nuclear medicine, articles on telenuclear medicine, the treatment of hyperthyroidism, neuroendocrine tumors and a comprehensive review of brain SPECT imaging.

Also and through a heartfelt welcome note and a detailed interview of Dr. Seigo Kinua, a friend of Francois and me, you will find all the information that you need to prepare for the 13th Congress of the World Federation of Nuclear Medicine.

The main theme of the WFNMB Congress in Japan will be on Theranostics. In collaboration with the Regional and National Societies of Nuclear Medicine and Biology, the WFNMB is preparing a series of events that will paved the way to Kyoto 2022. Please stay tune as more is to come on the road to Kyoto in the fall and winter issues of the magazine.

We hope you will enjoy reading this new issue of the magazine that illustrate nicely the current and future of our beloved specialty.

François Lamoureux
Jean-Luc Urbain



François Lamoureux
M.D.,M.Sc., FRCPSC
President, CANM

MEDICAL AND PHARMACOLOGICAL ADVANCES

"With a simple intravenous injection of F-18 FDG that is painless and without identifiable side effects, we are pushing the diagnostic limits ever further and tracking down cancer cells in their very last cellular bastions."

ANTIMATTER AT THE SERVICE OF NUCLEAR MEDICINE

We can now measure and visualize the metabolic activity of an organ in a human being and detect its functioning and integrity. This is positron emission tomography (PET) or, expressed another way, the functional imaging of cell metabolism.

Using PET, we can detect certain pathologies, such as cancer, which initially alter the normal physiology of cells.

In order to live, function and reproduce, the organism's normal cells need energy in the form of glucose (a sugar that can be metabolized by the organism.) This energy source is indispensable to all the living cells of the organism, and this sugar is found naturally in the blood. The more active a cell is, the more sugar it consumes.

A cancer cell that has lost all control over its unbridled multiplication must constantly consume large quantities of energy in the form of glucose (sugar).

In nuclear medicine, a glucose analog, deoxyglucose, is used as a decoy: it mimics glucose by entering cells but in a form that cannot be used as an energy source by the cancer cell.

To detect intracellular deoxyglucose, the molecule is radioactively labelled beforehand with a positron (antimatter) in the form of fluoride-18 (F-18).

As it accumulates in cancer cells, the positive electrons (e+) of F-18 come almost immediately in contact with the cell's negative electrons (e-). This produces a disappearance of the injected matter and antimatter, an annihilation reaction in which two photons are emitted at 180 degrees in the form of external radiation.

The cell becomes radioactive and the emitted rays are captured by an external PET camera. Powerful computers interfacing with the PET camera identify abnormal areas of radiation emission, a sign of the abnormal accumulation of F-18 FDG in the cancerous tissue.

The cancer tumour is detected and its activity is measured. Then a 3-D reconstruction is done, in multiple slices and dynamically. The result is an exploratory metabolic autopsy of the patient *in vivo* that is non-invasive.

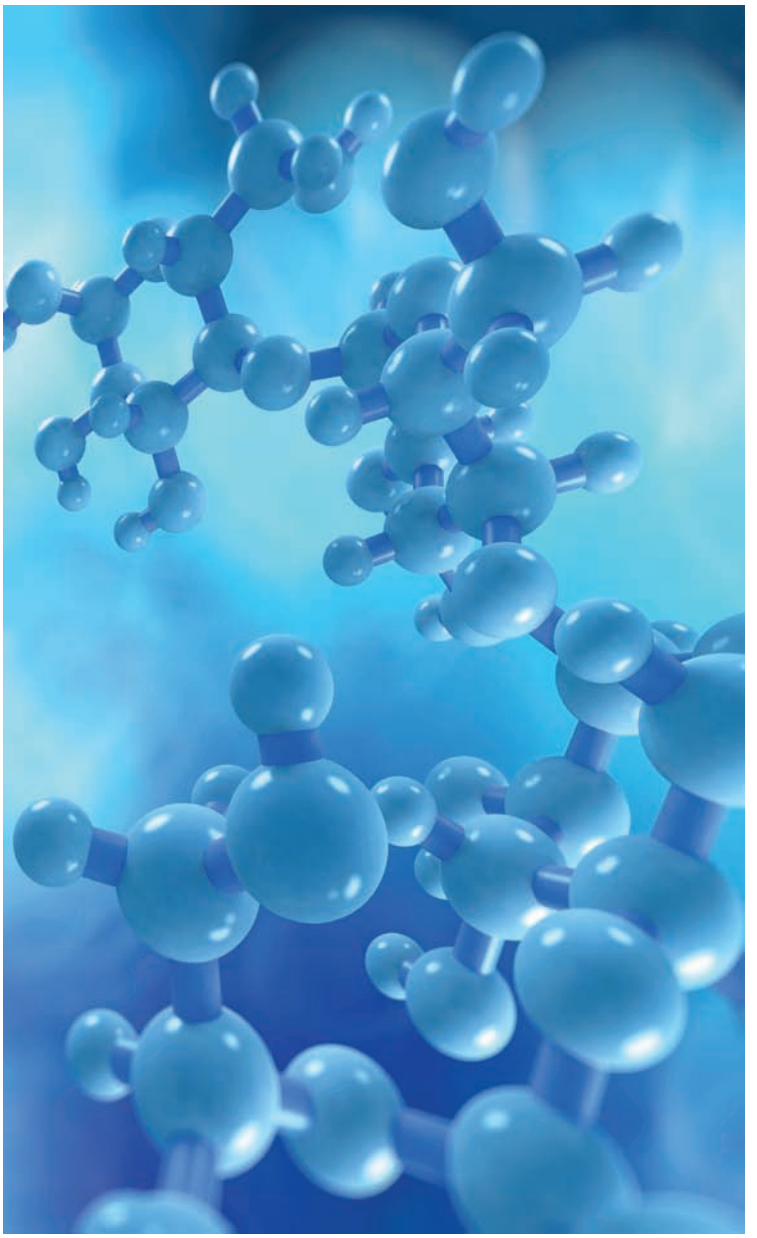
The external shape of the PET camera's detector resembles a tomodensitometer or magnetic resonance imaging device, but its function is completely different. The other two devices produce mainly anatomical images of the organs of the human body.

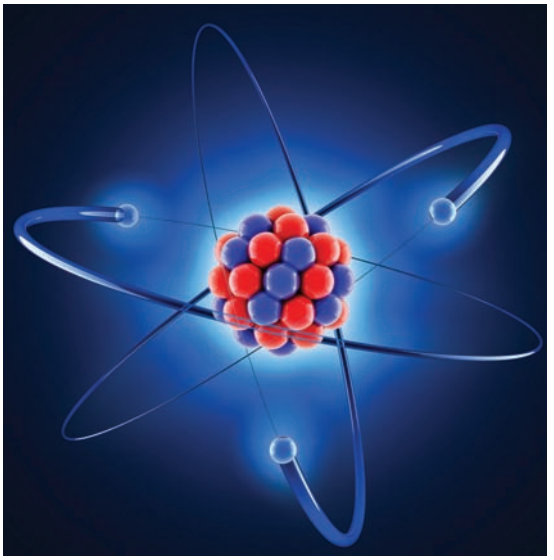
Moreover, today PET cameras are being teamed up with tomodensitometry detectors and, in the near future, will also be paired with magnetic resonance imaging devices in order to better localize the site of pathological processes.

With a simple intravenous injection of F-18 FDG that is painless and without identifiable side effects, we are pushing the diagnostic limits ever further and tracking down cancer cells in their very last cellular bastions.

While F-18 FDG is currently the most commonly used radioactive tracer, it is not the only one. Carbon-11, oxygen-15 and nitrogen-13, for example, can also be used to conduct neurological, cardiac or pulmonary exams.

In Quebec, PET technology is currently available in some nuclear medicine units. In mid-2008, thanks to new facilities in such places as Montréal, Quebec City, Chicoutimi, Gatineau, Rimouski and Trois-Rivières, this newly deployed technology enabled patients in centres that were not equipped with these cameras to have access to PET scans within a reasonable timeframe.





There are no inter-hospital charges or costs for either hospitalized patients or outpatients. The cost of each PET scan performed in a hospital centre is individually, directly and completely covered by the Government of Quebec. PET scans are prioritized based on a patient's clinical condition, whatever and wherever that may be, and not on the patient's physical location or the physical location of the PET camera.

Considering that PET technology has been applied as a just and universal social measure for all patients in Quebec, this is a success story and an example to follow. ■


2022 Congress of the WFNMB
in Kyoto-Kanazawa, Japan
WFNMB 2022 IN JAPAN WORLD FEDERATION OF NUCLEAR MEDICINE AND BIOLOGY
JAPAN
WORLD FEDERATION OF NUCLEAR MEDICINE AND BIOLOGY
13th
Congress of the World Federation of
Nuclear Medicine and Biology
Summarize
the past half century
and
discuss
the next half century
of
WFNMB
Japan
World Federation of Nuclear Medicine and Biology
September 7-11, 2022
Kyoto International Conference Center
Post-Congress Symposium
September 12-13, 2022
Kanazawa Art Hall
62nd Annual Scientific Meeting of the Japanese Society of Nuclear Medicine
42nd Annual Meeting of the Japanese Society of Nuclear Medicine Technology
2022

WELCOME LETTER

Welcome

On behalf of the Japanese Society of Nuclear Medicine (JSNM), I would like to cordially invite you to Kyoto, the host city of the 13th Congress of the World Federation of Nuclear Medicine and Biology to be held in 2022 (WFNMB 2022). The 1st WFNMB Congress was realized in Tokyo and Kyoto in 1974 and was a great success. We firmly believe that WFNMB 2022 will be an equally good opportunity to gather once again in Japan in order to summarize the accomplishments of the WFNMB during the past half century and discuss strategies for the future of the WFNMB as well as of nuclear medicine itself in the next half century. Kyoto was the city where the closing ceremony of the 1st Congress was conducted, making it fitting that it will become the opening door to a new era of WFNMB.

JSNM would like to enhance mutual collaboration among colleagues of the nuclear medicine community throughout the world. In order to promote nuclear medicine in daily clinical practice as well as the research field, as many countries as possible should discuss together at a single table in the WFNMB Congress. One of the major missions of WFNMB is to provide opportunities for education, study and research especially to young fellows. It is very important for them to obtain information of these activities in a timely manner. The WFNMB Congress is one of the key resources for these purposes. Therefore, we would sincerely like to request your country to join it to promote the bright future of all of our young fellows.

Kyoto is the cultural heart of Japan and boasts over a millennium of history featuring a stunning total of 17 UNESCO World Heritage Sites all located less than 30 minutes apart. The best way to discover the "real Japan" is to include Kyoto in your itinerary. Kyoto has been voted the best travel destination in Japan by various travel magazines and web media. This friendly city of 1.5 million people offers endless opportunities to gain meaningful hands-on experience of rich Japanese culture through tea ceremony, sake brewing, kimono wearing, swordsmanship and many more activities.

Post-congress cultural social activities will be planned in Kanazawa located just 2 hours ride by express train from Kyoto. Kanazawa is an old city of Samurai Culture in contrast to the Court Culture in Kyoto. It was a great castle town ruled by influential lords from the late 16th century to second half of the 19th century. The area surrounding Kanazawa is famous for hot springs and its cuisine making use of fresh fish and vegetables. The rice wine (sake) produced in this region is of high quality, smooth and sweet, derived from the rice grown in Ishikawa Prefecture as well as the considerable precipitation of the Hokuriku region.

The Department of Nuclear Medicine, Kanazawa University, where I have been serving as chairperson since 2006, was established in 1973 as the very first department of nuclear medicine at a Japanese university. Therefore, the length of the history of my place closely coincides with that of WFNMB. This coincidence is another reason making Kanazawa a suitable place, in addition to Kyoto, to talk about both the past and future of nuclear medicine.

It is my heartfelt wish that you allow us to welcome you all to Japan. We will do our best to be able to offer you a great time in both Kyoto and Kanazawa. ■

Sincerely,

Seigo Kinuya

WFNMB2022 Congress Chair
Professor, Department of Nuclear Medicine,
Kanazawa University,
Japan

INTERVIEW WITH *DR. SEIGO KINUYA*

You are the chair of the NEXT CONGRESS OF THE WORLD FEDERATION OF NUCLEAR MEDICINE AND BIOLOGY (WFNMB) IN KYOTO JAPAN 7-11 SEPTEMBER 2022.

Could you GIVE US AN OVERVIEW OF THE EVENT.

We are preparing to have on-site face-to-face congress. I hope that the pandemic of COVID-19 with the progress made in vaccination throughout the world.

We will focus on what's going on in nuclear medicine by inviting prenarry speakers on the topics of theranostics, neurology, cardiology, molecular imaging, AI and so on. One of Japanese Nobel Prize winners, Dr. Koichi Tanaka who invented mass spectrometric analyses of biological macromolecules, will be invited. Recently, his group published a key article in Nature regarding liquid biopsy for Alzheimer's disease. As you know, therapeutic drug, aducanumab, for Alzheimer's disease was approved by the US FDA very recently. Amyloid PET is connected to these trend, and Dr. Tanaka's lecture will have great impact on nuclear medicine community in this regard.

One of the major missions of WFNMB is to educate young people in the field and promote the development of nuclear medicine in developing countries. For this sake, we wil prepare travel grants to join the congress. Our President Dr. Jean-Luc Urbain gave me a very good idea to have a session dedicated to the educational challenges.

One of highlights of the very first congress of WFNMB held in 1974 in Tokyo was the attendance of the then Crown Prince and Princess at the opening ceremony. We are negotiating with the authority to invite a member of the Japanese Imperial Family for the opening ceremony once again. Our request form is now on the table of the Cabinet office and I am sure that the nuclear medicine community in the world will be celebrated

We are expecting 4000 participants domestically and internationally. You will be one of them!

What have been the most important changes that you have seen in the field of Nuclear Medicine over the last 5 years!

Development of theranostics in the world is the biggest one. In my country Japan, not many people paid attention to targeted radionuclide therapy for many years although therapies such as radioiodine therapy for thyroid disease and 89Sr bone pain palliative therapy have been widely adapted in the clinic. It was a kind of niche field in medicine. However, many people began to recognize the successful achievement of PRRT for neuroendocrine tumors and PSMA therapy prostate cancer. Introduction of alpha therapy with ^{223}Ra for prostate cancer patients further pushed them toward this field. Then, successful story of ^{225}Ac-PSMA ignited their hearts. I have been involved in targeted radionuclide therapy for 35 years. Frankly speaking, I have not expected to see the current situation. I would sincerely appreciate the big efforts of our colleagues in the world.

How do you see the field of Nuclear Medicine evolving during the next 5 years!

The role of theranostics will get bigger and bigger in clinical practice. In Japan, Lutathera, ^{177}Lu-DOTATATE, is going to be approved. ^{131}I-MIBG for pheochromocytoma will follow. Clinical trial of ^{177}Lu-PSMA for prostate cancer is being prepared. Physician-led clinical trial of ^{64}Cu-ATSM for brain tumors is on the way.

In addition, clinical trials of targeted alpha therapy with ^{211}At (NaAt) for ^{131}I-refractory thyroid cancer and ^{211}At-MABG for pheochromocytoma are almost ready to be initiated.

PET imagings will also surely grow. Currently, we are doing clinical trial of ^{68}Ga-PSMA aiming governmental approval in my University hospital. We are also expecting that amyloid PET will be reimbursed after the domestic approval of Aducanumab.

How do you see the training of residents and technologists in our Nuclear Medicine training programs!

In order to offer patients with proper medical management, all professionals including physicians, nurses, technologists and nuclear physicists should collaborate at the high level. All of them should acquire updated technique and information. Furthermore, communication is quite important.

Task shifting in hospitals has been promoted by the Ministry of Health, Labour and Welfare (MHLW) in my country for more than 10 years. For this sake, we should understand the roles of each occupation. Mutual training program should be needed. For instance, Japanese Society of Nuclear Medicine (JSNM) has been discussing about JSNM Technology in this regard in response to the Governmental order.

As the chair of the WFNMB congress, what is your greatest wish for the specialty of Nuclear Medicine!

For the future of nuclear medicine, new technologies in both instruments and drugs are of course required. However, development of human resources is the most important thing. In addition, we need more young people than ever in order to keep growing. In my country, we have not succeeded to get a good number of young fellows in nuclear medicine for many years primarily due to the shrink of nuclear medicine examinations because of the alteration of medical care insurance system about 20 years ago. However, we have now very attractive tools of theranostics and PET imaging in our hands. WFNMB congress is a very good opportunity not only for the international development but also for the advertisement of nuclear medicine to young doctors in my country.

You are currently the president of JSNM. What are you doing to promote nuclear medicine in Japan and your neighboring countries in Asia?

Perhaps, Japan is one of the most underdeveloped countries in theranostics mean. Lutathera is just going to be approved 4 years after EU approval. ^{68}Ga-DOTATATE/DOTATOC is not available due to complicated regulations, and we have to use old-fashioned ^{111}In-octreotide instead. Patients go abroad to undergo PRRT or PSMA therapy to Europe or Australia. This situation is a shame of the Japanese nuclear medicine community. Five years ago, JSNM launched the National Conference for Nuclear Medicine Theranostics in which I have been serving as the president. Nuclear physicians, clinicians, patients and industrial people gather in this platform. Lobby activities or advocacy activities to the officials of Ministries and members of Parliament are going to bear fruit. Now, we have many supporters among representatives. Officials are getting to understand the necessity to develop radionuclide therapy in this country. Consequently, the word "targeted radionuclide therapy" was installed in the official statements of MHLW such as "Cancer Control Act" and "Requirements for Core Hospitals for cancer control ".

One of the biggest issues is a lack of domestic production of therapeutic radionuclides. After years of lobby activities, 2 representatives required a plan for domestic production of radionuclides, especially ^{225}Ac, at the occasion of parliament assembly on May 31, 2021. Four Ministers related to this issue responded affirmatively.

Public lectures are often provided to make people know the role of nuclear medicine in clinic. Many of ordinary people even do not know what nuclear medicine is. They cannot imagine what targeted radionuclide therapy is. We need to continue this activity at any occasion.

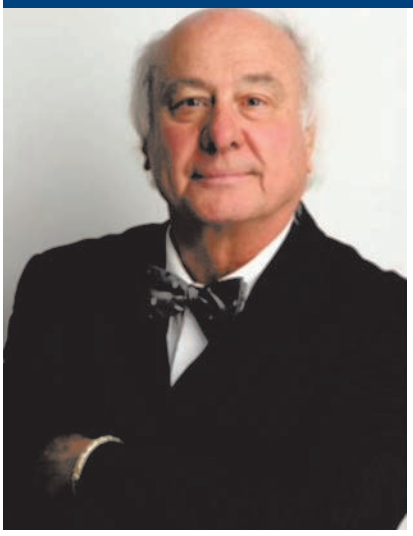
Mutual activities with other societies have been going on. We have MOU with SNMMI, EANM and the societies of Asian countries. JSNM proposes symposium in annual congress of SNMMI and EANM every year, and collaborative sessions are regularly prepared which have a good reputation.

Many of Asian countries are not well developed in nuclear medicine practice. So that, supporting educational activities is essential in this region. JSNM has been working together with Asia Oceania Association of Nuclear Medicine and Biology (AOFNMB), Asian Regional Corporative Council of Nuclear Medicine (ARCCNM) and so on.

The collaborative work with the International Atomic Energy Agency (IAEA) was initiated in 2018 by the leadership of the past president of JSNM, Prof. Jun Hatazawa. The Consortium of 11 Universities and Institutions in Japan has MOU with IAEA. This aims to provide young people in Asia with educational occasions. Workshops and hands-on meetings are set up in Japan. Although this activity is suspended now due to COVID-19, it will be resumed hopefully next year. ■

World Federation of Nuclear Medicine & Biology 2022-2024 Treasurer Candidate:

Dr. Francois Lamoureux



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  - Board Certified in Nuclear Medicine
- M.Sc: University of London, England
- Fellow Royal College of Canada
- Medalist of the city of Paris
- Professor at the University of Montreal
- Membership: EANM, SNMMI, SFNM, CANM
- Past President of the AMSMNQ, President of the CANM
- Several presentations/lectures in Europe, North & South America
- Editor in chief of the magazines Le Patient and ePatient
- Main interests: Precision Medicine, Theranostics, NM Education

As Treasurer of the WFNMB, I will work with all of you from across the world:

1. To maintain the stability and integrity of the WFNMB accounting practices by working in close collaboration with the auditors and immediate past treasurer of the WFNMB.

2. To develop methods and processes generating additional revenue streams in order to achieve long term sustainability of the WFNMB and to support the educational endeavors of the WFNMB

I am currently the president of the Canadian Association of Nuclear Medicine and our organization as for more than 30 years worked hand in hand with the WFNMB. I sincerely believe that the WFNMB plays a major role worldwide and bring a better and closer partnership between countries to ensure the plus value of Nuclear Medicine.

With the development of new detectors, new radiopharmaceuticals and the rapid deployment of theranostics more than ever the WFNMB is needed as a major interlocutor.

I have close relationships with IAEA and I strongly believe that through the IAEA the WFNMB could bring an increase in availability of Nuclear Medicine for the patients in the emerging countries. Everything is possible for an organization but we need some financial security and if I am elected as the treasurer, I will work to secure the financial viability of the WFNMB. It will be my first and main objective.

WFNMB is viewed around the world as a well-respected organization and I will be more than happy to be able to work in close relationship with the executive board to help to make more available and high-quality Nuclear Medicine around the world.

I am a university professor of Nuclear Medicine, I trained many residents, made many publications and I really believe that Nuclear Medicine has a tremendous future.

François Lamoureux M.D, M. Sc. FRCPC
President of the CANM-ACMN
+1 (514)889-0662
lamoureuxf@sympatico.ca

Dr. Jean-Luc C. Urbain
President
World Federation of Nuclear Medicine & Biology

Jean-Luc Urbain
M.D., Ph.D., CPE, FASNC

Born in Belgium in the mid 50's, I earned my Medical Degree at the University of Louvain, Belgium, and then pursued residency training in Internal Medicine and Nuclear Medicine. I subsequently obtained a Ph.D. in Genetics and Molecular Biology at Temple University in Philadelphia. Professor of Imaging, Medicine and Biology for more than two decades I have had the opportunity and privilege to visit hospitals and medical centers and give lecture on all continents. I consider myself as a citizen of the world.

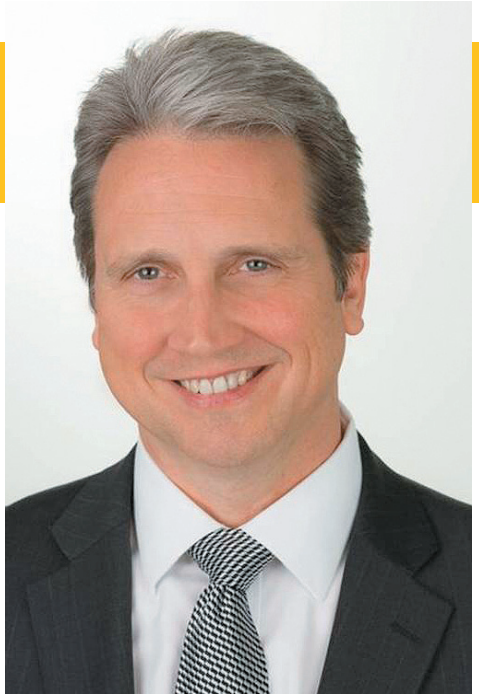
Through my career, I have held leadership and executive positions in Medical Imaging and Medicine in Belgium at the University of Leuven, in Canada at the University of Western Ontario and in the US at Temple University, Fox Chase Cancer Center, The Cleveland Clinic, the VA Administration and now Wake Forest University. I have extensive experience and expertise in committees and boards leadership, in the management of integrated health care systems and patient advocacy groups and at regional, national and international levels of government.

As Secretary of the Belgian Society of Nuclear Medicine in the 90's I introduced a multilingual and pluralist approach to the operational tasks of the Society. As President of the Canadian Association of Nuclear Medicine, I have worked closely with national and international medical associations and government health authorities to mitigate major the major health and medical isotopes crises of 2007-2008, analyzed and helped establish medical resources needs, benchmarks and allocation for key medical service areas. I have also served as consultant and advisor for Pharmaceutical, Radiopharmaceutical and Medical Systems companies. My current main interests are in Medical Isotopes Production and Supply, Patients' Education and Advocacy, Personalized Medicine and Theranostics.

The WFNMB is working tirelessly with the World Health Organization (WHO), the International Atomic Energy Agency (IAEA), the Health and Nuclear Medicine Authorities from across the globe, all national and regional Nuclear Medicine Societies and Associations and the Nuclear Medicine Industry to 1. Secure the supply of and access to Medical Isotopes 2. Develop NM educational tools accessible to the Nuclear Medicine Communities, Patients and Referring Physicians from around the world 3. Make sure that the Nuclear Medicine Association/Societies from the emerging countries benefit from the work of the WFNMB and the regional NM Associations/Societies 4. Promote the field of Diagnostic and Therapeutic Nuclear Medicine (Theranostics) across the globe, particularly in the underserved countries. ■

WORLD FEDERATION OF NUCLEAR MEDICINE AND BIOLOGY

INTERVIEW WITH *James McBrayer*



James McBrayer
CEO, Cyclopharm Ltd
Email: jmcbrayer@cyclopharm.com.au
Website: www.cyclopharm.com

You have been actively involved in the field of nuclear medicine for quite a while. Looking back at your career, what are the most significant changes that you have witnessed in the field over the past 10 years?

I have witnessed a great deal of change since starting in nuclear pharmacy as an intern in 1988. Following graduation from pharmacy school, I practiced nuclear pharmacy in the United States, Australia and New Zealand. Since taking on the role of CEO of Cyclopharm in 2008, given the numerous markets we distribute our products to, I have had the ability to view nuclear medicine from a global perspective.

In my opinion the top two changes in the past 10 years in nuclear medicine have been related to advancements in imaging technology and in Positron Emission Tomography (PET).

An example for advancement in imaging technology can be seen in diagnosing Pulmonary Embolism (PE). Nuclear medicine functional imaging with SPECT has reversed a previous trend toward anatomical imaging with CTPA. By replacing 2D Planar for 3D SPECT imaging and shifting from probabilistic outcomes, nuclear medicine physicians are delivering higher levels of sensitivity and accuracy in diagnosing PE at a fraction of the radiation dose compared to that of CTPA.

I believe the other area of major change in the past 10 years in nuclear medicine has been in molecular imaging with PET. In the past decade PET has grown from a few oncology studies primarily using FDG to a growing array of agents used diagnostically in oncology, neurology, cardiology and MSK.

PET continues to evolve rapidly by providing the platform for the development of Theragnostics. These diagnostic – therapeutic combinations acting on targeted biological pathways, predominantly used in oncology, are set to provide nuclear medicine its next major leap forward.

What is Cyclomedica?

Cyclomedica is a wholly owned subsidiary of the Australian listed company Cyclopharm (ASX:CYC). Cyclomedica is best known for our proprietary functional lung ventilation imaging product Technegas. First used clinically in 1986, Technegas is now available in 60 countries around the world.

Given Technegas' unique properties, there are no contraindications for its use, it is ideally suited for 3D SPECT imaging and dramatically reduces the potential for hotspots often seen with competitive nuclear medicine products such as DTPA aerosols.

Our largest regional market is Europe where we are referenced in the EANM Guidelines 2009 as the preferred ventilation imaging agent in diagnosing PE. Our largest single country market is Canada. We are approved for use in China and will be looking forward in the coming years to expand the use of Technegas throughout Asia.

We are currently involved in the final stages of our New Drug Application review with the USFDA and hope to bring Technegas to the United States very soon.

Lung Ventilation studies for the diagnosis of pulmonary embolism have been successfully performed across the world for many decades with Technegas. Can Technegas play a role for the quantitative evaluation of the lungs function in other diseases?

4.4 million patients have been imaged with Technegas. Whilst best known for diagnosing PE, with the advancement of more sensitive imaging technologies to include SPECT-CT combined with newly developed analytical software, Technegas is more relevant today than it was when it was first introduced in 1986.

Given that Technegas can show true functional ventilation to the point of gas exchange at the alveoli, we are seeing strong global interest from respiratory physicians to apply Technegas to both quantify the extent of disease and measure response to therapy. We are working with both nuclear medicine and respiratory physicians around the world in clinical trials targeting severe asthma, chronic obstructive disease, lung volume reduction and lung transplant to name a few. An example of one of these initiatives can be found via the following link: https://hmri.org.au/news-article/nuclear-imaging-clear-airway-diagnosis.

What do you anticipate the role of artificial intelligence (AI) be in the field of lung imaging?

Nuclear Medicine has always embraced advancements in technology. In lung imaging I have seen, where Technegas is available, that SPECT is replacing Planar imaging. Recent techniques using SPECT co-registered with low dose CT augmented with analytical software is providing another layer of information to clinicians not previously available.

In the September 2017 Lancet commissioned publication entitled "After Asthma: redefining airways disease" global leaders in the field of respiratory medicine call for tests that can incorporate "traits that can be measured" as well as measures "in the context of social and environmental factors and extrapulmonary comorbidities". Rather than focusing on a singular image interpretation, I see that AI's greatest contribution in patient outcomes will be in delivering personalized respiratory medicine by analyzing the numerous and complex inputs required to deliver on diagnostic, prognostic and therapeutic outcomes.

You have had the opportunity to read the first two issues of the NM magazine Pangea-ePatient. What do you think of the magazine and what would your suggestions be to improve it?

This publication is an important educational tool. Similar to AI, Pangea-ePatient is in its own way disruptive. I am entering my third decade in nuclear medicine and have never known of a publication with such global support within the discipline of nuclear medicine combined with such broad reader potential.

I am enthusiastic to learn about the endorsement from so many of the global Societies of Nuclear Medicine and trust that this level of support will only expedite the messages being shared throughout the world to our referring physicians.

Thank you for the honour of contributing to Pangea-ePatient and congratulations on the important work that you are doing. ■

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TECHNEGAS™

IMAGERIE PULMONAIRE FONCTIONNELLE

AVANTAGES
V/Q SPECT TECHNEGAS™

Précision de diagnostic prouvée
avec une sensibilité et une spécificité élevées [1]

Minimalement invasif
aide au confort et à la collaboration des patients [2]

Détection sous-segmentaire
de l'embolie pulmonaire (EP) [3]

Faible radiation
26 à 36 fois moins de dose absorbée au sein chez les femmes [4]

Technegas™ a des critères d'exclusion minimaux et peut être administré à la plupart des patients[4-6], y compris:
Insuffisance rénale | Allergie aux agents de contraste | Diabète
Maladie pulmonaire obstructive chronique (MPOC) | Gravement malade
Femme enceinte

V/Q SPECT TECHNEGAS™ ET LES RECOMMANDATIONS EN MÉDECINE NUCLÉAIRE

Les recommandations de l'EANM[7] conseillent fortement la tomographie par émission de photons pour les études pulmonaires de ventilation-perfusion (V/Q SPECT) car elle permet le diagnostic de l'EP avec précision, même en présence de MPOC et de pneumonie.

Les recommandations du CANM[8] considèrent Technegas™ comme l'agent de choix chez les patients souffrant de MPOC puisqu'il y a moins de dépôts dans les voies aériennes centrales, une meilleure pénétration périphérique et il ne s'élimine pas aussi rapidement que les aérosols traditionnels. Seulement quelques respirations sont suffisantes pour atteindre une quantité adéquate d'activité dans les poumons, ce qui réduit le temps de la procédure et l'exposition du personnel.

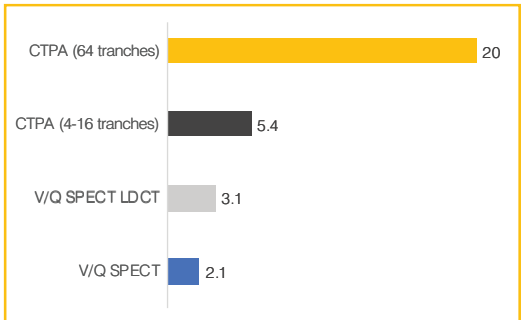

Tableau 1: Exposition à la radiation [8] (mSv)
(adapté des recommandations du CANM, 2018)

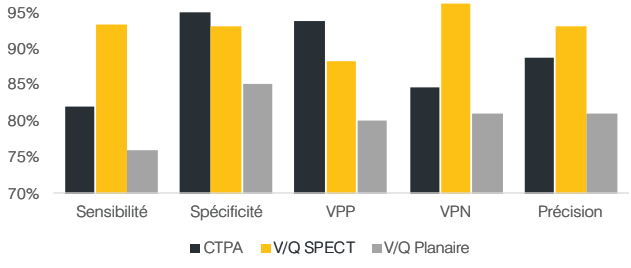

Tableau 2: Performances diagnostiques des différentes modalités à détecter l'EP (adapté de Hess et al, 2016)

Toutes les EP doivent avoir un contrôle final 3 mois après le diagnostic afin d'évaluer la reperfusion finale et pour bénéficier de la disponibilité d'un examen de base en cas de symptômes récurrents. Une faible exposition à la radiation permet des études répétées (tableau 1).

Avec l'adoption de l'imagerie SPECT, les résultats V/Q SPECT sont considérés comme supérieurs à l'imagerie planaire et à la tomodensitométrie (CTPA) lorsque l'on compare la sensibilité, la valeur prédictive négative et la précision de ces examens (tableau 2).[1]

Par conséquent, dans les situations d'EP aiguës, d'EP chroniques, de grossesse, de pédiatrie et de patients MPOC, l'imagerie V/Q SPECT peut être considérée comme une investigation de première ligne en raison de sa sensibilité et de sa spécificité élevées, de sa faible radiation et de l'absence d'effets indésirables.[8]

AFIN D'EN APPRENDRE DAVANTAGE SUR LA PROCÉDURE V/Q SPECT AVEC TECHNEGAS™, VISITEZ : https://bit.ly/2PZDDii

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Technegas™ n'est pas encore disponible à la vente aux États-Unis.
Dernière révision (A4): v.2.1 (14/avr/2021)
Pour plus d'informations, veuillez visiter **www.cyclomedica.ca** ou envoyer un courriel à **technegas.sales@cyclomedica.ca**

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INTERVIEW WITH:
DR. DANIEL BADGER

You are the president of the AUSTRALIAN AND NEWZEALAND SOCIETY OF NUCLEAR MEDICINE (ANZSNM).Could you succinctly describe the role of the ANZSNM inthe field of Nuclear Medicine?

The ANZSNM's role is to support all professionals working inthe field of Nuclear Medicine in Australia and New Zealand.This involves providing guidelines, training, education,professional development, professional standards, but morethan that, we are also a community of mutual support. Wealso liaise with Government agencies on matters relating toNuclear Medicine: funding, training and infrastructure. Weorganise an annual scientific meeting in April/May each year - http://www.anzsnmconference.com/ANZSNM2021/ Join usonline this May!

What have been the three most important changes thatyou have seen in the field of Nuclear Medicine over thelast five years?

- The biggest change has been radionuclide therapy agentsbecoming part of normal /first line care for cancer treatment.

- PET is so useful and beneficial. We now can declare that PETis no longer special, it should be available in every majorhospital.

- Theranostics – Seeing exactly what we are targeting with ourtherapy, and being able to look at treatment response makesa huge difference to patient outcomes.

How do you see the field of Nuclear Medicine evolvingduring the next five years?

The introduction of new targeted therapeutic agents that workon more cancers will mean a shift from a majority of diagnosticimaging to a majority of therapeutic procedures.

How do you see the training of residents andtechnologists in our Nuclear Medicine training programs?

They will need to focus a lot more on therapy. As a physicistworking a lot in radiation protection, I'm aware thatradionuclides used therapeutically carries higher risks forpatients and staff, and sometimes we can become complacentdue to being used to handling low risk radioactive materialsused for diagnostic imaging. Therapy requires a much higherstandard of radiation safety and preparation, and this startswith training programs.

Dr. Daniel Badger
Ph.D
University of Adelaide, South Australia

As president of the ANZSNM, what is your greatest wishfor the speciality of Nuclear Medicine?

My greatest wish is that all thedifferent professions andgeographically separatedgroups can work together inharmony to do much morethan any single group couldachieve alone. ■

AUSTRALIAN AND NEW ZEALAND SOCIETY OF NUCLEAR MEDICINE

www.anzsnm.org.au

ENTREVUE AVEC *Chantal Asselin*

CHANTAL ASSELIN, t.i.m.(E)

Vous êtes la responsable du programme de formation des technologues en médecine nucléaire du Québec, Canada. Pourriez-vous nous présenter un court résumé de votre parcours et de votre situation actuelle?

Enseignante au programme de Technologie de médecine nucléaire au Collège Ahuntsic depuis 1986 et Responsable de la coordination du département, des stages et Responsable de la radioprotection depuis 1997.

À titre de consultante en radioprotection, publication de plusieurs articles scientifiques, prestation de nombreuses formations et conférences dans plusieurs régions du Québec et provinces canadiennes ; réalisation de plusieurs avis ou normes pour l'Ordre des technologues en imagerie médicale et en radio-oncologie du Québec ; Technologue émérite en imagerie médicale depuis 2006 ; Mention d'honneur de l'Association québécoise de pédagogie collégiale (AQPC) en 2010.

Le centre de formation existe depuis quand et à ce jour combien de technologues en médecine ont été formés?

Depuis 1968 jusqu'à aujourd'hui, nous avons formé plus de 700 technologues qui travaillent dans une cinquantaine de services de médecine nucléaire aux quatre coins de la province.

Combien de professeurs (e) travaillent à la formation des étudiants ?

9 enseignant.e.s en Technologie de médecine nucléaire sont à l'emploi du collège Ahuntsic présentement et ils sont soutenus par 2 techniciennes de laboratoire.

L'excellence de nos technologues est reconnue dans le monde entier. En quelques lignes pourriez-vous nous décrire le parcours type d'un étudiant?

Durant les deux premières années du programme, les élèves apprennent à préparer les produits radiopharmaceutiques et à en contrôler la qualité grâce à la grande générosité de nos partenaires de l'industrie radiopharmaceutique. De plus, nos élèves s'entraînent à injecter des produits de façon sécuritaire, à produire des images de fantômes à l'aide de caméras et à analyser l'information recueillie à l'aide des mêmes logiciels que ceux utilisés dans les hôpitaux. Tout ce qui leur manque au collège, ce sont les patients !

Et ce sont les valeureux maîtres de stage et enseignants cliniques qui prennent la relève en centre hospitalier durant la troisième année du programme pour aider nos élèves à s'occuper des patients et à mettre en pratique ce qu'ils ont appris durant leurs deux premières années d'étude.

Nous sommes également très impliqués dans la planification et le placement de la main-d'œuvre. Sachez que nous avons augmenté le nombre d'admissions dans notre programme de 40 à 65 places ces dernières années. Toute l'équipe du collège travaille avec ardeur pour promouvoir notre profession et surtout pour favoriser la réussite des élèves.

Combien existe-il de technologues en médecine nucléaire actuellement actifs au Québec et dans combien de centres?

Environ 530 technologues en médecine nucléaire sont actuellement actifs au Québec et ils œuvrent dans une cinquantaine de services à travers la province.

Avec le développement accéléré de nouveaux radiotraceurs, de détecteurs hybrides et de la théranostique quels sont les défis les plus pressants auxquels vous êtes confrontée?

Le domaine de la médecine nucléaire est en constante évolution comme dans tous les domaines de l'imagerie médicale. De mon côté, je considère avoir vécu six grandes révolutions dans mes 35 années de carrière. Après l'arrivée des caméras gamma dans les années 70, j'ai débuté ma carrière de technologues avec l'arrivée des ordinateurs au début des années 80. J'ai participé à la formation des technologues lors de

l'arrivée des caméras tomographiques par émission monophotonique (TEMP) dans les années 90, suivie des caméras par émission de positrons (TEP) au début des années 2000 et par les caméras hybrides TEPM-TDM ou TEP-TDM au milieu des années 2000. La théranostique et la reconstitution des radiopharmaceutiques en milieu stérile sous hotte font partie des nouvelles formations que nous avons intégrées dans notre programme actuel et dans la formation sur mesure offerte aux technologues déjà gradués.

Aussi, depuis plus de 30 ans, le Collège Ahuntsic prend en charge la formation continue des technologues en offrant des formations théoriques et pratiques sur mesure portant sur les nouvelles technologies introduites dans notre domaine. Nous offrons également des formations à distance depuis déjà une quinzaine d'années, permettant ainsi de rejoindre les technologues de toutes les régions du Québec. Nous étions donc déjà prêts pour affronter le télétravail pandémique !

Quel serait votre plus grand souhait pour votre programme de formation des technologues en médecine nucléaire?

J'ai deux souhaits :

Améliorer l'attraction envers notre beau programme et cette magnifique profession afin d'obtenir plus de candidats en fonction des besoins des régions. À cet égard, nous allons entreprendre des démarches auprès du MSSS et des CISSS ou CIUSSS pour obtenir des bourses dédiées aux futurs technologues en médecine nucléaire pour pallier la pénurie de main d'œuvre qui sévit dans les différentes régions du Québec.

Que le ministère de l'Enseignement supérieur reconnaisse la valeur des équipements à la fine pointe de la technologie que nous possédons et que les budgets octroyés à la seule maison d'enseignement qui offre le programme soit à la hauteur de la qualité de la formation que nous offrons pour graduer des technologues compétents et autonomes prêts à intégrer le marché du travail à leur sortie de l'école. ■

INTERVIEW WITH *Chantal Asselin*

You are responsible for the training program for nuclear medicine technologists in Quebec, Canada. Could you give us a short summary of your background and your current position?

Teacher in the Nuclear Medicine Technology Program at Ahuntsic College since 1986 and Head of Department Coordination, Internships and Radiation Protection Officer since 1997.

As a radiation protection consultant, publishing several scientific papers, providing numerous trainings and conferences in several regions of Quebec and Canadian provinces; conducting several recommendations or guidelines for l'Ordre des technologues en imagerie médicale et en radio-oncologie du Québec (Quebec College of Medical Imaging and Radiation Oncology Technologists); Emeritus medical imaging technologist since 2006; Honorable mention of l'Association québécoise de pédagogie collégiale - AQPC (Quebec Association of College Education) in 2010.

How long has the training centre been in operations and to date, how many medical technologists have been trained?

From 1968 to today, we have trained more than 700 technologists who work in 50 nuclear medicine departments across the province of Quebec.

How many teachers work on student training?

9 teachers in Nuclear Medicine Technology are currently employed at Ahuntsic College and are supported by 2 laboratory technicians.

The excellence of our technologists is recognized around the world. In a few lines, could you describe a student's typical journey?

During the first two years of the program, students learn how to prepare and perform quality control of radiopharmaceuticals thanks to the collaboration with our partners from the radiopharmaceutical industry. In addition, our students practice injecting products safely, producing phantom images using cameras, and analyzing information collected using the same software utilized on a daily basis in hospitals. All they are missing at the college are the patients!

And it is the essential onsite supervisors and clinical teachers, who then take over in the medical center settings, during the third year of the program, to empower our students to develop their patient care skillset and put into practice what they learned during their first two years of the program.

We are also very involved in the planning and placement of the future workforce. Please note that we have increased the number of admissions to our

program from 40 to 65 places in recent years. The entire institution works hard to promote our profession and above all, to promote the success of our students.

How many nuclear medicine technologists are currently active in Quebec and in how many centres?

Approximately 530 nuclear medicine technologists are currently active in Quebec and work in about 50 departments across the province.

With the accelerated development of new radiotracers, hybrid detectors and theranostics, what are the most pressing challenges you face?

The field of nuclear medicine is constantly evolving as in all areas of medical imaging. For my part, I have witnessed six great revolutions in my 35-year career. After the arrival of gamma cameras in the 70s, I started my career as a technologist with the arrival of computers in the early 80s. I participated in the training of technologists with the arrival of Single Photon Emission Computed Tomography cameras (SPECT) in the 1990s, followed by Positron Emission Tomography cameras (PET) in the early 2000s and by the hybrid cameras SPECT-CT or PET-CT in the mid-2000s. Theranostics and the sterile compounding of radiopharmaceuticals in shielded isolators are amongst the new trainings we have integrated into our current program, and for the tailored training offered to post graduate technologists.

For more than 30 years, Ahuntsic College has been supporting the ongoing training of technologists by offering bespoke theoretical and practical training on new technologies that are introduced in our field. We have also been offering remote training for the past 15 years, allowing us to reach technologists from all regions of the Province of Quebec (1.5M km2). We were already prepared to face pandemic thanks to our remote capabilities!

6. What would be your greatest wish for your nuclear medicine technologist training program?

I have two wishes:

To improve the attraction to our exceptional program and this wonderful profession in order to get more candidates according to regional needs. In this regard, we will take steps with the Ministry of Health (MSSS), and Integrated Health and Social Services Centres (CISSS), and Integrated University Health and Social Services Centres (CIUSSS), to obtain grants dedicated to future nuclear medicine technologists to better address the labour shortage in the various regions of the Province of Quebec.

For the Ministry of Higher Education to recognize the value of the state-of-the-art equipment we have, and that the allocated budgets, to the only educational institution that offers the Nuclear Medicine Technology program in the Province, are aligned with the quality of the training we provide to ensure our students graduate as highly competent and autonomous technologists, ready to enter the nuclear medicine field. ■

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INTERVIEW WITH DR. RAYMONDE CHARTRAND

Until recently, few women held leadership positions in Nuclear Medicine. As a pioneer and scientist in this field, how have you been able to distinguish yourself so greatly as a nuclear physician?

In our Class of 1965, we were 15 women to graduate out of a total of 93 doctors. Times have greatly changed since then. After my residency in internal medicine, I completed one year at the Montreal General Hospital with Dr. Leonard Rosenthal in "Radioisotopes" as it was called at the time. The following year I embarked on a fellowship of the National Institutes of Health in the United States at Upstate Medical Center in Syracuse, NY with Dr. John G. McAfee (Canadian Radiologist from Toronto whose groundbreaking research led to major medical advances especially in blood cell labelling).

When I came back to Montreal in 1969, the Nuclear Medicine Specialty (distinct entity from Radiology) had just been created in the Province of Quebec. A first in Canada, and actually, in all of North America. In 1972, I passed the American Board of Nuclear Medicine exam. Four years later, in 1976, another board exam, this time at the Royal College of Physicians & Surgeons of Canada.

I have founded and opened the Hôpital St-Luc Nuclear Medicine Service in 1970 in Montreal. It required a lot of determination being a female physician, in charge, during this era. Being the only girl from a family of 5 siblings, I had quickly learned to defend my turf.

In 1976, Dr. François Lamoureux freshly back from London, after a Master of Science from university of London England, joined our service. He worked part time balancing his workload as he was also working at Hôpital Notre-Dame.

The Nuclear Medicine beginnings were extremely arduous due to the Quebec Government. Considered a quaternary specialty, the Ministry of Health had frozen all budgets to reduce spending. The freeze ended in 1978-1979.

I became President of the Pedagogic Committee and Director of the Nuclear Medicine Program, a position I held until 1990. From the small nucleus of colleagues since the very early days, we joined forces to establish a solid Nuclear Medicine program that would ensure medical coverage across the province including remote regions. We trained brilliant specialists. In parallel, the Ahuntsic College in Montreal, developed an excellent program for NM Technologists. These highly competent professionals play an essential role in a nuclear medicine service or department. This pivotal program utility was never doubted throughout the years.

I consistently evolved in a university environment alongside highly qualified physicians from all medical specialties. It was a stimulating environment where excellence and knowledge transfer were at the forefront. We educated the residents from the NM program but also to residents from all other specialties, general medical practitioners, technologists, nurses, and future pharmacists.

Through the years our hospital became part of the CHUM – Centre Hospitalier de l'Université de Montréal (merge of 3 major hospitals). The CHUM became a flagship institution for thyroid studies, especially cancers. I was extremely involved in the iodine therapies, the introduction of thyrotropin alfa, training all future NM specialists and an advisor to my colleagues throughout the province (NM physicians, endocrinologists, surgeons, etc.).

My involvement continued to evolve beyond the hospital and university settings. I became a Faculty Clinical Professor at Université de Montréal. I then

seated as chairman of the Royal College of Physicians & Surgeons of Canada, quickly followed by the Presidency of the Canadian Association of Nuclear Medicine. In 1987, I became an Ambassador Appointed from Le Palais des Congrès de Montréal after obtaining the 5th World Nuclear Medicine Congress in 1990.

I was always told that nature was generous with me. I continuously had tons of energy, enthusiasm, organization, and time-management skills. I am thankful for the support my family always provided: my husband, my 3 children, a loyal nanny for 25 years and last but not least, empathetic and devoted colleagues. My weekends were entirely focused on family and friends except, of course, when I was on-call at the hospital. I still remember my kids at a young age, with coloring books, with me, at the hospital while I was on duty…

Marie Curie is considered by many to be the mother of Nuclear Medicine. What human and professional qualities do you think she possessed to have succeeded in such a career and to lay the foundations for a new field of medicine?

Marie Curie was always present throughout my life and career (50 years) as a female Nuclear Medicine Specialist. I was never able to negate or forget the micro, milli and Curies, even though Becquerel later became the international metric unit for radioactive activity. For me, Marie Curie remains a model of determination and passion. She represents a strength of nature, being able to overcome life, adversity, confidence in her abilities and the willingness to excel sometimes to her own personal detriment.

As a medical professional, professor, and mentor what advice would you give to women interested in pursuing and succeeding in a medical career?

Any woman, nowadays, can become a doctor if that is her wish. It requires hard work, dedication, and perseverance. Our societies have greatly evolved for both men and women, now more than ever, individuals aim for a balance between professional, personal, and family life. In our field, female residents can start a family, extend their residency, if need be, without being penalized or impacted in their program. It certainly needs the support from the spouse or partner and family. That being said, this is no different than any profession or area of expertise.

How do you see the future of medical imaging and Nuclear Medicine? What role will women play in your opinion?

Nuclear Medicine never ceased to progress for the past 50 years considering the disappearing of certain studies and radiotracers but also, with the apparition of new compounds to allow for the detection of different conditions: for example, Parkinson's, cardiac amyloidosis, certain cancers, and the development of new therapies (theranostics).

The imaging devices also greatly improved from the days of rectilinear cartographs, to scintillation cameras to more advanced SPECT, SPECT-CT as well as PET-CT and PET-MR.

Informatics was slowly deployed in Nuclear Medicine in the 1980s and brought more possibilities. Speech recognition for example, was a game changer for physicians. Developments are happening every day, what will the future hold? What will the Artificial Intelligence bring?

Nuclear Medicine, even though, now combining anatomical modalities (with hybrid scanners) will always remain a separate field from Radiology due to its unique approach, focused on molecular markers for both diagnosis and treatment of disease. It is also a support field where we consistently contribute to all medical specialties, bringing valuable input with our state-of-the-art diagnostic services. The therapeutic aspect of Molecular Imaging will be revolutionary (not only from Iodine), but all the Theranostics where empathy and patient care will be of the greatest importance.

Women can tremendously perform in Nuclear Medicine: Applied sciences, physics, instrumentation, radiobiology, radiopharmacy are amongst the impressive list of areas that should not stop female candidates.

Finally after such a career in Nuclear Medicine what is your greatest wish for future nuclear physicians?

I have embraced my profession, my practice and more importantly my patients, I wish that all future Nuclear Medicine physicians bring dedication, enthusiasm, and passion at work in this great field while maintaining a good balance between their professional and personal lives.

Yes, this is my wish for the future of our field. The world pandemic, my age, and my children suggested that it was time for me to retire at 81 years old. ■

ENTREVUE AVEC DR. RAYMONDE CHARTRAND

Jusqu'à récemment, peu de femmes occupaient des postes de direction en médecine nucléaire. En tant que pionnier et scientifique dans ce domaine, comment avez-vous pu vous distinguer autant en tant que médecin nucléaire ?

Dans notre classe de 1965, nous étions 15 femmes à obtenir leur diplôme sur un total de 93 médecins. Les temps ont bien changé depuis. Après ma résidence en médecine interne, j'ai complété une année à l'Hôpital général de Montréal avec le Dr Leonard Rosenthal en « Radio-isotopes » comme on l'appelait à l'époque. L'année suivante, je me suis lancé dans une bourse des National Institutes of Health aux États-Unis au Upstate Medical Center de Syracuse, NY avec le Dr John G. McAfee (radiologue canadien de Toronto dont les recherches révolutionnaires ont conduit à des avancées médicales majeures, en particulier dans l'étiquetage).

À mon retour à Montréal en 1969, la spécialité de médecine nucléaire (entité distincte de la radiologie) venait d'être créée dans la province de Québec. Une première au Canada, et en fait, dans toute l'Amérique du Nord. En 1972, j'ai réussi l'examen de l'American Board of Nuclear Medicine. Quatre ans plus tard, en 1976, un autre examen du jury, cette fois au Collège royal des médecins et chirurgiens du Canada.

J'ai fondé et ouvert le Service de médecine nucléaire de l'Hôpital St-Luc en 1970 à Montréal. Il fallait beaucoup de détermination pour être une femme médecin responsable à cette époque. Étant la seule fille d'une famille de 5 frères et sœurs, j'avais rapidement appris à défendre mon territoire.

En 1976, le Dr François Lamoureux fraîchement revenu de Londres, après un Master of Science university of London England, rejoint notre service. Il travaillait à temps partiel pour équilibrer sa charge de travail puisqu'il travaillait également à l'Hôpital Notre-Dame.

Les débuts de la médecine nucléaire ont été extrêmement ardus à cause du gouvernement du Québec. Considéré comme une spécialité quaternaire, le ministère de la Santé avait gelé tous les budgets pour réduire les dépenses. Le gel a pris fin en 1978-1979.

Je suis devenu président du comité pédagogique et directeur du programme de médecine nucléaire, poste que j'ai occupé jusqu'en 1990. Du petit noyau de collègues depuis les tout premiers jours, nous avons uni nos forces pour établir un solide programme de médecine nucléaire qui assurerait une couverture médicale à travers la province, y compris les régions éloignées. Nous avons formé de brillants spécialistes. En parallèle, le Collège Ahuntsic à Montréal, a développé un excellent programme pour les Technologues NM. Ces professionnels hautement compétents jouent un rôle essentiel dans un service ou un département de médecine nucléaire. Cette utilité centrale du programme n'a jamais été mise en doute au fil des ans.

J'ai constamment évolué dans un environnement universitaire aux côtés de médecins hautement qualifiés de toutes les spécialités médicales. C'était un environnement stimulant où l'excellence et le transfert de connaissances étaient au premier plan. Nous avons formé les résidents du programme NM mais aussi les résidents de toutes les autres spécialités, les médecins généralistes, les technologues, les infirmières et les futurs pharmaciens.

Au fil des années, notre hôpital est devenu une partie du CHUM – Centre Hospitalier de l'Université de Montréal (fusion de 3 grands hôpitaux). Le CHUM est devenu une institution phare pour les études sur la thyroïde, notamment les cancers. J'ai été extrêmement impliqué dans les thérapies à l'iode, l'introduction de la thyrotropine alfa, la formation de tous les futurs spécialistes en NM et un conseiller auprès de mes collègues à travers la province (médecins NM, endocrinologues, chirurgiens, etc.).

Mon implication a continué d'évoluer au-delà du milieu hospitalier et universitaire. Je suis devenu professeur clinicien à l'Université de Montréal. J'ai ensuite occupé le poste de président du Collège royal des médecins et chirurgiens du Canada, rapidement suivi par la présidence de l'Association canadienne de médecine nucléaire. En 1987, je suis devenu Ambassadeur Nommé du Palais des Congrès de Montréal après avoir obtenu le 5e Congrès mondial de médecine nucléaire en 1990.

On m'a toujours dit que la nature était généreuse avec moi. J'ai continuellement eu des tonnes d'énergie, d'enthousiasme, d'organisation et de compétences en gestion du temps. Je suis reconnaissante pour le soutien que ma famille m'a toujours apporté : mon mari, mes 3 enfants, une nounou fidèle depuis 25 ans et enfin des collègues empathiques et dévoués. Mes week-ends étaient entièrement consacrés à la famille et aux amis, sauf, bien sûr, lorsque j'étais de garde à l'hôpital. Je me souviens encore de mes enfants à un jeune âge, avec des livres de coloriage, avec moi, à l'hôpital pendant que j'étais de service…

Marie Curie est considérée par beaucoup comme la mère de la médecine nucléaire. Quelles qualités humaines et professionnelles pensez-vous qu'elle possédait pour avoir réussi une telle carrière et jeter les bases d'un nouveau domaine de la médecine ?

Marie Curie a toujours été présente tout au long de ma vie et de ma carrière (50 ans) en tant que femme spécialiste en médecine nucléaire. Je n'ai jamais été capable de nier ou d'oublier les micro, milli et Curies, même si Becquerel est devenu plus tard l'unité métrique internationale pour l'activité radioactive. Pour moi, Marie Curie reste un modèle de détermination et de passion. Elle représente une force de la nature, capable de surmonter la vie, l'adversité, la confiance en ses capacités et la volonté d'exceller parfois à son détriment personnel.

En tant que professionnel de la santé, professeur et mentor, quels conseils donneriez-vous aux femmes intéressées à poursuivre et à réussir une carrière médicale ?

Toute femme, de nos jours, peut devenir médecin si tel est son souhait. Cela demande un travail acharné, du dévouement et de la persévérance. Nos sociétés ont beaucoup évolué tant pour les hommes que pour les femmes, aujourd'hui plus que jamais, les individus visent un équilibre entre vie professionnelle, personnelle et familiale. Dans notre domaine, les résidentes peuvent fonder une famille, prolonger leur résidence, si besoin est, sans être pénalisées ou impactées dans leur programme. Il a certainement besoin du soutien du conjoint ou du partenaire et de la famille. Cela étant dit, ce n'est pas différent de n'importe quelle profession ou domaine d'expertise.

Comment voyez-vous l'avenir de l'imagerie médicale et de la médecine nucléaire ? Quel rôle les femmes joueront-elles selon vous ?

La Médecine Nucléaire n'a cessé de progresser depuis 50 ans compte tenu de la disparition de certaines études et des radiotraceurs mais aussi, avec l'apparition de nouveaux composés permettant de détecter différentes pathologies : par exemple, la maladie de Parkinson, l'amylose cardiaque, certains cancers, la développement de nouvelles thérapies (théranose).

Les dispositifs d'imagerie se sont également considérablement améliorés depuis l'époque des cartographies rectilignes, des caméras à scintillation aux SPECT plus avancés, SPECT-CT ainsi que PET-CT et PET-MR.

L'informatique s'est lentement déployée en médecine nucléaire dans les années 1980 et a apporté plus de possibilités. La reconnaissance vocale, par exemple, a changé la donne pour les médecins. Des évolutions se produisent chaque jour, que nous réserve l'avenir ? Qu'apportera l'Intelligence Artificielle ?

La médecine nucléaire, même si, maintenant, combinant des modalités anatomiques (avec des scanners hybrides) restera toujours un domaine distinct de la radiologie en raison de son approche unique, axée sur les marqueurs moléculaires pour le diagnostic et le traitement de la maladie. C'est également un domaine de soutien où nous contribuons constamment à toutes les spécialités médicales, apportant une contribution précieuse avec nos services de diagnostic de pointe. L'aspect thérapeutique de l'imagerie moléculaire sera révolutionnaire (pas seulement de l'iode), mais de tous les théranostiques où l'empathie et les soins aux patients seront de la plus grande importance.

Les femmes peuvent être extrêmement performantes en médecine nucléaire : les sciences appliquées, la physique, l'instrumentation, la radiobiologie, la radiopharmacie font partie de la liste impressionnante des domaines qui ne devraient pas arrêter les candidatures féminines.

Enfin, après une telle carrière en Médecine Nucléaire, quel est votre plus grand souhait pour les futurs médecins nucléaires ?

J'ai embrassé ma profession, ma pratique et surtout mes patients, je souhaite que tous les futurs médecins en médecine nucléaire apportent dévouement, enthousiasme et passion au travail dans ce grand domaine tout en maintenant un bon équilibre entre leur vie professionnelle et personnelle.

Oui, c'est mon souhait pour l'avenir de notre domaine. La pandémie mondiale, mon âge et mes enfants ont suggéré qu'il était temps pour moi de prendre ma retraite à 81 ans. ■

Grégoire Blais MD, FRCP
Médecin nucléiste / Nuclear Medicine Specialist
Centre de santé et de service sociaux de la Haute-Yamaska
Granby

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VENEZ CONSULTER

https://www.facebook.com/AMSMNQ/

Venez consultez la page Facebook de l'association des médecins spécialistes en médecine nucléaire du Québec. Vous y trouverez de multiples informations concernant principalement la médecine nucléaire québécoise.

Nous y partageons des événements à venir, des articles intéressants et toutes nouvelles susceptibles d'intéresser la communauté de médecine nucléaire d'ici et d'ailleurs. Nous sommes aussi très fier de présenter les réalisations exceptionnelles de certains de nos membres.

N'hésitez pas à nous contacter si vous souhaitez nous partager une bonne nouvelle, une information, ou un article d'intérêt.

Grégoire Blais
Responsable de la page Facebook de l'AMSMNQ

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COME TO CONSULT

https://www.facebook.com/AMSMNQ/

Visit the Facebook page of the Quebec Association of Nuclear Medicine Specialists. You will find a wealth of information there concerning nuclear medicine in Quebec.

This is where we share upcoming events, interesting articles and useful information with the nuclear medicine community at home and abroad. We are also very proud to showcase the exceptional accomplishments of some of our members.

Please do not hesitate to contact us if you have any good news, information, or article of interest.

Gregoire Blais
Manager of the AMSMNQ Facebook page

AMSMNQ

ASSOCIATION DES MÉDECINS SPÉCIALISTES EN MÉDECINE NUCLÉAIRE DU QUÉBEC

L'IMAGERIE PERSONNALISÉE PAR LA MÉDECINE NUCLÉAIRE

« La mission du comité de développement professionnel continu (DPC) de l'Association des médecins spécialistes en médecine nucléaire du Québec (AMSNMQ) est de soutenir les médecins nucléistes à acquérir et à préserver leur expertise médicale, ainsi qu'à améliorer leurs compétences de collaboration et de communication dans le but de prioriser la qualité des soins aux patients. »

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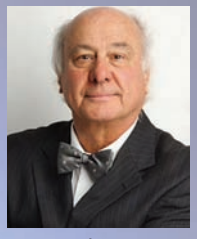
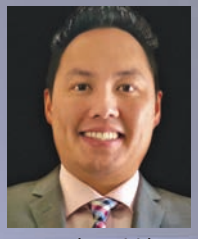

Dr. Francois Lamoureux
Président sortant (invité)


Dr.Keu Khun Visith
Conseillier

ORGANISATIONS

ACOMEN • American Society of Nuclear Cardiology • Association Canadienne de Médecine Nucléaire • Association Chinoise de Médecine Nucléaire • British Nuclear Medecine Society • Cancer de la Thyroïde Canada • Commission Canadienne de Sureté Nucléaire • Collège des Médecins du Québec • Collège Royal des Médecins et Chirurgiens du Canada • European Association of Nuclear Medecine • Fédération de Médecins Spécialistes du Québec • Fondation Canadienne de la Thyroïde • International Atomic Energy Agency • Pubmed • Société Française de Médecine Nucléaire et d'Imagerie Moléculaire • Society of Nuclear Medecine • Société Canadienne du Cancer • Université McGill • Université de Montréal • Université de Sherbrooke • World Federation of Nuclear Medicine and Biology

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INTERVIEW WITH TOM FRANCKE

Tom Francke, Assoc. Prof.
CEO of Hermes Medical Solutions

Tom, you are the President and CEO of Hermes Medical Solutions. Can you give us a short idea of the company?

Hermes Medical Solutions is one of the pioneering software companies in nuclear medicine and molecular imaging, and has supplied the medical community with image display, analysis and reporting software for 45 years. We are proud of focusing on innovation, to be the leader of new developments and bring the best applications to the market based on the latest clinical research.

Having a long scientific background, I believe in the value of science driven development and the value of a close collaboration with the scientific community. Our skilled personnel convert your experience into the applications of the future.

The Hermes software supports all clinically used NM/MI procedures. Hermes simplifies the workflow for the clinicians in diagnosis and therapy in nuclear medicine and molecular imaging providing excellent viewers, analysis and reporting tools.

With an HMS Workstation you have one work environment for all applications in a multivendor camera clinic, and can freely chose to buy additional cameras from any supplier without having to change workstation.

Our local and professional support staff is quickly responsive and match the nuclear medicine expertise of our customers. Hermes is unique in that all our clinical support staff are trained technologist with long clinical experience. We have installations in more than 40 countries and are present globally.

Where is Hermes Medical Solutions going and what will be the impact for the Hermes Medical Solutions users?

Hermes strives to always have the most accurate and advanced solutions for all clinical applications used in the nuclear medicine field. We ensure this by our wide and extensive collaboration with the scientific community, a large inhouse clinical expertise and skilled developers from a broad background.

The user interfaces is modern, intuitive, fast, flexible and configurable for every personal taste. The images can be reconstructed by the most advanced reconstruction algorithms on the market to give accurate and comparable uptake values regardless of camera brand and when the image was taken.

Artificial intelligence (AI) combined with experience and medically based knowledge is an important tool in everything we do. We are often driving the development of new clinical practices in nuclear medicine, especially in the fields of neurology, dosimetry, theranostics and oncology.

Don't miss the many new and unique functionalities and applications which will be released in the coming months. Primarily in oncology and Theranostics.

Anyone considering using an HMS Workstations in the future can be certain they will have the latest tools and workflows at hand; today and in the future. Regardless of which camera brands they chose to use.

How is Hermes Medical Solutions involved in the incontournable field of Theranostics? What will it mean to Hermes Medical Solution's partners?

Theranostics is growing rapidly and Hermes has for many years been the leader in the dosimetry software field that is essential for safe and effective internal radiotherapy. Hermes' dosimetry software is not only used in clinical practice, but also by the research community developing new clinical workflows. Most important, the pharmaceutical companies developing the new tracers to be used in Theranostics in the future use the Hermes software in their development and clinical trials. The most widely used organ dosimetry software, Olinda, is exclusively provided by Hermes.

Hermes positions itself as the flagship for safe personalized nuclear radiotherapy.

Finally, what is your greatest wish for Hermes Medical Solutions and its clients?

Our customers, and the whole medical community, is our strongest focus. We welcome all the feedback we can get to develop and give back the best possible products the community will need in the future. Let us continue and deepen the fruitful and mutual cooperation we have today.

We look forward to meet our colleagues again in person as soon as the pandemic allows.

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Next Generation Molecular Imaging

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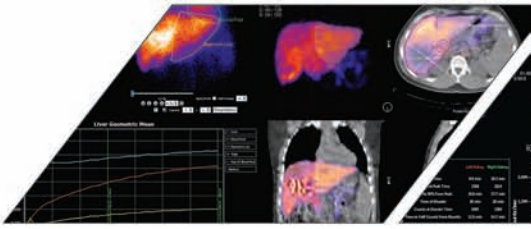
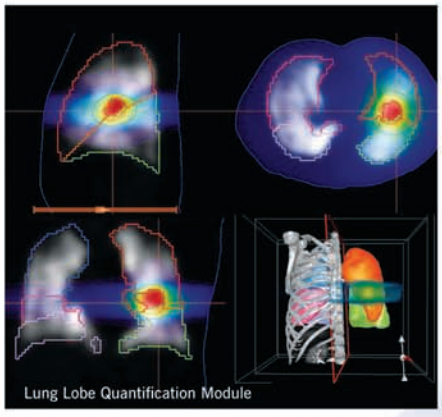


ENTERPRISE CLASS SOLUTIONS FOR MOLECULAR IMAGING

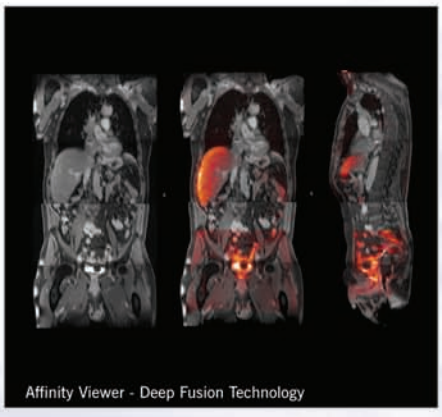
With more than 40 years of recognition for Clinical Excellence and innovation in Molecular Imaging, HERMES delivers Enterprise Class systems and software for integrating, visualizing, processing, reporting and archiving imaging data from different imaging modalities and devices within Molecular Imaging and Radiology. HERMES solutions are empowering physicians by enabling faster and more accurate diagnosis and treatment of patients, thereby improving patient outcomes and increasing efficiency. HERMES leadership within Molecular Imaging has been built on leading technological innovation, financial stability, and historical success. HERMES is committed to the continuous development of cutting-edge accessible software solutions for clinical environments, academic institutions and industry partners. HERMES will continue to offer its customers and proSPECTive clients, the most comprehensive Enterprise Molecular Imaging solutions available for diagnosis and treatment planning as healthcare moves into the new frontiers of Precision Medicine.

DISPLAYED BY HERMES™

Historically, nuclear medicine has benefited from excellent software but, rarely on a single platform. One computer is generally used to display a certain type of exam, another to archive the data and, another is used for specific or dedicated applications. This lack of integration and the non-uniformity of components, continues to cause serious workflow obstacles for professionals working in imaging departments.



Lung Lobe Quantification Module



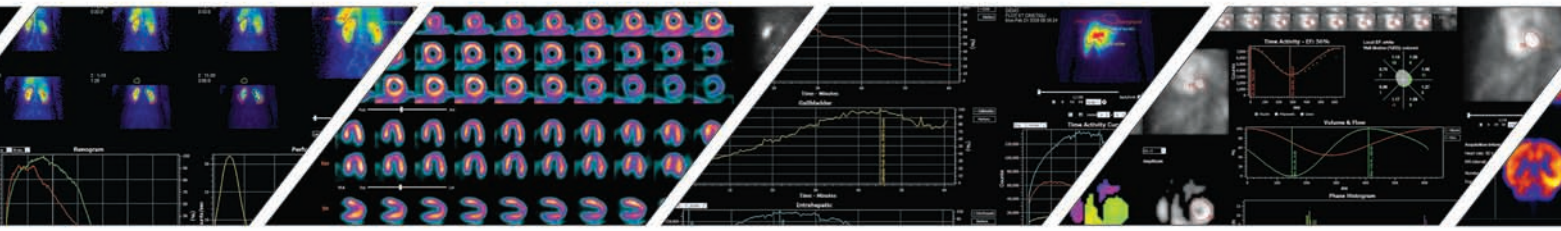
Affinity Viewer - Deep Fusion Technology

With crucial input from customers around the world, nuclear medicine pioneers, the HERMES R&D team has developed Hybrid Viewer PDR™ and Affinity Viewer: A unique and user-friendly software suite for Processing, Display and Reporting (PDR). This all-in-one tool allows the display of all medical imaging modalities (including angiography and ultrasound), image fusion (SPECT-PET-CT-MR) including analysis of this data, processing of conventional nuclear medicine and, the ability to generate medical reports. This technology is used on 6 continents and present in a majority of state-of-the-art NM Departments.

The raw and processed data is stored in a metadata VNA in DICOM, native format, MS-Word™, MS-Excel™, .wav audio files, Adobe PDF™, etc. fully integrating with existing equipment in today's departments under a single master worklist.

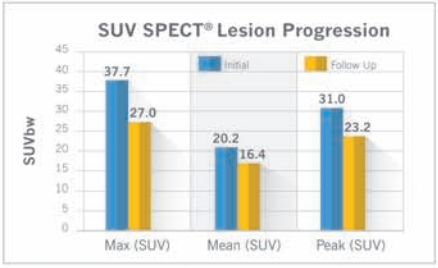
CONNECTED BY HERMES™

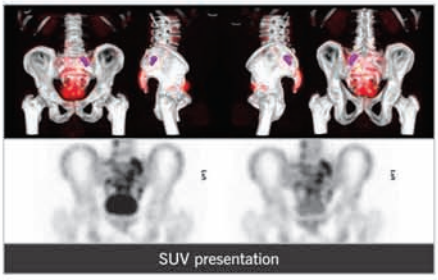
From the early days of nuclear medicine, quantification has been a key aspect; self-defining the practice and at the same time distinguishing from other imaging modalities. The arrival of Positron Emission Tomography (PET and its SUV scale) certainly contributed to advances in the field, but the essence of nuclear medicine still remains the SPECT environment for a vast majority of medical centers. The new breed of cameras coupled with CT components and optimized with advanced reconstruction tools started paving the way for the day when a SUV scale, similar to the one used in PET, would help us quantify images obtained from SPECT-CT scanners. Despite the increasing availability of PET, the number of specific tracers used with this technique is still suboptimal. Absolute SPECT-CT quantification (SUV) is now available and opens the door to a plethora of possibilities with dozens of proven tracers already in use.



RECONSTRUCTED BY HERMES™

The HERMES SUV SPECT® revolutionizes quantitative imaging by exploiting the use of SPECT's full potential in regions where a large portion of the population still does not have access to PET and/or associated reimbursements. HERMES SUV SPECT® software algorithms enable a conversion of the recorded counts per voxel into activity per unit volume with SUV calculations, providing essential and accurate quantitative results.





SUV presentation

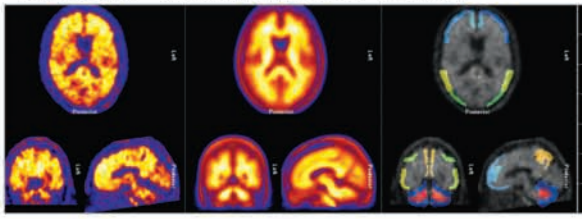
Combined with attenuation correction from a hybrid SPECT-CT scanner or SPECT-only camera (utilizing an independent CT) and a Monte Carlo-modeled scatter correction, HERMES SUV SPECT® brings SPECT-CT scanners from any manufacturer to the next level.

QUANTIFIED BY HERMES™

Mostly used for teaching purposes or display modelling, 3D applications enable automatic lesions detection or the ability to establish more accurate diagnostics in comparison with still largely used 2D tools. These amazing results can be obtained with the help of advanced segmentation methods especially useful with quantitative pulmonary studies. The Hybrid Viewer™ 3D module proceeds with an automatic co-registration of the SPECT-CT (and separate diagnostic CT if needed), an automatic L/R Lung and airways segmentation, a quick inter-lobar fissure definition, a fissure definition quality control, a lobar ventilation and perfusion quantification and an automatic report generation. Knowing that accurate results can drastically change the optimal surgical approach, comparative studies have been conducted between current 2D techniques (planar anterior image or real anterior reprojection divided in 6 segments) and 3D segmentation techniques. Preliminary results have shown differences ranging between -10% to +48% in the assessment of accurate volume calculation in ml. Similar tools for automatic hepatic and kidney segmentation are now available and will help promoting for a closer collaboration between quantitative imaging and surgical departments.

HERMES is extremely proud to participate in high-level research to support healthcare professionals in the detection and treatment follow-up of diseases such as epilepsy, brain tumors, schizophrenia, Parkinson's and most recently Alzheimer's. The market debut of NeuraCeq™, recently approved by Health Canada and commercialized by Isologic, synergizes HERMES efforts in assisting nuclear medicine physicians in university facilities as well as in community hospitals, by providing them with normal templates for a precise and reliable quantification of the patient illness state. This Isologic-HERMES partnership facilitates the utilization of the renown BRASS™ (Brain Registration & Analysis Software Suite) application, appearing in more than 350 scientific publications and presentations around the world and validated with over 2 million patients.

HERMES BRASS™ Quantification with NeuraCeq™ from Isologic



Region Name	SUVr (Z)
Average SUVr	1.65 (2.13)
L Frontal Ctx	1.52 (2.92)
R Frontal Ctx	1.68 (4.24)
L Ant Cingulate	2.15 (5.50)
R Ant Cingulate	2.31 (5.12)
L Occipital Ctx	1.30 (1.00)

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HERMES VNM™ includes HERMES VNA (Vendor-Neutral Archive) combined with the power of a complete clinical medical imaging platform, tailor-made for multi-vendor sites/multi-facilities integration. HERMES provides cost effective solutions worldwide from enterprise-wide architecture & infrastructure to storage, reading, analysis and processing services on its systems or via HERMES cloud, TeleHERMES™.

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ENTREVUE AVEC *Kristy Owen*

Kristy Owen, RTNM

À la suite de ses études à la faculté des sciences de University of British Columbia (UBC) de Vancouver au Canada, Madame Owen a obtenu son diplôme du programme de Technologie de médecine nucléaire du British Columbia Institute of Technology (BCIT) en 2006. Enseignante et coordonnatrice clinique à BCIT (faculté des sciences de la santé – médecine nucléaire) depuis plus de 10 ans, elle occupe également divers autres postes. En 2020, elle fut élue à titre de Directrice, membre du conseil d'administration de l'Association Canadienne des Technologues en Radiation Médicale (ACTRM) ainsi que membre ex officio du conseil consultatif de la même association pour la Colombie-Britannique. En juillet 2021, Mme Owen ajoutera le poste de co-responsable du programme de médecine nucléaire de BCIT à son CV.

En plus de sa présence sur de nombreux comités de leadership, publication de plusieurs articles scientifiques et implication dans la communauté de la médecine nucléaire, Kristy fut la récipiendaire de nombreux prix de reconnaissance tel que le Bowers Medical Suppliers Scholarship (BCIT), le BCIT Health Sciences Dr. Joseph Cohen Award for Outstanding Academic Performance, le UBC Entrance Scholarship for Outstanding Academic Performance et le Ministry of Education Provincial Scholarship.

POURQUOI MON TRAVAIL EN MÉDECINE NUCLÉAIRE EST COMME CETTE DESTINATION VACANCES FAVORITE QUE VOUS VOULEZ GARDER SECRÈTE ?

Avez-vous déjà déniché la plus magnifique des destinations vacances ? Parfaitement calme, météo optimale, privée, peu fréquentée, bon prix, disponible au moment idéal ? Si convoitée que vous hésitez à la partager avec vos amis de peur qu'ils ne vous la volent ? C'est ce que je ressens lorsque je pense à ma carrière en médecine nucléaire. Une carrière que je me considère choyée d'avoir trouvée. Avec seulement quelques recherches, je fus intriguée : un mélange de soins aux patients, une technologie de pointe, la science du rayonnement, la physique et le travail de laboratoire. Ce que je n'avais pas réalisé, c'est à quel point une journée dans la vie d'un technologue en médecine nucléaire est excitante, à quel point j'allais acquérir des connaissances en imagerie, à quel point l'avenir serait fascinant pour la détection et le traitement des maladies, comment cela aurait un impact direct sur la santé des patients, combien d'emplois diversifiés il y aurait et à quel point la communauté de la médecine nucléaire est dynamique. Une communauté dont je ferai toujours partie. Je n'avais jamais envisagé que bien des années plus tard, je me sentirais toujours comblée et fière de ma croissance personnelle et professionnelle. Permettez-moi donc de partager mon secret avec vous ...

Les technologues en médecine nucléaire commencent habituellement leur journée dans le « laboratoire chaud (radioactif) » où ils manipulent des produits radiopharmaceutiques (produits pharmaceutiques radioactifs), les testent pour en vérifier la qualité et les préparent à être administrés aux patients. L'immense variété d'études réalisées dans un département de médecine nucléaire peut être attribuée au fait que l'aspect fonctionnel de chaque système de corps humain peut être imagé pour détecter une série de maladies telles que l'infection, l'inflammation, ou le cancer. Au fur et à mesure que les patients arrivent tout au long de la journée, un ou une technologue administrera un traceur radioactif spécifique par voie intraveineuse, sous-cutanée, orale ou par inhalation. Chaque traceur est choisi et créé chimiquement pour mettre en évidence une fonction spécifique du corps des patients et est ensuite visualisé à l'aide d'une caméra hybride. Les caméras hybrides, comme la tomographie par émission monophotonique/tomodensitométrie (TEMP/TDM en français ou SPECT/CT en anglais) et la tomographie par émission de positons (TEP/TDM en français ou PET/CT en anglais), créent des images hautement sensibles et spécifiques qui sont évaluées et examinées de façon approfondie et dans un souci de qualité, par l'œil méticuleux d'un ou d'une technologue. Les technologues sont les experts de ce métier et peuvent souvent reconnaître des changements subtils sur une image avant qu'un médecin ne valide les informations. Cela signifie que le technologue a un impact direct et crucial sur les résultats d'examen et de l'état de santé de chaque patient. Des habiletés marquées de soins au patient

et un niveau élevé d'attention aux détails sont essentiels car les patients peuvent potentiellement être dans un état critique. Afin d'optimiser davantage les résultats pour les patients, les technologues en médecine nucléaire font partie intégrante de l'équipe de soins de santé et travaillent dans un environnement interprofessionnel avec d'autres modalités d'imagerie, des médecins, des infirmières et bien d'autres professionnels de la santé.

La physique des sciences de la radiation est une partie importante de l'ensemble des compétences des technologues en médecine nucléaire. Les rayonnements ionisants, historiquement associés à la peur et à l'hésitation, sont explorés en profondeur dans leur formation. La connaissance et l'éducation dans ce domaine sont primordiaux et les technologues maîtrisent les procédures de sécurité requises pour se protéger et protéger leurs patients. Au cours de leur formation exhaustive, les craintes sont démystifiées et la vérité sur les avantages et les risques associés aux différents types de rayonnement sont clarifiés. Des appareils de mesure personnelle du rayonnement sont portés pour vérifier leur diligence lors de la manipulation des rayonnements ionisants. La sécurité des patients, sous tous les aspects, est leur responsabilité et ils en sont perpétuellement responsables. Le rayonnement en médecine nucléaire est essentiel et sauve des vies tous les jours !

La médecine nucléaire va de l'avant à un rythme incroyable grâce à l'avancement de l'équipement technologique et le développement de nouveaux radiotraceurs. Les caméras hybrides ont apporté la capacité de parfaitement localiser les changements fonctionnels au niveau cellulaire dans le corps, la détection précoces des maladies, et ce avec précision et acuité. La technologie TEP/TDM, axée principalement sur l'oncologie, a eu un impact majeur sur les résultats de millions de patients atteints de cancer. Les nouveaux radiotraceurs TEP peuvent évaluer le cancer du sein et de la prostate ainsi que de nouveaux traceurs neurologiques de TEP qui peuvent diagnostiquer la maladie de Parkinson, la maladie d'Alzheimer et l'ENC (encéphalopathie traumatique chronique). La théranostique, véritable révolution en médecine nucléaire, ouvre de nouvelles voies pour des diagnostics et des traitements ciblés du cancer. La recherche dans ces domaines est continuelle et abondante. Les caméras TEP/TDM et TEMP/TDM surgissent partout au Canada générant un besoin criant de technologues pour les utiliser.

Après avoir obtenu votre diplôme d'une école accréditée et réussi un examen de certification, vous devenez technologue certifié en médecine nucléaire. Alors que plusieurs prennent leur retraite dans ce même rôle, la possibilité d'une variété de carrières vous attend. Au sein de mon réseau, des collègues technologues ont reçu une formation croisée pour effectuer d'autres procédures d'imagerie diagnostique comme la TDM, l'IRM et l'échographie. Certains sont passés à l'industrie et travaillent pour des fournisseurs d'équipements et de logiciels, des sociétés d'accréditation ou des organismes de réglementation. D'autres sont devenus gestionnaires, responsables de la pratique, enseignants, doyens, opérateurs de cyclotrons ou agents de radioprotection. Certains ont quitté le Canada pour travailler à l'échelle internationale. Fait intéressant, les technologues formés au Canada sont reconnus et très recherchés à l'échelle mondiale pour leur niveau de formation élevé. Trouver une niche dans cette industrie qui vous captive est non seulement gratifiant, mais aussi tout à fait accessible.

Qu'est-ce qui fait que tant de gens restent dans le domaine de la médecine nucléaire ? Eh bien, dans mon cœur, je crois que c'est la communauté que nous avons créée. À l'échelle provinciale, nationale et internationale, il y a un sentiment d'inclusivité et de lien entre les diplômés en médecine nucléaire de tous les niveaux. J'ai été directement témoin de la passion, de la sensibilisation, de la promotion et de la fierté de notre discipline lors d'événements partout dans le monde. En tant qu'enseignante au Programme de médecine nucléaire du British Columbia Institute of Technology – BCIT (l'Institut de technologie de la Colombie-Britannique) et Directrice, membre du conseil d'administration de l'Association Canadienne des Technologues en Radiation Médicale (ACTRM), mobiliser les nouveaux membres de ce domaine en pleine croissance et de cette communauté florissante est quelque chose dont je suis extrêmement fière. Attirer les futurs diplômés dès le début en les présentant aux principaux partenaires et intervenants leur offre de belles occasions d'établir des liens. Qu'il s'agisse de bénévolat, de participation à des conférences ou tout simplement partager l'excitation autour des innovations de la médecine nucléaire, ces nouveaux diplômés sont déjà investis dans notre communauté. Dans cette industrie, les gens se sentent connectés, et quand ils se sentent connectés à quelque chose de plus grand, cela leur donne un sentiment d'appartenance. Je crois que c'est ce sentiment d'appartenance qui crée une telle satisfaction au travail.

Que vous débutiez en tant que nouveau diplômé ou que vous soyez dans le domaine depuis des décennies, la médecine nucléaire offre des possibilités illimitées d'apprendre et d'explorer. Trouvez ce créneau parfait. Connectez-vous à d'autres personnes. Faites cette différence. Bien qu'aucune carrière ne puisse remplacer la destination vacances de vos rêves, si belle et parfaite, je peux vous assurer que cette discipline est précieuse et essentielle. La science fascinante, la technologie impressionnante, l'optimisation des soins aux patients et les résultats des traitements, le travail dans un milieu multidisciplinaire en constante évolution ne sont que quelques-unes des raisons pour lesquelles j'ai pu apprécier à quel point cette carrière m'a apporté une telle satisfaction personnelle jusqu'ici. ■

CANM ACMN

The Canadian Association of Nuclear Medicine
Association canadienne de médecine nucléaire

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✓ Its dedication to promote the **transfer of scientific bench discoveries** into molecular & personalized medical diagnostics and therapies.

✓ Its ability to **promote, develop and support** the use of medical isotopes **in the emerging countries**.

✓ Its proven commitment to educate and provide **high level training** to nuclear medicine professionnals from across the world, **particul-arly from emerging countries** in collaboration with the **Royal College of Canada**.

✓ **The Pangea** project.

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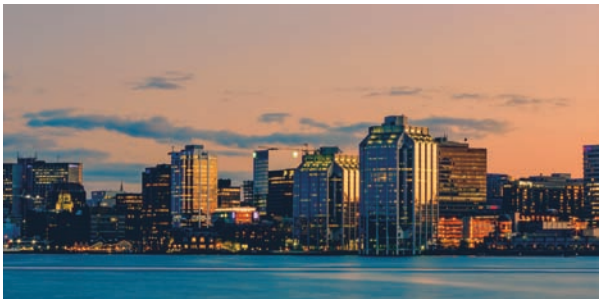

CANM ACMN
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CANM-ACMN ANNUEL SCIENTIFIC MEETING
Virtual 6 November 2021

CANM VIRTUAL CONFERENCE
NOVEMBER 6, 10 AM - 6:30 PM ET

- Response to Therapy -IMMUNOTHERAPY
- Nuclear medicine response
- The future in Nuclear Medicine

CANM ACMN
VIRTUAL CONFERENCE 20
CONFÉRENCE VIRTUELLE 21

One-day virtual conference
Registration to come!
Deadline to Register:
November 1, 2021
Offered to CANM Members
and open to any others.

COLLOQUE VIRTUEL

SFMN	2-4 septembre 2021	Beffroi de Montrouge
EANM	20-23 october 2021	Virtual
CANM	6 november 2021	Virtual
CANM	7-10 april 2022	Montreal
AMSMNQ	22-24 april 2022	Sherbrooke
SNMMI	11-14 june 2022	Vancouver
WFNMB	7-10 september 2022	Kyoto
EANM	15-19 october 2022	Barcelona

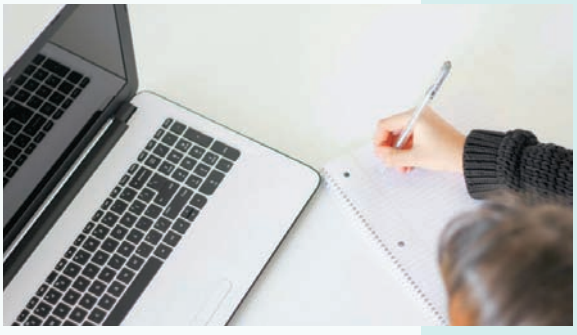
In the meantime, please mark your calendar!

SAVE IMPORTANT DATES

Annual General Meeting (AGM)

Wednesday, September 22, 2021 @ 7pm ET
Registration to come!
Deadline to Register: September 17, 2021
Offered to CANM only.

The Canadian Association of Nuclear Medicine strives for excellence in the practice of diagnostic and therapeutic nuclear medicine by promoting the continued professional competence of nuclear medicine specialists, establishing guidelines of clinical practice, and encouraging biomedical research. We work with all professionals in nuclear medicine to ensure that Canadians have access to the highest quality nuclear medicine services.



SISTER ORGANIZATIONS

SNMMI Society of Nuclear Medicine and Molecular Imaging
EANM European Association of Nuclear Medicine — Biomedical Imaging and Therapy for Personalized Healthcare
World Federation of Nuclear Medicine and Biology
APRIS
ARCENM
ASNC
ARSNM Arab Society of Nuclear Medicine
AOFNMB
IAEA International Atomic Energy Agency
alasbimn
South African Society of Nuclear Medicine
SFMN

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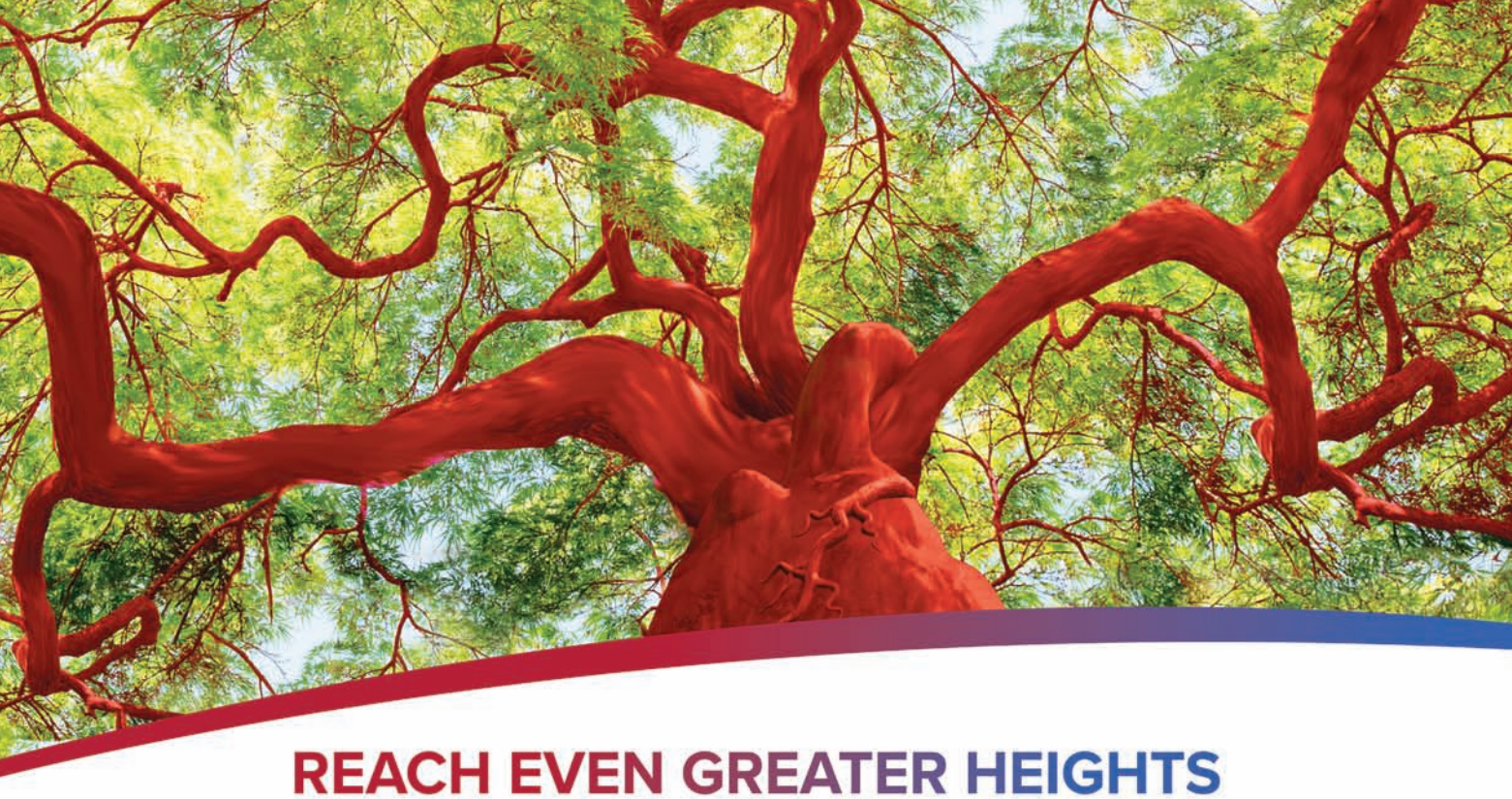

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INTERVIEW WITH SERGIO CALVO

Sergio, you are the president of the Radiopharmaceuticals Division of Jubilant Pharma. Can you give us a brief summary of your involvement in Nuclear Medicine and Jubilant?

First, I would like to thank e-Patient for the opportunity. I have a background in engineering. I have worked in nuclear medicine since 1999, at Siemens, GE Healthcare, and joined Jubilant one and a half years ago. I was fortunate to be a part of the development and market introduction of breakthrough technologies like digital PET/CT, and the inception of Artificial Intelligence (AI) applications for medical imaging. I was attracted to Jubilant for the opportunity to work for the pharmaceuticals side of nuclear medicine, which is a fascinating field. It is a privilege to have both perspectives, and one of my goals is to increase the synergy between radiopharmaceuticals and medical devices.

Jubilant Pharma has evolved into a global pharmaceutical company offering a wide range of products and services from specialty pharmaceuticals to contract manufacturing, generics, complex generics and active pharmaceutical ingredients. The Radiopharmaceuticals Division has a similar heritage, being formed with the acquisition of Draximage in 2008, which was founded 66 years ago----essentially at the birth of Nuclear Medicine. We are based in Montreal, present in 22 countries, and market leaders in North America in lung imaging and iodine therapies. We have unique products like the Cardiac PET technology leading product RUBY-FILL Rb-82 Generator and a large pipeline of breakthrough innovations. Being part of this larger organization gives us access to Jubilant peer companies rich in R&D and innovation which has significant application potential to both diagnostic and therapeutic Nuclear Medicine.

Jubilant Radiopharma is well established in the global nuclear medicine market. What are the biggest challenges of the nuclear medicine industry in the next five years?

Challenges bring opportunities, and I am very positive about the opportunities we see, which will help propel the specialty to greater success and patient benefit; but there is work to do in some areas. Isotope supply is a concern as demands for new and existing isotopes increase with the adoption of novel imaging tracers and radiopharmaceutical therapies (RPTs). We need to grow capacity and need to transfer this capacity to industry. As you know, developing and approving radiopharmaceutical therapies require multiple clinical trials of increasing size, complexity, cost and risk of success. Although big pharma is investing in RPTs, our industry consists of small and mid-sized companies with limited resources and expertise to conduct large clinical trials. We need to make the clinical development process more efficient. Logistics will get more complicated with radiotherapy isotopes for broad distribution on a global scale. Radioactive waste will also be a concern with long-lived isotopes, especially alpha emitters. We will have to train nuclear medicine workers to manage more complex isotopes and handling procedures to assure high level of safety to workers and staff. At the same time, there is a greater recognition of the value of RPTs by other medicine disciplines and they will be keen to get the training and capability to use these advances. This will require Nuclear Medicine Physicians to collaborate and keep their training relevant and robust. This will be good for the patients and the field as the best minds will be involved and identify further advances in therapy---especially about RPTs and non-radioactive therapies and/or RPT facilitators. Reimbursement will be a specific concern as more expensive therapies enter the market, and the healthcare systems will need education on the benefits of RPTs and may not be prepared for this increase in expense. Finally, with so many treatment options, we need to educate consumers so that the potential patients know that nuclear medicine treatment options are available, and how they compare to other methods, and what combination therapies might be better than either alone---as often seen in standard medical oncology.

As you mentioned in the previous question, the approval process of new radiopharmaceuticals is long and expensive worldwide. Is there a way for companies and medical community to ease the process to the benefit of our patients?

It is true that the process is still long and expensive though it has been improving over the years. One example is the excellent work of the ICH (International Council for Harmonization), which has significantly improved interagency collaborations.

There is room for even more harmonization of requirements. With universal requirements, we will be able to collaborate more efficiently worldwide, and make the process cheaper by using the same clinical data across markets. This would accelerate the approval process and timelines, and coupled with timely education of healthcare community and patients about

the product will ensure that new products are adopted faster into the practice of medicine and position it for expansion of indications and life cycle management.

On the industry side, we need to invest in and improve utilization of digital technologies to store and share clinical data safely and efficiently, which has the added benefit of providing a platform for development of AI applications.

The key words are collaboration, simplification, trust and transparency. Jubilant believes that a key way to benefit patients is to have a well-designed product development roadmap with robust data, relevant medical indications and meticulous investigators.

Nuclear Medicine Theranostics is growing and already impacting patients. How will Jubilant contribute to this emerging field of Nuclear Medicine?

Theranostics is the opportunity of our lifetimes and is at the core of Nuclear Medicine's unique value and technology. Because of the complex biochemistry of humans, there are nearly unlimited possibilities in oncology and other specialties. The targeted nature of radiopharmaceutical therapies in particular, and Nuclear Medicine in general, means that each application will require a different and specific targeted molecule. There typically is no 'one-size' fits all, no silver-bullet, which has been the approach of big pharma until recently. They, too, now see the need and value to provide more specific molecules for specific targets. The outcome is a lot of work for small, medium and large companies in the development of theranostics.

Jubilant is all in. We are leaders in Iodine-131, the first theranostic application developed 75 years ago that set the template for the long-awaited targeted therapies. We also have a clinical-stage MIBG program for neuroblastoma, which, when approved, with improve lives of hundreds of sick children every year.

Our core competencies in R&D, Medical Affairs, Clinical Development, Regulatory, Quality, Marketing and Sales are fit for innovation and being shaped to develop theranostic applications. We are also investing in strategic alliances and commercial partnerships to expand our portfolio, and working closely with drug discovery experts of our parent company, Jubilant Pharmova, with vast resources that include computational algorithms to discover and develop precision therapeutics.

We will not only play in theranostics, we want a leading role in this field.

How do you see the future of Nuclear Medicine in the next five years?

The future is already happening. We are seeing the strongest momentum in nuclear medicine ever with radiopharmaceutical therapies coming into mainstream. More specifically, I have no doubt that we will see wide adoption of therapies targeting PSMA, with several recent approvals, and fibroblast-activated protein which is highly expressed in many cancer-associated fibroblasts. The data available on FAP inhibitors for imaging and therapy has been significant and consistent, and is so compelling that clinical success is self-evident.

I also expect nuclear medicine imaging to grow into whole new applications. Rheumatoid arthritis, for example, is biochemically complex and can be treated with different types of expensive biologics. There is an unmet need to predict and monitor treatment response; a clear opportunity for nuclear medicine.

Finally, and as mentioned at the beginning of this interview is the promise and now, developing, reality of AI applications which will undoubtedly be part of diagnostic imaging. This may be a concern for nuclear medicine as we are late to the AI applications. By harvesting more information from data, AI makes medical images more clinically insightful. We usually think about how AI will impact the work of imaging physicians. Another aspect is how AI will impact imaging modalities and how they compete against each other. Anatomical modalities powered by AI will be more capable of, for example, measuring function. Likewise, nuclear and molecular imaging powered by AI will be incredibly more insightful for disease evaluation and treatment strategy. However, our community must hurry to collaborate and develop AI applications. As of today, there is much more activity in AI developments for anatomical modalities; and given the inherent strengths of what Nuclear Medicine can uniquely provide we have strong AI potential.

Finally, what is your greatest wish for Jubilant, nuclear medicine and the patients you serve?

I have many wishes. One of them is that nuclear medicine will impact even more broadly than today the field of cardiology. Myocardial perfusion PET has proven itself to be the most powerful non-invasive test to assess coronary artery disease. Referring physicians embrace the Cardiac PET modality whenever available as it helps them make better treatment decisions. I strongly believe Cardiac PET can and should grow 10-fold or more in the US, and 100-fold in the rest of the world.

In a broader perspective, my wish is that nuclear medicine realizes its full potential to diagnose and treat disease, becoming one of the pillars of personalized medicine.

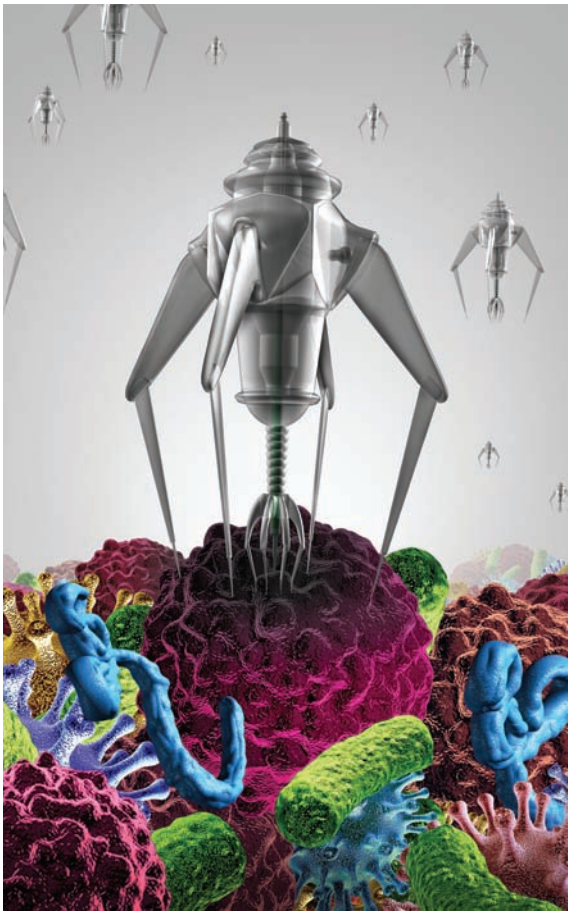
And for my company, I wish Jubilant Radiopharma to be an innovation leader, constantly renewing the mission statement set forth in 1955: to improve patients' lives through nuclear medicine. Benefiting the patient is what we stand for along with the healthcare providers who use our products. ■

JUBILANT DRAXIMAGE

François-Alexandre Buteau, MD, FRCPC
Spécialiste en médecine nucléaire, CHU de Québec
Université Laval

Frédéric Arsenault, MD, MSc, FRCPC
Spécialiste en médecine nucléaire, CHU de Québec
Université Laval

LA THÉRANOSTIQUE AU SERVICE DES TUMEURS NEUROENDOCRINES



LES TUMEURS NEUROENDOCRINES

Les tumeurs neuroendocrines (TNE) représentent un groupe de cancers trouvant une origine commune lors du développement de l'embryon durant de la grossesse chez l'être humain. Ces tumeurs peuvent se développer à partir de plusieurs organes, dont les intestins, le pancréas et les poumons. Initialement, les patients atteints d'une TNE sont asymptomatiques. Puis, au fil du temps, ils développeront des symptômes souvent non spécifiques, compliquant le diagnostic. Ces symptômes incluent notamment de la diarrhée, de la douleur abdominale, des bouffées de chaleur, des troubles respiratoires ainsi que la perte de poids. Ces signes et symptômes peuvent être facilement confondus pour ceux de la ménopause, d'un côlon irritable, de la maladie cœliaque, de l'asthme, etc.

LA CLASSIFICATION DES TUMEURS NEUROENDOCRINES

Les TNE sont tout d'abord classifiées d'après quel organe elles proviennent, puis selon si elles sécrètent ou non des substances bioactives (hormones, protéines). Ces substances peuvent causer des symptômes et diminuer la qualité de vie des patients. Certaines substances sécrétées par les TNE peuvent même potentiellement menacer la vie.

Les TNE sont classées selon 3 grades (G1 à G3), basés sur leur taux de prolifération tumoral. En règle générale, les tumeurs G1 sont les mieux différenciées et les plus quiescentes, tandis que les tumeurs G3 sont plus dédifférenciées et plus agressives. Les TNE bien différenciées ont une évolution qui sera généralement lente : il n'est pas rare de voir des patients atteints de TNE mener une vie active pendant 10, 15, et parfois même plus de 20 ans. Différents traitements ou combinaisons de traitements seront administrés au cours de cette période. Ces traitements visent essentiellement deux objectifs : ralentir la progression de la maladie et redonner une qualité de vie aux patients.

À leur surface, la plupart des cellules tumorales des TNE surexpriment des récepteurs à la somatostatine à des degrés divers. La somatostatine est une hormone agissant sur la motilité de l'estomac et de l'intestin, ainsi que sur les fonctions hépatiques et pancréatiques. Il existe 5 sous-types de récepteurs à la somatostatine (SSTr1 - SSTr5), le plus fréquemment rencontré dans les tumeurs étant le SSTr2. Certains traitements, notamment les analogues de la somatostatine (octréotide, lanreotide) peuvent s'y fixer et ainsi limiter la prolifération cellulaire (donc, ralentir la progression) et inhiber la sécrétion des substances bioactives (améliorer la qualité de vie).

LA THÉRANOSTIQUE

Le mot théranostique est une contraction des termes thérapeutique et diagnostique. La théranostique consiste à élaborer un traitement ciblé pour une maladie à partir de tests ou d'examens spécifiques en médecine chez un patient. Ces tests permettent de prédire une réponse favorable significative de la maladie à un traitement ciblé avant même d'avoir tenté le traitement.

La théranostique n'est pas spécifique à la médecine nucléaire : par exemple, en oncologie on va rechercher une mutation génétique (exemple : BRAF) afin d'offrir un traitement ciblant cette mutation (exemple : anti-BRAF, comme le dabrafenib), et ce peu importe qu'il s'agisse d'un cancer de la thyroïde, d'un cancer colorectal ou d'un mélanome. En médecine nucléaire, il nous sera possible d'imager précisément les cellules tumorales surexprimant les SSTr, qui guidera ensuite un traitement ciblé visant à déposer de la radiation localement à ces cellules, via les SSTr.

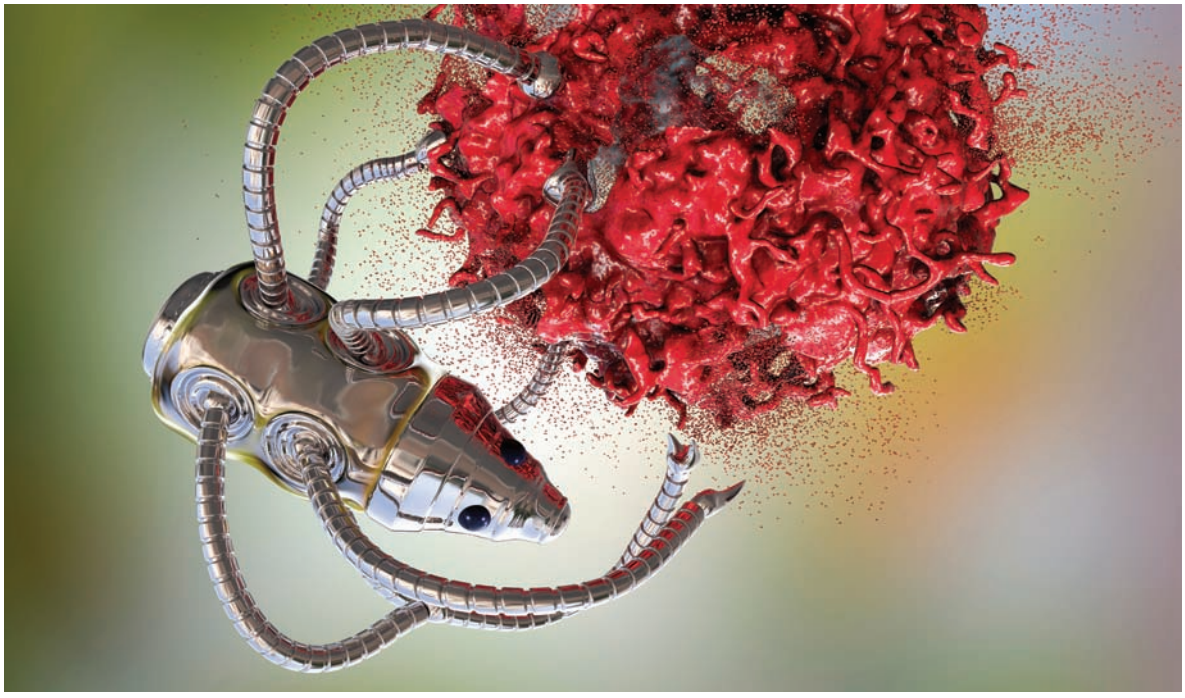
L'IMAGERIE DES TUMEURS NEUROENDOCRINES

En médecine nucléaire, il est possible d'administrer un radiotraceur permettant d'imager les organes et les tumeurs surexprimant les récepteurs à la somatostatine. Ceci se fait à l'aide de peptides (analogues de la somatostatine, tels octréotate, octréotide) liés à un radioisotope propice à faire des images (le gallium-68 a remplacé presque entièrement l'utilisation de l'Indium-111).

Ces examens d'imagerie médicale permettent de répondre à quatre objectifs : le diagnostic d'une tumeur neuroendocrine, la recherche de métastases à distance, déterminer le degré de surexpression des SSTr à la surface des tumeurs, et le suivi du traitement. Dans l'histoire naturelle de la maladie, les cellules tumorales vont finir par se dédifférencier, et perdre peu à peu leur capacité à exprimer les SSTr à leur surface. Ces tumeurs consommeront alors une importante quantité de glucose et nécessiteront donc une imagerie au Fluoro-deoxy-glucose (FDG). Comme la maladie n'est pas parfaitement homogène chez un même patient, il est fréquent de devoir réaliser les deux études TEP (imagerie fonctionnelle des récepteurs à la somatostatine et imagerie métabolique au FDG), selon le jugement du médecin traitant le patient.

LE TRAITEMENT DES TUMEURS NEUROENDOCRINES

Lorsque la maladie est diagnostiquée à temps, le seul traitement pouvant guérir la maladie est une opération au cours de laquelle le cancer sera complètement réséqué. Malheureusement, la maladie est souvent trop avancée localement ou elle est métastatique au moment du diagnostic. Il faut donc contrôler la progression de la maladie et ses symptômes. Les traitements de chimiothérapie et la radiothérapie n'auront qu'un effet limité sur le contrôle de la croissance de la maladie et la survie des patients, sauf en cas de maladie agressive (G3). L'opération et les autres thérapies locales (embolisation, radiofréquence, hépatectomie partielle, etc.) offrent un excellent contrôle local de la maladie et des métastases ciblées



(cytoréduction). Pour certains sous-types de tumeurs, de plus récentes biothérapies incluant les inhibiteurs du mTOR (everolimus) et les inhibiteurs de la tyrosine kinase (sunitinib) peuvent s'avérer efficace surtout pour le contrôle des symptômes, et d'une efficacité limitée quant au contrôle de la progression de la maladie et de la survie des patients.

LE TRAITEMENT À L'AIDE D'ISOTOPES RADIOACTIFS

En médecine nucléaire, il est possible de traiter quelques cancers en allant déposer de la radiation locale précisément aux cellules néoplasiques. Cette radiation est produite par certains radioisotopes émettant des particules chargées. Le Lutétium-177 qui émet des particules chargées de type bêta est maintenant couramment utilisé dans le monde pour le traitement de certains cancers, comme les TNE et les cancers de la prostate. Son utilisation a été démontrée efficace et sécuritaire.

D'autres atomes radioactifs sont actuellement étudiés pour une utilisation clinique. On revient au principe de théranostique : il est possible de substituer un atome émettant des particules chargées au radiotraceur qui nous a permis d'imager les tumeurs surexprimant les SSTr, et on sait ainsi que toutes les tumeurs qui ont été vues à l'imagerie fonctionnelle recevront une dose significative de radiation déposée localement. Donc, selon l'atome radioactif utilisé, le même agent est utilisé pour faire des images médicales, ou pour traiter ensuite la maladie.

Pour les tumeurs neuroendocrines, il est possible de substituer un atome de Lutétium-177 à l'atome de Gallium-68 utilisé pour faire des images sur les peptides se liant aux SSTr. Ce traitement est mieux connu sous l'acronyme PRRT, pour « Peptide Receptor Radionuclide Therapy ». L'octreotate agit comme le messager qui permettra de livrer localement de la radiation principalement aux cellules cancéreuses surexprimant les récepteurs à la somatostatine, identifiées lors de l'acquisition des images diagnostiques.

L'effet de la radiation locale ciblée sera triple : direct, par des bris d'ADN, indirect par la modification du milieu environnant des cellules hostile pour le cancer (création de radicaux libres) et par l'effet abscopal, caractérisé par une activation du système immunitaire du patient contre les cellules cancéreuses.

LES ÉTAPES PRÉALABLES À L'ADMINISTRATION DE LA PRRT

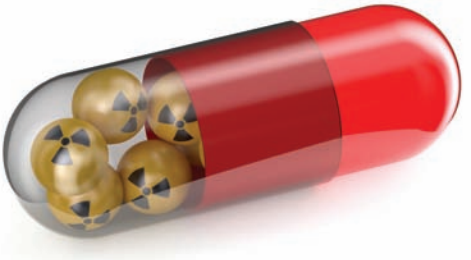
Ce traitement s'adresse aux patients symptomatiques et/ou avec une maladie progressive. Un médecin spécialiste en médecine nucléaire s'assurera que le traitement sera sécuritaire et adéquat pour le patient. Notamment, il est important de s'assurer que toutes les lésions connues surexpriment suffisamment les récepteurs à la somatostatine. Comme la substance radioactive se distribue dans le corps et se concentre dans une moindre mesure dans quelques organes dits critiques (par exemple les reins et la moelle osseuse), une évaluation de la fonction de ces organes sera réalisée et répétée périodiquement durant les cycles de traitement afin de s'assurer d'une bonne tolérance.

L'ADMINISTRATION DE LA PRRT

Il existe plusieurs protocoles d'administration de la PRRT, certains centres administreront une plus grande activité à chaque cycle du traitement, alors que d'autres administreront une dose moindre, mais davantage de cycles tant que les patients les tolèrent. Le protocole le plus répandu consiste en une phase d'induction de 4 cycles où une activité fixe de substance radioactive (7,4 GBq ± 10 %) est administrée aux 8 ± 1 semaines.

Chaque injection est précédée d'administration d'acides aminés, réduisant la dose de radiation aux reins, ainsi que d'antinauséeux. De cette façon, le traitement est alors très bien toléré. Suite au traitement, il est possible d'obtenir des images par scintigraphie à partir des photons émis du lutétium-177. On peut ainsi confirmer que le traitement se fixe là où initialement prévu lors de l'étude diagnostique, et il est possible d'effectuer des calculs de dosimétrie pour les tumeurs et les organes critiques. On s'assure ainsi que la quantité de radiation reçue par ces organes demeure dans les limites jugées sécuritaires, et que la radiation reçue par les tumeurs soit significativement supérieure à celle aux organes sains.

Une réponse à la PRRT est jugée favorable lorsqu'il y a 1) diminution des symptômes liés à la sécrétion hormonale; 2) arrêt de la progression de la maladie, voir diminution de la charge tumorale. Une réponse complète est exceptionnelle dans 1-2% des cas. Dans de rares cas, il peut y avoir un échec au traitement, c'est-à-dire que le patient ne répond pas à la PRRT, et la maladie continue sa progression. D'autres options thérapeutiques seront alors à considérer. ■



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不同TSH抑制治疗对分化型甲状腺癌术后TSH、FT3、FT4的影响

【摘要】目的：探讨不同促甲状腺激素（TSH）抑制对分治疗化型甲状腺癌术后 TSH、游离三碘甲状腺原氨酸（FT3）、血清游离甲状腺素（FT4）的影响。方法：选取 2018 年 8 月 -2019 年 2 月本院收治的分化型甲状腺癌患者 80 例为观察对象，按随机数字表法将其分为对照组（n=40）与试验组（n=40），两组均给予甲状腺癌根治术治疗。术后，对照组给予常规剂量左旋甲状腺素治疗，试验组给予抑制剂量左旋甲状腺素治疗。比较两组治疗前后甲状腺功能、骨生化指标、心血管与骨骼系统不良事件发生及复发情况。结果：治疗后，试验组 TSH 低于对照组，FT3、FT4 均高于对照组（P<0.05）。治疗后，两组血钙、血磷及碱性磷酸酶（alkaline phosphatase，ALP）比较，差异无统计学意义（P>0.05）。对照组心血管与骨骼系统不良事件发生率为 17.50%，复发率为 7.50%；试验组不良事件发生率为 12.50%，复发率为 5.00%，试验组心血管与骨骼系统不良事件与复发率稍低于对照组，但两组比较差异均无统计学意义（P>0.05）。结论：对分化型甲状腺癌术后患者实施抑制剂量左旋甲状腺素治疗，可改善甲状腺功能，且不良事件发生风险较低，临床应用价值显著。

【关键词】 促甲状腺激素 抑制治疗 分化型甲状腺癌 游离三碘甲状腺原氨酸 血清游离甲状腺素

甲状腺癌根据组织学分类可分为分化型、非分化型，其中分化型甲状腺癌（differentiated thyroid carcminoma，DTC）在甲状腺癌中占比可达 95%，是一种常见的内分泌恶性肿瘤，具有恶性程度较低，手术效果较好的特征 [1]。术后多采用促甲状腺激素（Thyroid stimulating hormone，TSH）抑制或替代治疗、放射性 131I 治疗等辅助方式，以提高手术治疗效果，改善预后。尤其是 TSH 抑制治疗不仅能抑制垂体分泌 TSH，还能维持甲状腺功能，以发挥其维持与抑制的双重作用 [2]。但有临床研究认为，甲状腺激素会促使骨量丢失与骨代谢，继而引发骨折或骨质疏松等不良事件 [3]。因此，在本次研究观察中，选取本院 2018 年 8 月 -2019 年 2 月收治的60 例 DTC 患者手术治疗后实施 TSH 抑制治疗，并对 TSH、FT3、FT4 水平及用药安全性展开讨论与分析，现报道如下。

1 资料与方法

1.1 一般资料 选取 2018 年 8 月 -2019 年 2 月本院收治的 DTC 患者 80 例为观察对象。纳入标准：均符合《甲状腺结节和分化型甲状腺癌诊治指南》[4]诊断标准，且经甲状腺超声或甲状腺发射单光子计算机断层扫描（ECT）检查诊断为甲状腺实性、冷结节，术后病理诊断为 DTC；既往无甲状腺功能亢进或减低病史；术后行放射性 131I 清除残余甲状腺组织。排除标准：既往行颈部放射治疗；术前口服甲状腺素制剂或口服碘制剂；合并下丘脑垂体轴方面疾病；合并术后并发症如感染、乳糜漏等；术前合并骨质疏松或影响骨代谢疾病者。按随机数字表法将患者分为对照组与试验组，每组 40 例。所有患者及家属均知情同意并签署知情同意书，本研究已经医院伦理委员会批准。

1.2 方法 两组均行甲状腺癌根治术治疗，所有患者均于全身麻醉下实施甲状腺癌根治术，对于术中快速病理提示淋巴结转移患者，给予颈部淋巴结功能性清扫术。经颈部 CT 检查以及颈部彩色多普勒超声检查均未见残余甲状腺组织者视为清甲治疗成功。对照组给予常规剂量左旋甲状腺素治疗。每天口服 2.0 μg/kg 左旋甲状腺素钠（生产企业：常州康普药业有限公司，批准文号：国药准字 H20030502，规格：50 μg）。试验组给予抑制剂量左旋甲状腺素治疗。每天口服 2.5 μg/kg 左旋甲状腺素钠。治疗中密切监测患者甲状腺功能，其中对照组需要维持 TSH 水平在 2~10 mU/L、游离三碘甲状腺原氨酸（free triiodothyronine-3，FT3）水平在 2.8~7.1 pmool/L、血清游离甲状腺素（serum free thyroxine，FT4）水平在 10.3~31.0 pmol/L；试验组FT3、FT4 维持水平同对照组，TSH 指标水平则低于0.3 mIU/L。两组术后均持续治疗 6 个月。

1.3 观察指标与判定标准 （1）比较两组治疗前后的甲状腺功能。于治疗前后清晨空腹状态下采集两组静脉血 5 mL，行抗凝与离心处理，应用血清自动免疫分析仪（瑞士罗氏公司 Roche Cobas e411）检测患者 TSH、FT3、FT4 水平。（2）比较两组治疗前后骨生化指标。采用上海索莱宝生物科技有限公司生化试剂盒对血清钙、磷、碱性磷酸酶（alkaline phosphatase，ALP）水平采用比色法检测。比较两组患者治疗后心血管及骨骼系统不良事件发生与术后 1 年复发情况，包括心悸、心绞痛、心动过速、钙丢失、骨质疏松等。

1.4 统计学处理 采用 SPSS 21.0 软件对所得数据进行统计分析，计量资料用（x-±s）表示，比较采用 t 检验；计数资料以率（%）表示，比较采用 字2 检验。以 P<0.05 为差异有统计学意义。

2 结果

2.1 两组一般资料比较 对照组男 17 例，女 23 例；年龄 46~73 岁，平均（59.50±13.50）岁；平均术后 131I 用量（109.85±12.55）mCi。试验组男 15 例，女 25 例；年龄 45~74 岁，平均（59.35±14.35）岁，平均术后 131I 用量（110.45±12.85）mCi。两组一般资料比较，差异均无统计学意义（P>0.05），具有可比性。

2.2 两组治疗前后甲状腺功能比较 治疗前，两组各项甲状腺功能指标比较，差异均无统计学意义（P>0.05）。治疗后，试验组 TSH 低于对照组，FT3 与 FT4 均高于对照组，差异均有统计学意义（P<0.05）。见表 1。

表1 两组治疗前后甲状腺功能比较（$\bar{x}\pm s$）

组别	TSH mIU/L		FT_3 pmol/L		FT_4 pmol/L	
	治疗前	治疗后	治疗前	治疗后	治疗前	治疗后
对照组（n=40）	4.11±0.56	2.71±0.34	2.25±0.30	4.34±0.61	11.27±3.15	18.50±3.78
试验组（n=40）	4.15±0.59	0.39±0.08	2.28±0.32	6.56±0.74	11.30±3.16	26.17±4.01
t 值	0.311	42.009	0.433	14.641	0.043	8.803
P 值	0.757	0.000	0.667	0.000	0.966	0.000

表2 两组治疗前后骨生化指标比较（$\bar{x}\pm s$）

组别	血钙 mmol/L		血磷 mmol/L		ALP U/L	
	治疗前	治疗后	治疗前	治疗后	治疗前	治疗后
对照组（n=40）	2.15±0.36	2.20±0.42	1.10±0.27	1.09±0.24	87.52±15.28	84.49±15.23
试验组（n=40）	2.16±0.38	2.17±0.40	1.12±0.26	1.11±0.25	87.60±15.31	85.12±15.26
t 值	0.121	0.327	0.338	0.365	0.023	0.185
P 值	0.904	0.744	0.737	0.716	0.981	0.854

表3 两组心血管与骨骼系统不良事件发生与复发情况比较 例（%）

组别	心血管与骨骼系统不良事件					复发
	心悸	心动过速	钙丢失	骨质疏松	合计	
试验组（n=40）	1（2.50）	2（5.00）	1（2.50）	1（2.50）	5（12.50）	2（5.00）
对照组（n=40）	2（5.00）	1（2.50）	2（5.00）	2（5.00）	7（17.50）	3（7.50）
χ^2 值	0.866	0.866	0.866	0.866	0.980	0.533
P 值	0.352	0.352	0.352	0.352	0.322	0.465

2.3 两组治疗前后骨生化指标比较 治疗前，两组各项骨生化指标比较，差异均无统计学意义（P>0.05）。治疗后，两组血钙、血磷及 ALP 指标比较，差异均无统计学意义（P>0.05）。见表 2。

2.4 两组心血管与骨骼系统不良事件发生与复发情况比较 试验组心血管与骨骼系统不良事件发生率与复发率均稍低于对照组，两组比较差异均无统计学意义（P>0.05），见表 3。

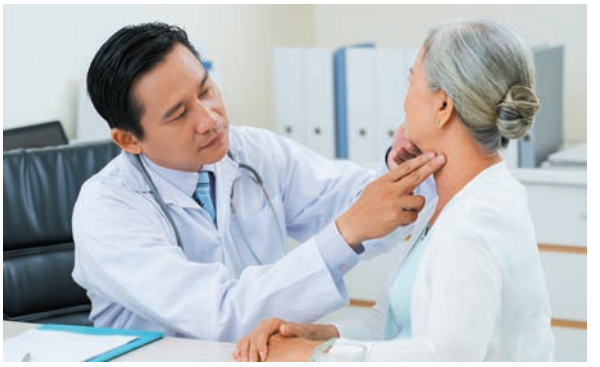
3 讨论

DTC 作为甲状腺癌最为常见的类型，近年来，其发生率在全球均呈现出增高趋势，但死亡率无明显变化 [5]。DTC 是起源于甲状腺滤泡上皮的恶性肿瘤，临床表现单一，为无痛性甲状腺结节、颈部肿块，其质地坚硬 [6]。但随着病情发展，肿瘤逐渐增大会对邻近器官、组织造成压迫和侵犯，继而并发面容潮红、心动过速、吞咽困难、呼吸困难等症状 [7]。目前临床中对甲状腺癌确切病因仍未完全明确，但认为癌基因、电离辐射、性别、碘摄入及遗传等影响因素均与 DTC 发生、发展有着直接关系 [8]。甲状腺癌根治术作为治疗 DTC 的主要方式，TSH 抑制治疗则是术后治疗首选方法，通过联合治疗可提高患者生存质量。因 DTC 患者癌细胞表面存在可被 DTC 刺激受体，术后容易增生或复发，经抑制TSH，则能够控制术后肿瘤复发 [9]。TSH 是一种由腺垂体分泌的激素，经由与 TSH 受体相互结合，经 cAMP 信号通路对 Tg、TPO、NIs 水平表达进行调节，从而对细胞增生分化调控，利用甲状腺反馈性抑制 TSH 水平，达到抑制残留甲状腺癌组织生长的积极效果 [10]。

虽然 TSH 抑制治疗效果得到公认，但长时间TSH 抑制治疗会影响患者机体内环境变化，将成骨细胞与破骨细胞之间的动态平衡打破，从而干扰骨代谢过程，致使患者术后并发骨质疏松症状 [11-12]。且邱海江等 [13] 研究认为，TSH 水平与治疗时间存在交互作用，尤其是中、高危女性患者，TSH 治疗会引发骨质疏松，且绝经后女性影响更明显，分析原因得知，其一在于绝经后女性运动能力降低，自身骨骼重建速率下降；其二为绝经后性激素变化，雌激素分泌减少导致垂体分泌的 FSH 呈代偿性增加，将原有骨代谢平衡打破，因此临床中对于 TSH 剂量选择一直存在争议 [14]。马超 [15] 研究报道中显示，DTC 患者行甲状腺癌根治术后给予常规剂量 TSH 对于甲状腺激素无明显抑制作用，可能诱发甲状腺特异性蛋白表达水平增高，促使残留甲状腺肿瘤组织增生。而给予抑制剂量用药干预后则提示 TSH 水平降低，FT3、FT4 水平增高，表明 TSH 抑制治疗有助于帮助患者术后甲状腺功能维持在亚临床甲亢状态，降低癌灶增殖风险 [16]。

在本次研究中，通过对试验组实施 TSH 抑制治疗后甲状腺功能得到明显改善，骨代谢情况则与治疗前差异不明显，表明抑制剂量的甲状腺激素对于患者骨生化在短期内无明显影响，但 ALP 指标水平稍有上调，提示患者破骨与成骨细胞活性提高，这可能与 TSH 信号传导改变相关，对于骨重建有一定影响；同代瑞等 [17] 研究结果基本一致。本研究试验组术后心血管及骨骼系统不良事件发生率及术后 1 年复发率较对照组降低，但两组差异不明显，这是因长期使用超生理剂量甲状腺激素，可导致心脏负荷加重与心肌缺血，严重情况下可致使心律失常；而 TSH 抑制治疗则能减轻对心脏与骨代谢影响，再次证实，TSH 抑制治疗对于避免肿瘤复发，降低病死率有着积极作用 [18-19]。但需注意，骨密度与骨代谢变化是一个缓慢过程，在短期内虽未发现其对于骨骼系统影响，但还需延长观察时间，并在行TSH 抑制治疗同时展开抗骨质疏松初级预防，确保钙离子摄入，加强对 DTC 患者术后辅助治疗过程中风险评估 [20]。

综上所述，对分化型甲状腺癌术后患者实施抑制剂量左旋甲状腺素治疗，可改善甲状腺功能，且不良事件发生风险较低，临床应用价值显著。



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LA TÉLÉMÉDECINE À L'HEURE DE LA PANDÉMIE À LA COVID-19

Depuis mars 2019 sévit l'importante pandémie à la « COVID-19 ». Depuis cette période il y a eu un confinement important et c'est imposé la distanciation sociale et le port du masque. Ces mesures ont impacté sur le travail de tous et chacun car on nous demandait de sortir que pour des raisons essentielles. Heureusement les mesures ce sont adoucit au fil des mois. Toutefois selon l'évolution récente de la pandémie les mesures sanitaires pourraient se resserrer.

Cette crise sanitaire a favorisé grandement le télétravail. Bien que déjà utilisé par beaucoup de professionnels et entreprises son usage a littéralement explosé et ce à la grandeur de la planète. Et la médecine n'y a pas fait exception. Beaucoup de médecins ont découvert une nouvelle façon de travailler avec ses avantages et inconvénients. Bien que rien ne remplace une consultation en présentiel, beaucoup de celles-ci se faisaient par téléphone ou virtuellement. Évidement les patients nécessitant un examen en personne avec un médecin était possible mais l'affluence aux hôpitaux et cliniques a diminuée de façon impressionnante comme on le souhaitait.

En plus des téléconsultations de nombreuses réunions, webinaires, formations ou colloque ce sont fait presqu'exclusivement en mode virtuel.

En imagerie médicale certaines procédures exigent la présence d'un médecin sur place. Par contre une très bonne partie du travail peut se faire à distance avec le matériel approprié. Tant en radiologie qu'en médecine nucléaire le télétravail ou télémédecine est bien implanté depuis plus d'une dizaine d'années et ce pour les gardes de soir, de nuit ou de fin de semaine.

Certains médecins ont des stations de télémédecine aussi efficaces à leur domicile qu'à l'hôpital ou à leur clinique. Avec l'avancement importante de la technologie, ces stations de télétravail sont disponibles à des prix non prohibitifs. La plupart du temps ces consoles ont les mêmes fonctionnalités

TELEMEDICINE IN THE AGE OF THE COVID-19 PANDEMIC

Since March 2020 the significant "COVID-19" pandemic has raged. From this period, there was significant confinement, social distancing and the wearing of masks were imposed. These measures have impacted on everyone's work because we were only asked to go out for essential reasons. Fortunately, the measures have softened over the months. However, depending on recent developments of the pandemic, health measures could tighten.

This health crisis has greatly favored teleworking. Although already used by many professionals and companies, its use has literally exploded all over the planet. Medicine was no exception; many doctors discovered a new way of working with advantages and disadvantages. Although nothing replaces a face-to-face consultation, many of these were done by phone or virtually. Obviously, patients requiring in-person examination with a doctor was possible, but the flow to hospitals and clinics declined dramatically as expected.

In addition to the teleconsultations, many meetings, webinars, trainings and seminars were held almost exclusively in virtual mode.

qu'en milieu clinique, c'est-à-dire logiciel de dicté, PACS, etc,.

Ces stations de travail peuvent prendre la forme d'une tour avec de multiples écrans ou encore être un portable ou tablette. Cette dernière option permet donc de faire du télétravail n'importe où.

Lorsque la pandémie est arrivée il a été rapide et simple de mettre les nucléistes et radiologiste en télétravail. Il a fallu tout de même augmenter significativement le nombre de station de télétravail. La principale difficulté fut d'obtenir les autorisations informatiques et c'était bien compréhensible vue les demandes tous azimuts de télétravail.

Lors de la pandémie, grâce à ces systèmes de télétravail bien établie, les médecins de l'imagerie ont pu rapidement s'adapter aux mesures de confinements. Cela fut utile aussi pour les médecins mis en quarantaine mais apte à travailler.

Les systèmes de télémédecine permettent en plus du télétravail à domicile, de brancher les systèmes d'imageries dédiés d'hôpitaux distants entre eux. Pour se faire les protocoles d'échange de données doivent être compatibles. L'utilité de ces échanges de données est multiple. Par exemple si un milieu temporairement sans médecin pour faire interprétation ses examens à distance par un autre médecin. On évite de cette façon de déplacer un patient et d'avoir des ruptures de services. Cela permet aussi à deux médecins se

In medical imaging, some procedures require the presence of a physician on site. However, a very good part of the

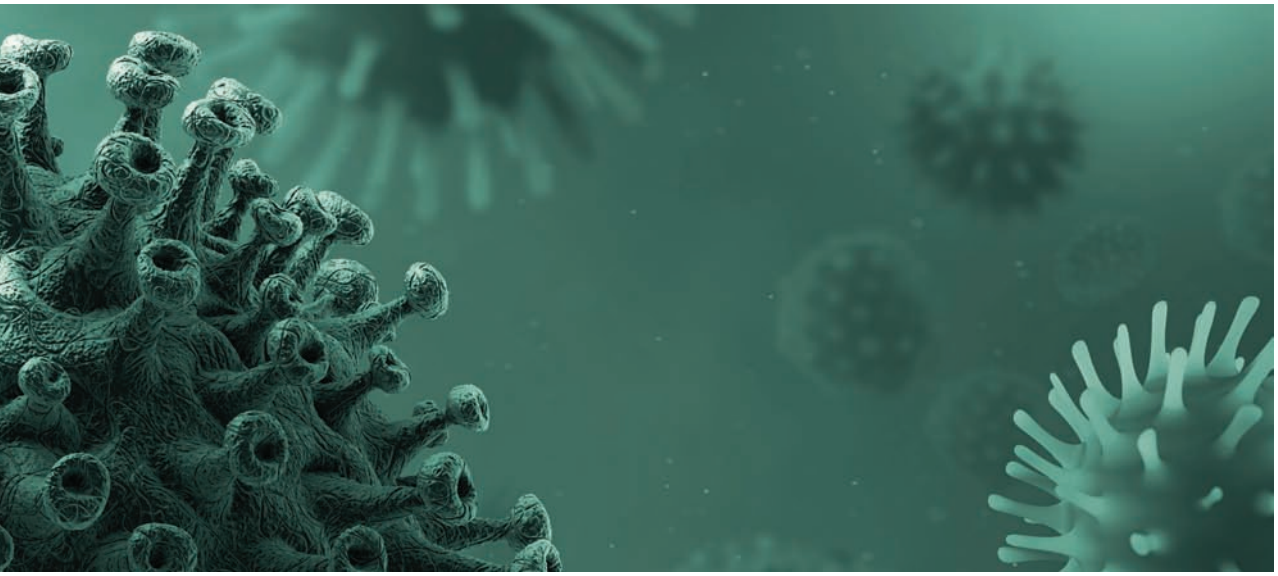
work can be done remotely with the appropriate equipment. In both radiology and nuclear medicine, teleworking or telemedicine has been well established for several years. Whether for evening, night or weekends shifts.

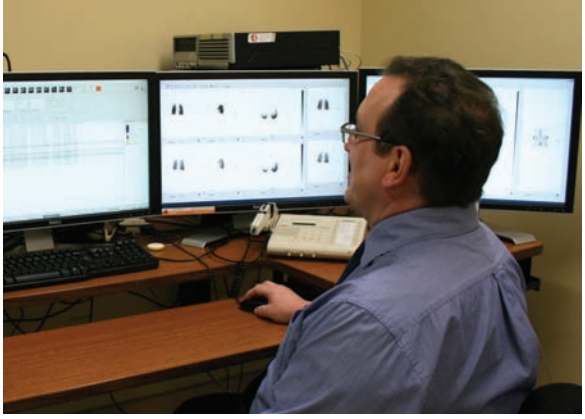
Some doctors have telemedicine workstations that are just as effective in their homes as they are in hospitals or clinics. With the significant advancement in technology, these telecommuting workstations are available at reasonable prices. Most of the time, these consoles have the same functionality as in a clinical setting, i.e. dictation software, PACS, etc.

These workstations can be a tower with multiple screens or even be a laptop or tablet. This last option therefore makes it possible to telework anywhere.

When the pandemic started, it was quick and easy to telecommute the nuclear medicine physicians and radiologists. However, the number of teleworking workstations had to be significantly increased. The main difficulty was getting the computer permissions and that was understandable given the all-out demands for teleworking.

During the pandemic, thanks to these well-established teleworking systems, imaging doctors





situant à des kilomètres de distance de discuter d'un cas compliqué.

Depuis le début de la pandémie les hôpitaux universitaires ont dû composer avec la proximité des résidents et spécialistes dans les salles de lectures. Pour respecter la distanciation sociale dans bien des cas la supervision des résidents a dû se faire à distance. Encore une fois grâce à une télémédecine bien établie en imagerie le déploiement de la technologie a pu se faire rapidement.

Au milieu des années 2000 le gouvernement de la province du Québec a voulu implanter une interface entre les différents système PACS de la province. Cette liaison entre les différents système PACS devait permettre d'échanger d'une façon fluide les examens d'imagerie entre les différents établissements de soins québécois. Malheureusement quinze ans plus tard l'exercice n'a pas été concluant, et principalement en médecine nucléaire. Parallèlement à cela, un groupe informatique dédié à l'informatique en médecine nucléaire le groupe HERMES SOLUTIONS MEDICALES, a développé tranquillement un réseau d'utilisateurs HERMES dans de nombreuse unité de médecine nucléaire québécoise. Ces différents services ayant le système HERMES peuvent donc échanger facilement des données, aussi complexes qu'elles soient. Un des avantages des systèmes HERMES est qu'ils peuvent recueillir des données natives ou non des différentes compagnies œuvrant en médecine nucléaire. Un tel réseau d'utilisateurs comme celui d'HERMES est précieux et surtout en période de pandémie. Avoir de nombreux utilisateurs reliés prévient la découverture, aident aux consultations entre collègues et aide a réaliser des projets de recherches multicentriques.

Cette période de pandémie a amené de nouveaux paradigmes dans le travail hospitalier ainsi que dans les autres sphères de travail. En médecine le télétravail est devenu une nouvelle norme qui ne disparaitra pas lorsque la pandémie sera finie. En médecine la téléconsultation s'avère très utile mais elle ne remplace pas toute une visite en présentiel. Certains réunions scientifiques ou formation se feront virtuellement. En imagerie le télétravail était bien implanté avant la pandémie mais ce fut une belle opportunité pour le consolidé. Médicalement nous seront mieux préparer s'il y a une nouvelle vague de la COVID-19. ■

were able to quickly adapt to containment measures. Very useful also for doctors quarantined, but able to work.

Telemedicine systems allow, in addition to teleworking from home, to connect the dedicated imaging systems of distant hospitals to each other. To do this, exchange protocols must be compatible. The usefulness of these exchanges is manifold. For example, if a site is temporarily without a doctor, exams can be interpreted by another doctor remotely. In this way, we avoid moving a patient and having service disruptions. Also, two doctors standing miles apart discussing a complicated case.

Since the beginning of the pandemic, university hospitals have had to deal with the proximity of residents and specialists in the reading rooms. To respect social distancing, in many cases the supervision of residents had to be done remotely (room nearby or in another establishment). Once again, thanks to a well-established telemedicine in imaging, the deployment of the technology was able to be done quickly to avoid a breakdown in supervision.

In the mid-2000s, the government of the province of Quebec wanted to establish an interface between the various PACS systems in the province. This link between the different PACS systems was supposed to make it possible to exchange imaging examinations in a fluid way between the different healthcare establishments in Quebec. Unfortunately, fifteen years later the exercise was not successful, and mainly in nuclear medicine. At the same time, an IT group dedicated to computing in nuclear medicine, the HERMES SOLUTIONS MEDICALES group, has gradually developed a network of HERMES users in numerous nuclear medicine units in Quebec. These different departments with this computer system can easily exchange data, regardless of the data complexity. One of the advantages of this computer platform is that it can collect data from different companies working in nuclear medicine. Such a network of users of this system is precious, especially during a pandemic. Having a large number of connected users prevents uncovering, helps consultation between colleagues and helps to carry out multicentre research projects.

This period of pandemic brought new paradigms in hospital work as well as in other spheres of work. In medicine, telecommuting has become a new norm that will not go away when the pandemic is over. In medicine, teleconsultation is very useful, but it does not replace an entire face-to-face visit. Some scientific meetings or training will take place virtually. In imaging, teleworking was well established before the pandemic, but it was a great opportunity to consolidate it. Medically, we will be better prepared if there is a new wave of COVID-19. ■

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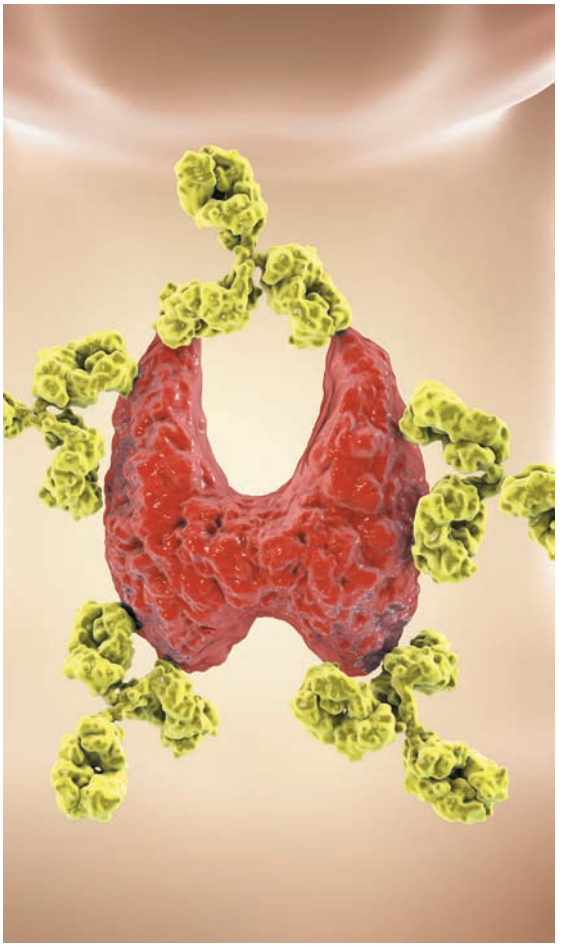
TERAPIA CON YODO – 131 (YODO RADIOACTIVO) EN HIPERTIROIDISMO



La tiroides es la glándula endocrina más grande de nuestro cuerpo y cumple funciones muy importantes, como la producción de hormonas tiroideas. Se necesita que haya niveles de hormonas tiroideas normales para que exista un funcionamiento de todos los tejidos y órganos en el cuerpo. Se estima que existe cerca de un 11% de la población con alteraciones en la glándula tiroides y que ocurre hipertiroidismo en un 2-3% de la población adulta, siendo más frecuente en mujeres (6:1 con respecto a los hombres).

Las causas más comunes de hipertiroidismo son el hipertiroidismo autoinmune, o enfermedad de Graves; el bocio multinodular tóxico y el adenoma tóxico. Existen algunas causas menos comunes de hipertiroidismo: tiroiditis destructiva (generalmente causada por medicamentos como la Amiodarona) y el hipertiroidismo facticio (autoinducido por medicamentos).

La enfermedad de Graves está causada por anticuerpos del propio organismo contra los receptores de TSH en la célula tiroidea, mientras que el bocio multinodular tóxico y el adenoma tóxico están causados por una mutación que activa ciertas células de la glándula tiroides.

Algunos de los síntomas del hipertiroidismo incluyen: temblor fino simétrico, intolerancia al calor, pérdida de peso (a pesar de un buen apetito), nerviosismo, irritabilidad, pérdida de la concentración, taquicardia, arritmias, hiperdefecación, debilidad muscular, trastornos de la menstruación y, en la enfermedad de Graves, puede haber alteraciones oculares (orbitopatía) y en la piel. La mayoría de los pacientes tienen aumento de tamaño de la glándula tiroides (bocio) que puede ser difuso, uni o multinodular.

Los hallazgos en los exámenes de laboratorio en pacientes con hipertiroidismo generalmente muestran el de TSH bajo, T4libre y T3libre altos y autoanticuerpos contra el receptor de TSH (TRAb) positivos, en pacientes con hipertiroidismo por Enfermedad de Graves.

La ecografía se utiliza para determinar el tamaño y la vascularización de la glándula tiroides; también para localizar el número, tamaño y características de algún nódulo tiroideo. La ecografía y los exámenes de laboratorio son el acercamiento diagnóstico de primera línea en pacientes en quienes se sospecha hipertiroidismo, para diferenciar sus varias formas.

La gamagrafía de tiroides con yodo radioactivo o con Tecnecio-99m pertecnetato es muy útil para caracterizar las diferentes formas de hipertiroidismo y provee información útil para planificar la terapia con radioyodo. Existen varios patrones gamagráficos, de acuerdo a la causa del hipertiroidismo. La gamagrafía de tiroides, cuando se realiza con yodo – 123 o yodo – 131 permite

calcular el porcentaje de captación en la glándula tiroides, lo cual aporta información importante para planear la terapia con yodo.

TRATAMIENTO DEL HIPERTIROIDISMO

Existen tres opciones para el tratamiento del hipertiroidismo en los pacientes:

1. Medicamentos antitiroideos
2. Tiroidectomía o cirugía de remoción de la glándula tiroides
3. Terapia metabólica con yodo radioactivo

Generalmente en tratamiento se realiza de forma inicial con los antitiroideos (Metimazol, Carbimazol o Propiltuiracilo). Estos medicamentos rápidamente producen una respuesta favorable con disminución de los síntomas y de las hormonas tiroideas circulantes, pero presentan una alta tasa de recurrencia si se suspenden, por lo cual deben administrarse por un tiempo prolongado, lo cual puede a su vez, producir efectos secundarios, que pueden variar desde efectos leves (como una erupción cutánea) hasta complicaciones importantes como agranulocitosis o hepatitis por medicamentos) y por lo tanto, deben realizarse controles periódicos de laboratorio y seguimiento médico.

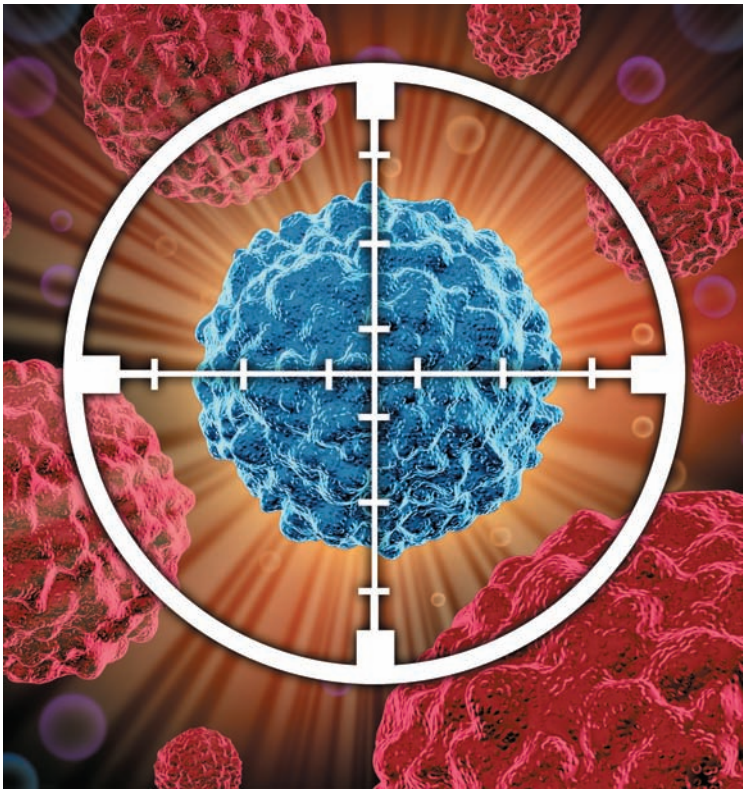
La cirugía generalmente se reserva para pacientes con enfermedad de Graves recurrente; enfermedad de Graves con oftalmopatía severa o pacientes con un bocio multinodular que no se controle con la terapia médica, especialmente en pacientes con un bocio muy grande que esté causando compresión a estructuras vecinas.

TRATAMIENTO CON YODO RADIOACTIVO

El yodo – 131 es un isótopo radioactivo del yodo, que cuando se está desintegrando como parte del proceso de ser radioactivo, emite radiación ionizante en forma de partículas β- que son responsables del 94% de los efectos biológicos de este radioisótopo.

Los efectos radiobiológicos del yodo en los tejidos pueden ser indirectos, por interacción de las partículas β- con el agua de nuestro cuerpo, que producen radicales libres, que interactúan con ciertas moléculas de la célula, o directos, por interacción con el DNA del núcleo de la célula. Estos efectos combinados producen daño de la célula tiroidea, con destrucción de los folículos tiroideos, que son reemplazados por tejido fibrótico.

El efecto final de esta forma de terapia es comparable a la remoción quirúrgica del tejido tiroideo, pero de una forma no invasiva y sin las posibles complicaciones quirúrgicas o anestésicas en los pacientes. Si bien el objetivo final de esta terapia es que el paciente recupere la función



normal de la glándula tiroides, en pacientes con enfermedad de Graves es el de producir hipotiroidismo, una condición que causa menos complicaciones en los pacientes y que puede tratarse de forma fácil con hormonas tiroideas.

Indicaciones
La terapia con yodo radioactivo está indicada en pacientes con hipertiroidismo que no respondan (o tengan intolerancia) a los medicamentos antitiroideos y que tengan orbitopatía leve a moderada.

Contraindicaciones
La terapia con yodo radioactivo está contraindicada en embarazo y lactancia. Algunas contraindicaciones son relativas, como por ejemplo: la incapacidad para seguir las medidas de radioprotección para el público luego de la terapia; sospecha de cáncer tiroideo concomitante, hipertiroidismo descontrolado.

En pacientes con enfermedad de Graves y oftalmopatía, la terapia debe ser cuidadosamente vigilada por la posibilidad de aumentar esta condición, especialmente en pacientes fumadores.

Preparación para la terapia
Debe confirmarse el hipertiroidismo con exámenes de laboratorio; realizar ecografía de tiroides para calcular el volumen de la glándula y gamagrafía tiroidea con test de porcentaje de captación para una mejor caracterización de la enfermedad y la planeación de la terapia con yodo. En mujeres en edad fértil se debe descartar el embarazo.

Se le debe explicar al paciente y sus familiares de forma cuidadosa el procedimiento, sus posibles efectos secundarios, las alternativas terapéuticas y las medidas de radioprotección para los familiares y para el público en general.

En caso de lactancia, ésta debe suspenderse o la terapia con yodo radioactivo debe posponerse hasta que se termine la lactancia, para disminuir la dosis de radiación en el bebé y en el tejido mamario.

Los medicamentos antitiroideos deben suspenderse previamente a la terapia, entre 3 y 10 días, según el tipo de medicamento.

El paciente también debe suspender previamente a la terapia los medicamentos que contengan yodo, como por ejemplo la Amiodarona.

Debe evitarse el uso de exámenes diagnósticos que utilicen medio de contraste yodado al menos 60 – 90 días antes de la terapia, ya que el yodo no radioactivo que contiene el medio de contraste podría afectar la efectividad del tratamiento.

Efectos secundarios

A corto plazo: aumento de los síntomas del hipertiroidismo: esto se debe a la liberación de hormonas tiroideas al torrente circulatorio por la destrucción del tejido tiroideo por el radioyodo y ocurren en los primeros 5 a 10 días luego de la terapia. Generalmente es bien tolerado y se puede evitar reiniciando los antitiroideos luego de 5 días de la administración del yodo.

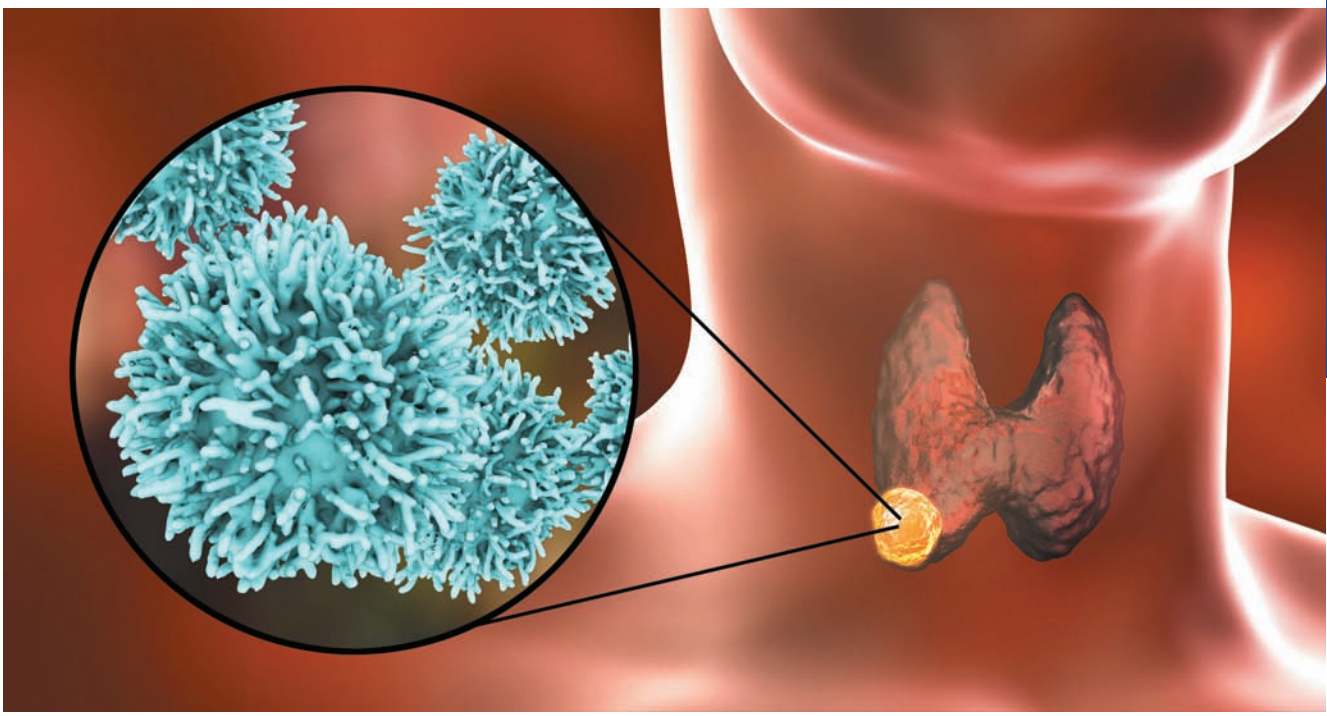
También puede ocurrir tiroiditis por yodo, que está dada por el efecto inflamatorio de la radiación ionizante y que cursa con dolor e hinchazón en la región anterior del cuello y que puede tratarse fácilmente con medicamentos antiinflamatorios.

Efectos a largo plazo: puede ocurrir hipotiroidismo hasta en un 80% de los pacientes (recordar que éste es uno de los objetivos de la terapia). En pacientes en quienes falla la primera terapia y continúan con hipertiroidismo, puede hacerse una segunda terapia, con la cual se obtienen resultados en cerca de un 90% de los pacientes. Si falla la segunda terapia, debe considerarse cirugía.

Puede ocurrir, como ya se mencionó, oftalmopatía tiroidea o puede empeorarse si el paciente ya la tenía, especialmente en pacientes fumadores. Los pacientes que sufren de esta condición y van a ser tratados con yodo radioactivo, deben premedicarse con corticosteroides orales para prevenir el empeoramiento de esta complicación.

Aunque no se ha demostrado que el radioyodo produzca infertilidad, en hombres debe esperarse 4 meses después de la terapia para que puedan concebir, tiempo en el cual ocurre un completo recambio de los espermatozoides y en mujeres, al menos 6 meses, para valorar la presencia de hipotiroidismo y poder iniciar el tratamiento adecuado antes de un embarazo.

Aunque existe el riesgo potencial de padecer algún tipo de cáncer por el uso de radiación ionizante, éste no ha sido demostrado, con lo cual se puede deducir que esta terapia que se ha usado por al menos 70 años es completamente segura. ■



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Neuroendocrine Tumours: Finding Zebras with Nuclear Medicine

NEUROENDOCRINE TUMOURS

Neuroendocrine Tumours (NETs) are of much clinical interest these days, due to their rising prevalence, unusual clinical manifestations, and new impactful imaging tests and therapies. Unlike most tumours which are associated with a specific organ (such as lung cancer arising from the lungs), NETs arise from specialized neuroendocrine cells disseminated throughout the body. Neuroendocrine cells are similar to nerve cells (neurons), but they also produce hormones like endocrine cells. The small bowel is the most common site of origin, with the pancreas and lungs also being common. Other sites include the adrenal glands, other parts of the gastrointestinal tract, and less frequently the thyroid, prostate, ovaries, and other organs.

A minority of NETs are considered poorly-differentiated, and they behave as aggressive cancers. The majority however are well-differentiated, meaning they retain many of the properties of the parent tissue and organ from which they arise, and these are less aggressive. They may spread throughout the body (metastasize), for example to lymph nodes, the liver, and bones, but they tend to do this slowly, over years. Thus while the number of people diagnosed with a NET in any given year may be low, the number of people living with NETs and their symptoms is substantially higher due to the longer survival. A hallmark of neuroendocrine tumors is that many secrete hormones and peptides which can cause significant clinical health problems.

The type of hormone produced reflects the organ of origin of the NET. NETs originating in the small bowel (most common site) often produce serotonin which leads to the "carcinoid syndrome", causing excessive diarrhea, flushing, asthma-like symptoms, and potentially critical damage to heart valves. NETs arising from the pancreas can produce excessive amounts of insulin (leading to dangerously low blood sugars), gastrin (leading to overproduction of gastric acid and damage to the lining of the stomach), and others. NETs arising from the adrenal glands overproduce hormones such as adrenalin, leading to bouts of severe hypertension which can have dangerous complications. In addition to these hormone-related syndromes, NET patients often present with abdominal pain due to the local effects of the tumours, including bowel obstructions.

Although neuroendocrine tumours are relatively uncommon, their documented prevalence is rising significantly, in part due to better awareness and testing. NETs are infamous for eluding initial diagnosis. The symptoms are often non-specific, potentially attributable to a wide variety of other disorders, many of which are much more common. It is not rare for patients with symptoms of NETs to go many years before the diagnosis is correctly made. This scenario has led organizations such as the Canadian Neuroendocrine Tumour Society to adopt the zebra as their mascot. This is a reference to the old medical school adage "when you hear hoofbeats, think of horses, not zebras", a plea to trainees to think first of the common conditions and not to first think of rare ones. Clearly the call now is to also think of the zebras! The ultimate identification of a NET depends on clinical assessment, lab work, and imaging. Many of the lab and imaging tests are specific to NETs, requiring the physician to have first thought of a NET before ordering.

NUCLEAR MEDICINE IMAGING OF NETS, WITH EMPHASIS ON ^{68}GA-DOTATATE PET

Management of many diseases is greatly aided by modern medical imaging, and as with many tumours imaging of NETs is facilitated by Nuclear Medicine. ^{68}Ga-DOTATATE PET scanning has emerged as the premiere imaging modality in NETs. DOTATATE (or similar molecules such as DOTATOC or DOTANOC) binds to somatostatin receptors which are present in very high numbers on the surface of neuroendocrine tumours. The attached radioisotope ^{68}Gallium (^{68}Ga) emits energy which is detected by a special nuclear medicine camera, a Positron Emission Tomography (PET) scanner. Scanning a patient after injection of ^{68}Ga-DOTATATE creates detailed images which show with great accuracy the presence of neuroendocrine tumours in the body (see Figures).

^{68}Ga-DOTATATE PET scans play important roles throughout the NET patient's journey:

Diagnosing a NET

As discussed NETs can be very difficult to diagnose. If a NET is suspected a ^{68}Ga-DOTATATE PET can be instrumental in finding the primary NET.

Staging

When a NET is diagnosed, ^{68}Ga-DOTATATE PET scanning is often the most accurate way to find out how far the tumours have spread in the body, which is important for deciding on the best therapy for a patient. In comparison with other imaging tests this method often finds more sites of disease, leading to important changes in treatment approach in a significant number of patients.

Monitoring of Therapy

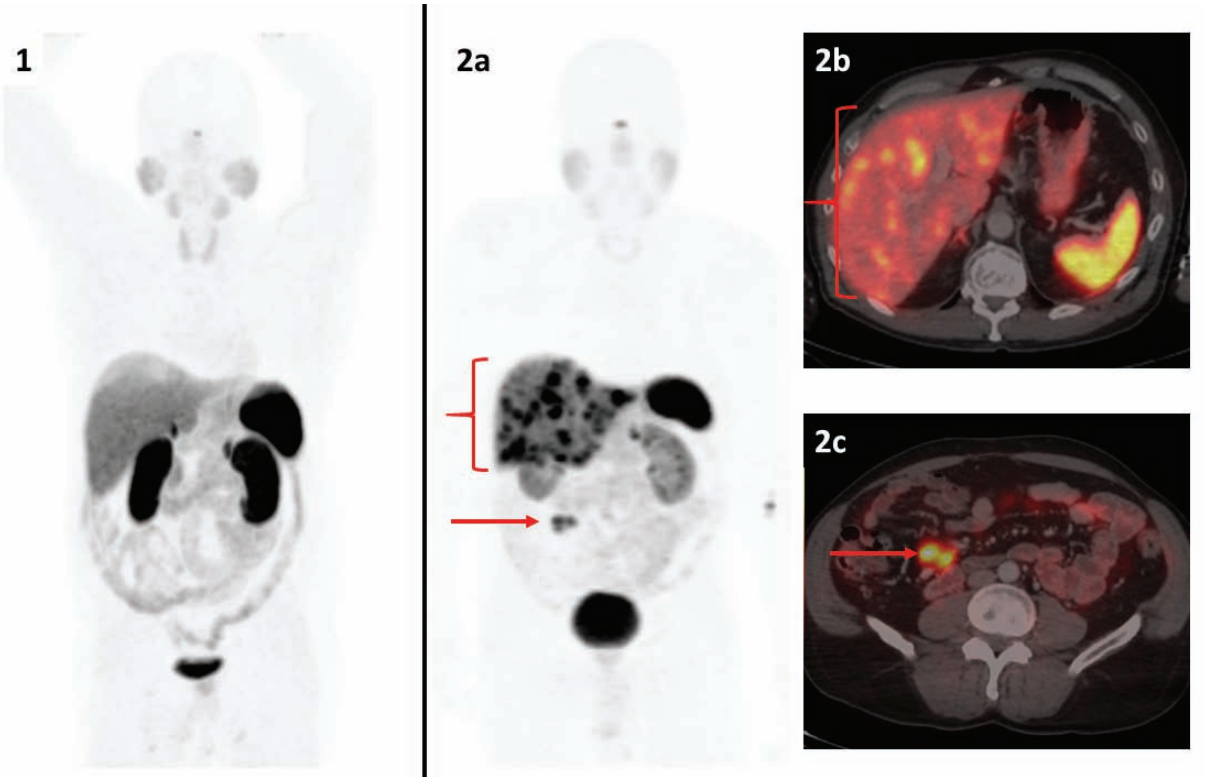
^{68}Ga-DOTATATE PET scanning is often the most accurate test for monitoring a NET patient's response to treatment, such as somatostatin analogs, chemotherapy, biologically-targeted therapies, or radioisotope therapies.

Assessing for Recurrence

When recurrence of a treated NET is suspected, ^{68}Ga-DOTATATE PET scanning can confirm the recurrence and its extent.

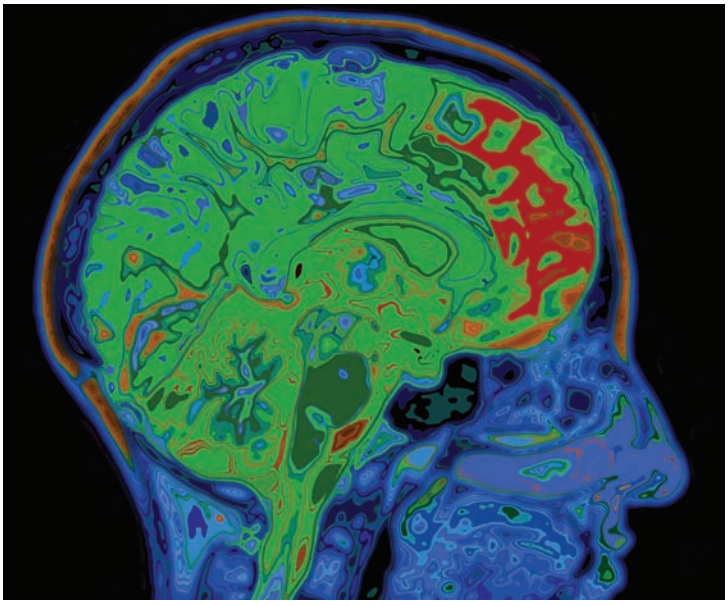
Determining Appropriateness for Therapy with ^{177}Lu-DOTATATE

This exciting new therapy utilizes the same NET-seeking molecule DOTATATE as used in scanning discussed above. However, the attached radioisotope, ^{177}Lutetium, gives off radiation that treats the tumours rather than creating images. This concept is known as Theranostics, in which the same tumour-seeking molecule is used for both Therapy and Diagnostics by being combined with different radiation-emitting isotopes. Neuro-endocrine Tumour scanning with ^{68}Ga-DOTATATE and therapy with ^{177}Lu-DOTATATE is opening the door to important new Theranostic pairs, for example in prostate cancer, bringing concepts refined in the management of NETs to wider cancer applications.



^{68}Gallium-DOTATATE PET Scans. Figure 1: Normal Scan. This overview ("MIP") image demonstrates normal distribution of ^{68}Gallium-DOTATATE in several organs. Figure 2: Metastatic Neuroendocrine Tumour. 2a: MIP image shows spread to multiple areas in the liver ({) and to the central abdomen (arrow). 2b and 2c: Cross-sectional PET-CT images from the same scan show details of the liver metastases and lymph node metastases in the central abdomen. This is a very common pattern of spread of neuroendocrine tumours.

CANM ACMN
The Canadian Association of Nuclear Medicine
Association canadienne de médecine nucléaire



CANM GUIDELINES FOR BRAIN PERFUSION SINGLE PHOTON EMISSION COMPUTED TOMOGRAPHY (SPECT)

ABSTRACT

These guidelines are submitted to the Canadian Association of Nuclear Medicine (CANM). Except for Procedure Guidelines issued in 2018 by the European Society of Nuclear Medicine (ESNM), there have been no updates on the use of brain perfusion single photon emission computed tomography (SPECT) since 2009 [1]. These guidelines are meant to compliment and extend the use of Brain Perfusion SPECT primarily based on the existing guidelines issued in 2009 by the European Association of Nuclear Medicine Neuroimaging Committee (EANM) (ENC). The purpose of the guidelines, similar to those in 2009, is to assist nuclear medicine practitioners and clinicians when making recommendations, performing, interpreting, and reporting the results of brain perfusion single photon emission computed tomography (SPECT) studies using 99mTc- labelled radiopharmaceuticals. It is the intent of the authors to focus on new extensive studies expanding the use of brain perfusion scintigraphy in brain trauma, neuro-psychiatry, and inflammation. In addition, new instrumentation is now available using solid state detectors and multiple pinhole detectors. Like the EANM guidelines, the aim of this review is to assist Canadian nuclear medicine specialists in conducting standard examinations for brain perfusion SPECT imaging, which will increase the diagnostic impact of this technique in clinical practice. Like the 2009 EANM guidelines which replaced a former version of the guideline published in 2001 [2] and the individual experience of experts in European countries, the CANM guidelines are intended to present information specifically adapted to Canadian practice.

AUTHOR KEYWORDS

Brain Dementia Ethyl Cysteine Dimer Epilepsy HMPAO Perfusion SPECT Traumatic Brain Injury, Neuro-Psychiatry

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Introduction

As described in the 2009 EANM guidelines [1], SPECT is a nuclear medicine procedure producing tomographic and three-dimensional images of the distribution of a radiopharmaceutical as Maximum Intensity Projection (MIP) or as Normal Database Comparison 3D images..

Using well established radiotracers, hexamethyl propylene amine oxime (HMPAO, Ceretec) and ethyl cysteine dimer (ECD, Neurolite), both radiolabeled with ^{99m}Technetium (^{99m}Tc), this technique can be used to measure regional cerebral perfusion. Three physiological properties were noted by the EANM which radiopharmaceuticals must exhibit to be useful for the measurement of brain perfusion by SPECT. First, they are required to cross the tight junctions of the blood-brain barrier. Second, their extraction should approximate unity and the extraction itself should be independent of blood flow so that initial distribution is proportional to regional cerebral blood flow (rCBF). Finally, tracers must be retained within the brain in their initial distribution long enough for diagnostic tomographic images to be obtained [3]. Ideally, tracers should show no redistribution, so that initial tracer uptake remains unchanged for several hours. This produces a "frozen image" which reflects rCBF at the time of injection.

There are differences between the two commercially available radiopharmaceuticals ECD and HMPAO, including in vitro stability, uptake mechanism, cerebral distribution, [4] and dosimetry. In normal brain tissue, the kinetic properties of the two agents are very similar. Both agents enter the brain cells passing through the blood-brain barrier due to their lipophilic nature and remain there due to conversion into hydrophilic compounds. For ECD retention, de-esterification is the crucial reaction leading to hydrophilic conversion, while for HMPAO, instability of the lipophilic form and glutathione interaction have been proposed. Differences in the retention mechanisms may account for some different of the tracers in specific disorders such as subacute stroke, where ECD distribution seems to reflect metabolic activity more closely, whereas HMPAO is better correlated with cerebral perfusion [5]. As a consequence, both tracers can be used, but they are not interchangeable.

In the 2009 EANM guidelines, it was stated that neither ECD nor HMPAO SPECT provide absolute quantitative flow values. As an alternative, quantitative SPECT with SUV uptake values can be used with the brain perfusion agents. In clinical practice, SPECT is usually used to estimate relative regional flow differences based on the comparison of count density ratios between various regions such as right/left asymmetries, or ratio in relation to reference regions, such as the cerebellum or visual cortex.. Increasingly, quantitation has been used to assess uptake values relative to normal data bases.

As with the EANM guideline, the CANM guideline deals with the indications, assessment, processing, interpretation and reporting of brain perfusion SPECT using the commercially available ^{99m}Tc-labelled radiopharmaceuticals ECD and HMPAO.

A. Indications

A.1 Evaluation of suspected dementia [6-53].

SPECT perfusion now allows differentiation of Alzheimer's Disease (AD) from controls, AD from Fronto-Temporal Dementia (FTD), AD from vascular dementia, AD from Lewy body dementia (LBD), and studies indicate that SPECT has predictive value in Mild Cognitive Impairment (MCI)

Taken together, studies of perfusion SPECT in the diagnosis of AD with comparison to a longitudinal clinical course or histopathology demonstrate sensitivity in the range of 82–96% and specificity in the range of 83–89% [17]. Neuroimaging data supports that different types of Vascular Dementia can be distinguished by SPECT [31]. Differentiating AD from FTD with quantitative analysis of multi-headed gamma camera data compared to autopsy findings had a 96% sensitivity and an 80-84% specificity [14] [17][33]. The sensitivity for differentiating AD from LBD was 89%, while the specificity was 84% [17] [34-38]. A total of 495 patients with MCI have been followed over 2–5 years [17][39][41-50] in 10 longitudinal studies that included a baseline SPECT scan. All studies used multi-headed gamma cameras and quantitative analysis [17][39-50], and yielded an overall sensitivity of 89% and specificity of 89% [17] compared to clinical assessment alone [47].
PET/CT, PET/MR and amyloid tracers are also available to diagnose dementia. The use of other technologies complement brain perfusions SPECT, but the optimal diagnostic test is determined by availability, costs, and government or insurance reimbursements.

A.2 Presurgical lateralization and localization of epileptogenic foci [54-62].

Ictal SPECT studies (preferably complemented by inter-ictal investigations) are indicated in temporal and extra-temporal focal epilepsies for localization of foci prior to epileptic surgery.

A.3 Evaluation of traumatic brain injury [63-72]

SPECT has shown perfusion abnormalities in traumatic brain injury despite normal morphology, and results are considered to have a prognostic value for persistence of neuropsychological sequelae.

A 2014 systematic review by Raji and colleagues [64] showed Level IIA evidence for the utility of brain SPECT in the evaluation of TBI. The review identified 52 cross sectional studies and 19 longitudinal studies with a total of 2,634 individuals over 30 years of literature supporting this conclusion. Perfusion SPECT proved more sensitive than CT or MRI [65-70]. Jacobs and colleagues followed a group of patients with TBI who had SPECT scans within three weeks of injury. They found an abnormal baseline SPECT had a sensitivity of 100% and specificity of 85% for predicting persistent neuropsychological deficits at 12 months, while a negative baseline SPECT had a negative predictive value of 100% for neuropsychological deficits at 6 and 12 months after injury. In total, 18 cross sectional studies showed correlation between abnormal SPECT findings and neuropsychological deficits [64]. This suggests that abnormalities found with brain SPECT can correlate with and, therefore, be predictive of functional outcomes.

A retrospective study of over 20,000 subjects showed that SPECT can distinguish TBI from PTSD with 80-100% sensitivity and an average of 70% specificity [71]. Replication of this study in a smaller sample of 196 military veterans with TBI, PTSD, or both showed accuracy of between 83% and 94% in distinguishing between these conditions [72].

A.4. Evaluation of inflammation, toxin exposure, substance abuse [73-112]

Perfusion SPECT may be indicated and provide helpful information in progressive inflammatory disorders (e.g. Rasmussen's syndrome) [73], viral encephalitis (e.g. herpes simplex encephalitis) [69], vasculitis (e.g. systemic lupus erythematosus, Behçet's disease) [75,76], and HIV-encephalopathy [77].

Solvent-induced encephalopathy has been demonstrated with perfusion SPECT [78-81]. Perfusion SPECT revealed diffuse hypo-perfusion in 94% of cases in one study [79].

Perfusion SPECT reveals diffuse hypoperfusion in metal toxicity [82], mold toxicity [83], and other toxin exposure [81,84,85], including recreational toxins [85-91].

SPECT is also beneficial in the identification and grading of severity of hepatic encephalopathy due to ammonia toxicity [92-96], even in mild cases [97], as well as for tracking progress [96].

Carbon monoxide poisoning is characterized by decreased perfusion of the bilateral frontal cortex, bilateral temporal cortex, and the globus pallidus [75] [98-103].

Specifically concerning recreational drugs, perfusion SPECT imaging reveals diffuse hypoperfusion throughout the cerebral cortices, but predominately in the frontal and temporal cortices [104-108].

A.5 Assessment of Neuropsychiatric Disorders [113-172]

The use of perfusion SPECT neuroimaging for psychiatric indications has increased significantly over the past two decades. Unlike neurological diagnoses, which can be verified by biopsy, there are no recognized histopathological markers for psychiatric diagnoses. Psychiatric disorders are defined by the DSM-5 (Diagnostic and Statistical Manual of Mental Disorders Version 5), based not on pathology but upon a constellation of symptoms.

Comorbidity is the rule rather than the exception in psychiatric conditions. In bipolar disorder, for example, the comorbidity of attention-deficit-hyperactivity-disorder (ADHD) occurs in approximately 57% of adult bipolar patients [119] and up to 98% of pediatric bipolar cases [117]. With depression many depressed patients also are comorbid for anxiety in up to 60% of cases [115, 116, 121] Patients with ADHD frequently have coexisting mood disorders (59%), anxiety, oppositional disorders, or learning disorders [115, 118, 122-124]. For all these reasons, it is highly unlikely that a pathognomonic finding or a "neuroimaging fingerprint" will be found for any pure psychiatric disorder [125].

Despite its limitations, a substantial body of research literature exists for brain perfusion SPECT in the evaluation of psychiatric disorders

ADHD

Decreased frontal lobe perfusion is a consistent finding in ADHD across multiple SPECT studies [81, 126-133] and confirmed by multiple functional MRI studies [134, 135] and infrared spectroscopy [136]. For example, SPECT scans of medication-naïve children with ADHD (N=40) were compared to normal controls using statistical parametric analysis [126]. Decreased perfusion was found in the prefrontal cortex, orbitofrontal cortex, and middle temporal gyri, while increased perfusion was found in the somatosensory cortex and anterior cingulate gyri [126]. With stimulant treatment, perfusion increased in the prefrontal cortex [126, 131]. Clinical experience has heavily supported these findings [81, 137].

Perfusion SPECT neuroimaging also is beneficial in the differential diagnosis of ADHD. Since inattention, impulsivity, and hyperactivity are non-specific signs of frontal lobe dysfunction, it is not surprising that toxicity, concussive brain injury, incipient bipolar disorder, infection, and inflammation can produce similar symptoms complexes as ADHD. SPECT can reveal these alternative causes [81, 114, 138].

Bipolar Disorder

In contrast, bipolar mania, which can present symptomatically like ADHD, often demonstrates increased perfusion in the frontal cortex, particularly the dorsolateral prefrontal cortex and possibly greater on the left [139, 140]. Patients with bipolar mania also typically do not show the decrease in prefrontal perfusion unless they have comorbid ADHD as described above [81]. While the total number of subjects studied in ADHD and bipolar disorder number less than 200, the clinical experience among experts worldwide across hundreds of thousands of scans supports the correlation of these disease processes with these perfusion patterns.

Increased and asymmetric perfusion of the thalamus may serve as a possible endophenotypic pattern of Bipolar Disorder in the manic or euthymic states [141, 142]. Bipolar depression may be similar to unipolar depression in terms of decreased frontal cortex perfusion [143], but it is possible the two can be distinguished by differences in the perfusion of the thalamus and basal ganglia in the depressed state. Perfusion, whether measured by SPECT or fMRI, is increased in the thalamus in bipolar disorder [139,140,143,144]. It must be emphasized that these types of endophenotypic patterns may not be evident upon visual inspection of tomographic data for an individual SPECT scan. Rather, these findings may only be manifest in the statistical comparison of perfusion data to normative databases.

Depression

Over 150 studies of perfusion SPECT imaging of depression containing more than 12,100 subjects have been completed. A consistent finding in early SPECT (Xenon or HMPAO) studies of depression was decreased perfusion in the frontal, and often temporal, cortices, as well as the superior anterior cingulate gyri [145-148]. Later, two distinct patterns of perfusion were recognized – decreased perfusion in typical and melancholic depression and increased frontal lobe perfusion in atypical depression [149-152]. Increased perfusion in the subgenual anterior cingulate gyrus in treatment-resistant depression was first described by Goodwin and colleagues [153], but has been recognized as a hallmark sign of treatment resistant depression, subsequently [152, 156, 157]. Remission or response to treatment is characteristically followed by increased perfusion in the affected areas [153-155]. Response to antidepressant therapy could be predicted by the degree of frontal hypoperfusion and of subgenual hyperperfusion. Notably, response to serotonin reuptake inhibitors was predicted by higher frontal and cingulate perfusion [156, 158-159], while response to electroconvulsive therapy (ECT) or transcranial magnetic stimulation (TMS) was predicted by lower frontal and cingulate perfusion. Increased metabolic activity and perfusion in the thalamus [160, 161] is also a frequently reported finding in unipolar depression. Increased symmetrical perfusion of the thalamus has been consistently seen by expert clinicians worldwide on tens of thousands of perfusion SPECT scans.

OCD

Obsessive-compulsive disorder (OCD) is considered to result from an abnormal overactivity of a circuit involving the frontal cortices, anterior cingulate gyri, caudate nuclei and the thalami [162]. Increased perfusion of the caudate nuclei

and the anterior cingulate gyri have been reliable perfusion SPECT findings across 12 studies involving 229 subjects with OCD vs. 139 controls. Similar increased metabolism in these same areas has been found in studies utilizing FDG-PET and functional MRI. These findings were recently reviewed [163].

PTSD

The symptom overlap between post-traumatic stress disorder (PTSD) and traumatic brain injury has complicated the correct diagnosis, particularly among military personnel [164, 165]. Perfusion SPECT studies and fluorodeoxyglucose (FDG)-PET studies have made similar findings in PTSD. Increased perfusion of the caudate nuclei is often found in PTSD [72, 166, 167]. Another SPECT study showed that compared to controls, PTSD patients had increased cerebral blood flow in the limbic regions along with decreased perfusion in the superior frontal, parietal, and temporal regions [168]. A systematic analysis of multiple regions of the default mode network revealed that PTSD resulted in increased perfusion in the basal ganglia, cingulate gyri, thalamus, prefrontal cortices, and medial temporal cortices in both military [72] and civilian [167] populations. Provocation studies using perfusion SPECT, perfusion PET and fMRI have shown increased perfusion in the amygdala, hippocampus, insula, but decreased perfusion in the medial prefrontal cortex [169-172].

A.6 Assessment of brain death [173-195].

Scintigraphic assessment of arrest of cerebral perfusion is an accurate technique to confirm brain death [173]. Brain death scintigraphy is indicated for the assessment of brain blood flow in patients suspected of brain death. This study may be helpful when clinical assessment and electroencephalography are less reliable in diagnosing brain death because of conditions such as severe hypothermia, coma caused by barbiturates, electrolyte or acid–base imbalance, endocrine disturbances, drug intoxication, poisoning, and neuromuscular blockade. Brain death scintigraphy may also be helpful in patients who are being considered as possible organ donors or when family members require documentation of lack of blood flow.

A.7 Cerebrovascular Disease [196-208]

Brain SPECT has been shown to be efficacious in the understanding of cellular viability, hemodynamic reserve and cellular ischemia in the context of severe cerebrovascular diseases [196]. In particular, SPECT can be useful to evaluate cerebrovascular reserve using a vasodilatory challenge.

Cerebrovascular reserve assessment using brain perfusion SPECT is most commonly completed using acetazolamide, which inhibits carbonic anhydrase causing carbonic acidosis and results in cerebrovascular vasodilatation. This results in an increase in cerebral blood flow by decreasing vascular resistance. An initial SPECT baseline scan is completed and compared with the second scan after acetezolamide challenge. Areas of hypoperfusion are identified.

This can be useful in patients with TIA, completed stroke, carotid artery stenosis or occlusion, vascular anomalies, post carotid surgery, before and after cerebrovascular surgery or stent placement. Vasodilatory challenge can also be used to differentiate neuronal causes of dementia versus vascular dementia.

The acetazolamalide challenge should not be completed within 3 days of a recent ischemic stroke or intracranial hemorrhage. Acetazolamide is known to provoke migraine in a patient with a history of migraine and the challenge is contraindicated in patients with known sulfa allergy.

B. Contraindications

1. Pregnancy
2. Sulfa allergy
3. Breast Feeding unless able to stop for 24 hours after scan
4. Inability to remain stationery or supine for duration of the scan

C. Patient preparation

C.1 Prior to Injection

Patients should be told to avoid stimulants (such as coffee, cola and energy drinks), alcohol, smoking, and any drugs known to affect cerebral blood flow.

Check to insure the patient can cooperate during the procedure. Confirm there are no contraindications.

C.2 Injection

1. Patient should be positioned in a quiet, dimly-lit room
2. An intravenous cannula should be started 10-15 minutes prior to injection.
3. Patient should be positioned in a comfortable (preferably supine position).
4. Patient may keep eyes open, or be offered an eye mask. Ears can be unplugged.
5. No interaction should take place with the patient for at least 5 minutes before and up to 5 minutes after the injection
6. Note any alterations that might affect the rCBF during injection of the radiopharmaceutical (e.g. Patient motion or talking.)
7. Allow 30-40 minute washout period during which the patient is encouraged
8. to drink water and to urinate.
9. Patients should be informed they will be required to lie still for 30-60 minutes during the scan..

If patients are assessed as being unable to lie still for the examination, because of neurocognitive disorders or dementia, it may be a consideration to use conscious sedation such as a short acting benzodiazepine. The sedative can be administered approximately 5 minutes after tracer injection, when it is unlikely to affect biodistribution. If a sedative is used, it is important to have EKG monitor or pulse oximetry available.

D. Information pertinent to performing rCBF SPECT studies

1. Patient history should include neurological and psychiatric disorders, as well as indicated reason for the SPECT scan, history of previous surgery, allergies, radiation or trauma to the brain.
2. Results of recent anatomic imaging studies (CT or MRI)
3. Results of recent functional studies – such as EEG, fMRI, PET scans

E. Precautions

There should be continuous supervision of the patient by the technologist or nurse during the course of the study. Patients with epilepsy or suspected dementia or psychiatric concerns should be especially closely monitored.

F. Radiopharmaceutical

F.1 Radionuclide ^{99m}Technetium

F.2 Pharmaceutical
1. ECD
2. HMPAO stabilized preferentially, or unstabilized

F.3 Preparation
1. Use pertechnetate from generators that have been eluted within 24 hours
2. Use fresh generator pertechnetate not older than 2 hours, especially for HMPAO.
3. For HMPAO, the manufacturers recommendation regarding incubation time before injection should be respected. Non-stabilized HMPAO (injection as soon as possible), blue-dye stabilized and Cobalt stabilized HMPAO (30 minutes incubation).

F.4 Quality Control

Radiochemical purity should be determined on each vial prior to injection according to manufacturers recommendations in the package inserts. It should be >90% for ECD and >80% for HMPAO

F.5 Timing the Injection

Injection may proceed once quality control is passed., but not later than 30 minutes after drug vial is reconstituted for unstabilized ^{99m}Tc HMPAO, 4 hours for stabilized ^{99m}Tc HMPAO, and 6 hours for ^{99m}Tc ECD

F.6 Administered Activity

1. Adults: 555-1110 MBq (typically 740 MBq of either radiopharmaceutical

2. Children:

a. Administered activity = "baseline activity" x multiple (from dosage card – see EANM Paediatric dosage card table v. 1.5.2008)

b. For ECD: "baseline activity" = 32 MBq (minimum recommended activity = 110 MBq)

c. For HMPAO" "baseline activity = 51.8 MBq (minimum recommended=110 MBq)

Doses of radiation following administration of radiopharmaceutical is shown below:

Table 1 Radiation dosimetry

Client Group / radiopharmaceutical	Organ receiving the largest radiation dose	Absorbed Dose (mGy/MBq)	Effective dose (mSv/MBq)
Adults			
99mTc-ECD a	Bladder	0.05	0.0077
^{99m}Tc-HMPAO b	Kidney	0.034	0.0093
Children (5 years)			
^{99m}Tc-ECD a	Bladder	0.110	0.022
^{99m}Tc-HMPAO b	Thyroid	0.14	0.027
Reference a	ICRP PUBLICATION 106 Radiation Dose to Patients from Radiopharmaceuticals, Addendum 3 to ICRP Publication 53, ICRP Publication 106, Approved by the Commission in October 2007 , page 107		
Reference b	ICRP PUBLICATION 80 Radiation Dose to Patients from Radiopharmaceuticals ,Addendum 2 to ICRP Publication 53, Also includes Addendum 1 to ICRP Publication 72, Page 100		

G. Data acquisition

G.1 Time from injection to start of data acquisition

1. Try always to keep the same time delay from injection to the start of data acquisition.
2. ^{99mTc}-ECD: For best image quality allow a delay of 30-60 minutes since wash-out due to non-specific uptake improves the signal to noise ratio in this period.
3. ^{99mTc}HMPAO: For best image quality allow a delay of 30-90 minutes
4. Imaging should be completed within 4 hours after injection. Excessive delay should be avoided because of radioactive decay.

G.2 Set-up for data acquisition

1. Positioning of the patient

• The patient should be encouraged to void prior to beginning the study for maximum comfort and to avoid movement. Following completion of the study the patient should be asked to void again to decrease radiation exposure.

• The patient should be told about how much time the study will take to complete, and positioned for maximum cooperation with the study. Since post-processing can correct for minor movements of the head, the patient's comfort is more important to a successful scan than perfect alignment of the head.

• The patient should be cautioned not to move during the study. If the patient is unable or unwilling to avoid movement, sedation may be considered. A head immobiliser is not necessary but some light restraint such as pillows or tape might be used.

H. Imaging Devices

H.1 Background

The study is most commonly performed with dual head detectors. A SPECT-CT hybrid scanner has advantages of x-ray attenuation correction, but dual head detectors face limitations of being able to get collimators close to the patient because of patient shoulder obstruction. A dedicated Brain SPECT system, with triple detectors is preferable, if available, particularly with fan-beam collimation.

New detectors, using Cadmium Zinc Telluride (CZT) solid state ring systems or Sodium Iodide scintillation (NaI) scanners with multiple scanning or pinhole detectors are becoming available, and are likely to compete with PET in terms of resolution and count-rates. Clinical studies however with these detectors are currently limited, but it is likely these types of detectors will become more common in the next decade.

Low Energy High resolution (LEHR) or LEUHR parallel-hole collimators remain the most readily available collimators for brain imaging. They are acceptable if sufficient count rates are obtained. LEAP or Low Energy All Purpose collimators are not suitable. Generally, the highest resolution collimator is best. Newer detectors using multiple pinholes are preferred, or fan-beam collimators, compared to the parallel-hole collimators. There is always generally a trade-off between resolution and sensitivity. In the case of fan beam collimators, or newer multiple pinhole detectors, it is important to make certain the entire head is in the field of view, particularly the cerebellum.

Of all nuclear medicine imaging procedures, a brain SPECT scan is one of the hardest to do correctly. The overall quality of the scan depends on getting many details right, and the procedure is not very forgiving when all aspects of the imaging technique are not flawlessly executed. Because of the enormous variability in brain scan images, it is especially important to have great consistency in performing these scans such that interpretation and comparisons of these studies can be done more reliably.

Brain SPECT procedure volumes are small and account for less than one percent of all NM procedures. One of the reasons why brain SPECT imaging is not prescribed more often is that poor execution, combined with a lack of experience, produces sub-optimal images causing unhelpful findings, resulting in fewer referrals.

H.2 Instrumentation

Dedicated brain SPECT imaging systems, such as a triple detector gamma camera with fan beam collimation, are no longer produced due to a declining interest in these scans. This means that most brain SPECT studies today must be acquired with a general-purpose SPECT camera, typically a dual detector camera with large field of view detectors.

Unfortunately, a general-purpose camera system can make it more difficult to execute a high-quality brain SPECT scan, e.g., clearing the patient's shoulders without clipping the lower part of the brain. However, with proper technique, good results can be obtained.

Note: Certain specialized cameras may deviate and not be equipped with traditional detector heads, such as ring detector systems. For these systems, some of the requirements provided in this document may not be applicable. In these cases, the operator should follow the recommendations of the equipment vendor.

	Best	Better	Good
Camera type	dedicated brain scanner	triple detector	dual detector
Collimator type	dedicated	Fan beam	LEHR parallel hole
Counts in study	10M+	8-10M	6-8M
Radius of rotation	<160mm	160-180mm	180-200mm

H.3 Count statistics

Like in all nuclear medicine studies a trade-off must be made between counts (statistics) and scan time. For patient comfort, shorter scan times are preferred, and it is recommended to keep acquisition time within the clinical tolerable limit (30 min). For good image quality, more counts are better, and it is recommended to acquire 10M counts minimum.

There are several factors that have an impact on the acquired number of counts in a scan. The following factors increase the number of counts, and they are reviewed below

1. Utilizing a camera with multiple detectors
2. Using a collimator with higher sensitivity
3. An increase in acquisition time
4. A higher injected dose
5. Increasing the width of the energy window

H.4 Number of detectors

Brain SPECT scans require a full 360^0 rotation around the subject's head. The total number of acquired counts increases proportionally with the number of detectors. A minimum of two detectors is recommended because the acquisition time for a single detector camera will be outside of the clinical tolerable range. Note: Certain specialized cameras may deviate and not be equipped with traditional detector heads, such as ring detector systems. For these systems, some of the requirements provided in this document may not be applicable, and in these cases the operator should follow the recommendations of the equipment vendor.

H.5 Collimators

The reconstructed resolution of a gamma camera system is determined largely by the collimator resolution. Brain SPECT perfusion studies are acquired with ^{99m}Tc and require a 'low energy' (LE) collimator. Collimator design is a trade-off between resolution, sensitivity, and septal penetration (rejection of unwanted photons). Because collimator terminology is not standardized between vendors, it is important to review the collimator specifications rather than relying on terms like high resolution (LEHR), general purpose (LEAP).

H.6 Acquisition time

The total number of counts in a SPECT scan is proportional to the acquisition time. Longer acquisition times will increase the susceptibility of patient motion which has a detrimental effect on image quality. Therefore, every effort should be made to maximize patient comfort during the scan. However, there is a limit to how far the acquisition time can be extended without risking patient motion. A practical limit is 30 min. Occasionally, other measures may be necessary such as head restraints or sedation.

H.6 Injected dose

The total number of counts is proportional to the injected dose. However, there is a limit to how much activity can be administered to the patient without exceeding the maximum radiation exposure limits. It is recommended to maximize the allowable dosage for best results.
Note: The operator must always follow all local rules and regulations pertaining to the allowable administered dosage.

H.7 Energy window

Because a gamma camera has a limited energy resolution, an energy acceptance window must be set based on the energy level of the radioisotope in use (140keV for ^{99m}Tc). Opening the energy window will increase the number of counts in a scan but will also increase the fraction of scattered events (bad counts). The measured location of a scattered event does not represent its original source location.

Thus, scattered events deteriorate image quality by increasing the noise level.

Reducing the energy window will decrease the number of scatter events but also reject some of the non-scattered (good counts) events due to the limited energy resolution of the imaging system. Most used energy window settings are 15% or 20% for ^{99m}Tc. For most situations, the operator is advised to follow the recommendations provided by the equipment vendor. Note: Some camera systems may include an option for scatter correction. H.8 Image reconstruction

A series of raw images (i.e., projection data) as acquired by a SPECT camera cannot be interpreted directly but must first be digitally reconstructed. Reconstruction is a part of the image generation process and should therefore be considered an extension of the gamma camera. In other modalities, such as CT, the user is often removed from the reconstruction process but in SPECT imaging the choice of reconstruction parameters is paramount to the attainable image quality and depends strongly on the imaging equipment, the local acquisition parameters, and quite often the patient itself.

In terms of image reconstruction, a general distinction is made between filtered back projection and iterative reconstructions. They differ considerably and are discussed in some detail below.

There are some other image processing functions that can be considered part of image reconstruction, most notably: attenuation correction, which is an essential element of brain SPECT imaging. Other optional functions include scatter correction and resolution recovery which are discussed below.

H.9 Filtered back projection (FBP)

The traditional reconstruction method used in tomography is back projection (BP) because it is simple and fast and can be implemented easily on off-the-shelf computer systems without any need for specialized hardware.

However, using BP for the reconstruction of SPECT data has its limitations and is in fact not the best suited method. The prerequisites for BP to work correctly are that it is expected that the data has unlimited statistics and has perfect resolution (pencil beam reconstruction). For SPECT data these two requirements are not valid and an approximation at best. SPECT data is count poor (low statistics) and of low resolution which also is not constant but changes with distance from the detector surface.

To deal with these limitations a filtering function is introduced to reduce the noise level in the reconstructed images to make them interpretable. The filter makes out of back projection, filtered back projection (FBP). The filter is commonly implemented as a pre-filter, i.e., the raw projection images are filtered prior to back projection. The typical type of filter used in SPECT imaging is the Butterworth filter which is controlled by two parameters: cut-off and order. The order is usually fixed at 3 or 5, and the cut- off determined the final resolution and noise level (image texture). Please note that the cut-off is related to the sampling, i.e., the pixel size of the images. Higher sampling, i.e., smaller pixels, require a lower cut-off to achieve a similar smoothness compared to images acquired with larger pixels.

Since FBP is a well-defined reconstruction method, the differences in implementation between vendors are small which allows for a standardization in reconstruction parameters based on the type of study and the acquisition parameters. This is an advantage because it makes it easier to establish imaging guidelines that, when followed, produce consistent and good quality data.

There are other reconstruction methods that are better suited to SPECT data, but they do require a much higher computational effort and only recently became feasible for general-purpose computer hardware.

H.10 Iterative reconstruction (IR)

Unlike FBP, iterative reconstruction is more of an umbrella term, which does not say much about the method or its performance.

Two of the most common generic iterative reconstruction schemes are known as MLEM (maximum likelihood estimation method) and OSEM (ordered subset expectation maximization). The latter is more frequently used in SPECT imaging because it is a faster algorithm. For performance reasons, most OSEM implementations were initially in 2D (i.e., slice by slice) but nowadays most vendors have switched to a full 3D implementation. OSEM-3D is the preferred method in SPECT because the limited resolution of the data results in considerable crosstalk between slices which is ignored in 2D implementations.

An iterative reconstruction engine goes through several iterations whereby the forward projection of the reconstructed slices is compared to the raw projection images. An error signal is added, or multiplied, to the synthetic projections and back projected again. This process repeats itself until the differences between the original projections and the computed projections are below a certain error threshold or until a set number of iterations is reached.

The most important advantage of iterative reconstruction in SPECT imaging is the fact that the imaging system (i.e., gamma camera and collimator) can be modelled in the algorithm, resulting in more accurate images. For example, the intrinsic resolution, the energy resolution, and other physical parameters of the camera can be considered when computing the reconstructed slices from the raw data. Also modelling of the collimator geometry is of significant benefit because the overall SPECT image resolution is primarily determined by the collimator design.

Iterative reconstruction methods tend to provide greater image contrast, i.e., the differences between areas of high and low up take are enhanced and the overall dynamic range of useful information is extended. However, it also causes structures that appear singular and smooth in FBP to be visualized as clusters of hotspots. The images have the appearance of being sharper and of higher resolution, however the additional detail can also be perceived as noisy, especially without correlation to detailed anatomy such as an MRI scan on the same subject. This can make the SPECT images more difficult to read because the interpreter thinks in larger structures and must use his/her imagination to lump several hotspots together to come to an interpretation. This poses a considerable mental effort on the readers and they often prefer some filtering to ease interpretation. The

smoothing can simply be achieved by applying a post-reconstruction filter, or can be implemented as a control to the reconstruction engine which specifies the desired/expected resolution of the final images.

H.11 Attenuation correction (AC)

All SPECT imaging is affected by attenuation which in most procedures can be tolerated but must be corrected for in brain imaging. The effect of attenuation depends on the energy of the emitted gamma quants, the density of the medium, and the distance traveled by the quant through the patient's body. The loss of transmission due to attenuation is an exponential function of distance. For ^{99m}Tc (140keV) the attenuation coefficient is 0.15cm^{-1}, which translates to a transmission loss of 50% when photons travel 4.58cm through water (density = 1.0). As a result, photons originating from the center of the brain (basal ganglia) are detected with an apparent lower count rate than photons originating from the surface of the brain (cortex). Since the objective of brain SPECT perfusion imaging is to measure and compare regional blood flow in different functional areas of the brain; this cannot be done without attenuation correction.

Note: the theoretical attenuation coefficient of 0.15cm^{-1} for ^{99m}Tc in water must typically be reduced to 0.12cm^{-1} to compensate for the presence of scatter. The exact value can be determined through a phantom measurement acquired under the same conditions as a brain SPECT scan.

The most common implementation of attenuation correction in brain SPECT imaging is a post- reconstruction technique based on the method developed by Chang [209 210] This method assumes that the attenuation within the patient's brain is uniform which is a first order approximation because it does not consider the bony structures surrounding the brain which are of a higher density than the brain tissue itself. However, given the overall resolution of SPECT imaging this simplification is thought to be acceptable because the differences compared to a more accurate representation of attenuation are considered insignificant compared to other limitations in SPECT imaging such as scatter.

Chang's method of attenuation is computed and applied on a slice-by-slice basis. The traditional implementation is manual and requires the operator to draw elliptical shaped contours around the patient's head (including bone and scalp). From these contours, and the attenuation coefficient, a correction matrix is calculated for each slice that produces the AC corrected slice by multiplication with the original uncorrected slice.

Note: Chang attenuation correction must be performed in the original orientation of the scan, i.e., prior to any reorientation.

Manual attenuation correction is a time intensive process and is rather subjective, i.e., the process is operator dependent and not reproducible. Some implementations automate the process by analyzing the background noise in the images (scatter) which falls off outside of the patient's head. This typically produces an irregular contour which however can be constrained programmatically to produce a shape consistent with the expected outline of a human head. This can work quite well most of the time, however in both cases it is recommended to save the outlines overlayed on the slices as a QC image for review.

Modern iterative reconstruction methods may include a reconstruction of the patient's head shape from a separately acquired scatter window, typically positioned just below the photopeak window. This reconstructed shape, associated with an attenuation coefficient, can then be used to simulate the attenuation in the forward and backward projection paths as part of the reconstruction engine. This can be considered an improvement but because it is no longer a post-reconstruction method it cannot be called Chang anymore.

Hybrid SPECT/CT cameras have a CT scanner on board which can be used to obtain a real density map of the patient's head from which an attenuation map, a so-called -map, can be derived. This -map is then used within the iterative reconstruction engine to correct for attenuation during the forward and backward projections (CTAC). Although the CT scan itself is of limited diagnostic use in brain SPECT perfusion imaging, and the CT scan adds to the total radiation exposure, it is still considered the most accurate implementation of attenuation correction.

Note: some SPECT/CT camera systems may not be compatible with fan beam collimators. In those situations, one must decide if the value of CTAC outweighs the sensitivity improvement of a fan beam collimator.

H.12 Resolution recovery

The resolution of a gamma camera equipped with a collimator changes with distance. A parallel hole collimator basically is a slab of lead of a certain thickness, with lots of small (circular) holes in it. The intent is to only pass gamma photons that enter a hole perpendicular to the surface of the collimator. Photons arriving from different angles are attenuated by the lead walls between the holes and do not reach the detector. Due to the final length of the holes, they have an acceptance angle, i.e., photons arriving from angles that are slightly off perpendicular still make it to the detector. Looking back from the detector through the collimator holes, the circular area that is seen increases with distance which means the resolution of the imaging system decrease with distance. This is the reason why in nuclear medicine the imaging distance is so important to obtaining data of high quality (resolution).

The loss of resolution with distance is a pure geometrical effect and it is constant for a given collimator design. The collimator can be modelled in the iterative reconstruction engine with just a few parameters. During each forward and backward projection cycle the change in resolution is accounted for, and thereby resolves a higher resolution image. This method is also known as collimator deblurring which more accurately describes its function.

Today most iterative reconstruction implementations for SPECT imaging include this function. It is a good reason to switch from FBP to iterative as it brings a real advantage to the imaging chain.

H.13 Scatter correction

All gamma camera systems can acquire multiple energy windows simultaneously. This feature was originally developed for dual-isotope imaging to capture photon events at multiple energy levels. However, it can also be used to capture scattered events which can information that can be used to our advantage.

Scatter correction typically requires the acquisition of two additional energy windows, surrounding the photopeak window, in separate image channels (triple energy window technique). Because the scatter windows contain scattered events only, and their energy is in close proximation of the photopeak events, their noise spectrum is considered like the noise spectrum of the scattered events recorded in the photopeak window. By means of a weighted subtraction technique, the noise content of the photopeak images may be reduced, however it can never be completely removed.

In theory, scatter correction will increase signal to noise ratio of the acquired images. Phantom measurements are typically used to show its effectiveness; however, its performance on clinical data is highly dependent on the correct adjustment of weighting and care must be taken not to overcorrect the images. We want to separate the good counts (wanted signal) from the bad counts (noise), by subtracting out an estimation of the noise. Because the noise estimation can never be exact, it can unfortunately subtract too much background and degrade our signal.

H.14 Comparing methods

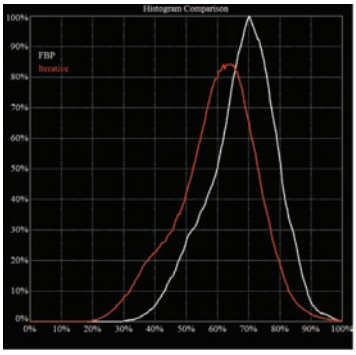

Fig. 1a - Histogram comparison

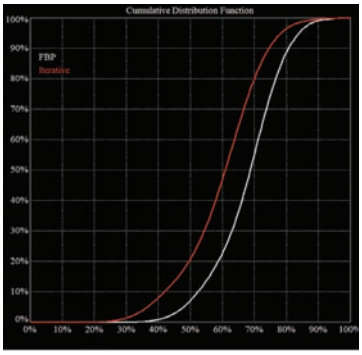

Fig. 1b – Cumulative distribution function

Images produced by FBP and iterative reconstruction from the same projection data will be different. Most of the differences will be due to image texture, e.g., signal to noise, resolution, etc. However, it can not be excluded that different images can lead to a different interpretation. This can be a complication, especially in a mixed environment. Because each brain is unique, it can take years of

experience to become a fully rounded reader. Therefore, it is important to produce images in a consistent way. Despite their assumed superiority over FBP, the challenge for using iterative reconstruction is the lack of standardization.

These figures illustrate the difference in behaviour of FBP vs IR on the same clinical projection data. The area under the histogram curves is the same but the peak is shifted downwards for IR. This is consistent with our expectation that IR will increase image contrast, i.e., the noise is pushed down and a higher max is resolved.

I. Interventions

I.1 Vasodilatory challenge

The following recommendations focus on acetazolamide (Diamox TM). Some studies have been performed with dipyridamole (Persantine) SPECT stress. Dipyridamole (0.57 mg/kg) is given intravenously 3 minutes before infusion of ^{99m}Tc-HMPAO, with patients studied 30 minutes after Injection. Acetazolamide is a carboanhydrase inhibitor and leads to an increase in rCBF in normal cerebral vessels via dilatation of the cerebral arteries.

I.2 Indications

The evaluation of cerebrovascular reserve in TIA, completed stroke, carotid artery stenosis or occlusion, vascular anomalies, and evaluation of the results of carotid surgery, preoperative evaluation of the need for selective carotid shunting during carotid endarterectomy, evaluation of cerebrovascular reserve before and after cerebrovascular surgery or stent placement. It may also be useful to help distinguish vascular from other causes of dementia.

I.3 Contraindications

1) Known sulfa allergy.
2) Use of acetazolamide is not recommended within 3 days of an acute stroke or recent intracranial hemorrhage.
3) Use of acetazolamide may provoke migraine in patients with a migraine history
4) Caution should be used in patients with renal or hepatic insufficiency.

I.4 Acetazolamide dosage and properties

1) Dosage:
   a) Adults: 1000 mg by slow intravenous push
   b) Children: 14 mg/kg body weight
2) Acetazolamide is a diuretic (patients should void prior to positioning under the camera)
3) Adverse effects: mild vertigo, tinnitus (perioral) paresthesia, and rarely nausea. In general these effects are self-limited and do not require specific treatment. Postural hypotension may also occur.

I.5 Study protocols
Since the vasodilatory effect is most pronounced around 15 to 20 minutes after injection of acetazolamide, the radiopharmaceutical should be injected within this time frame.

Various protocols have been used to study rCBF under baseline condition, and acetazolamide provocation. The 2-day repeat study technique is simplest and therefore preferable (allow sufficient time between the investigations for residual activity to clear, e.g. 24-48 hours). Either test, whether baseline or challenge, may be performed first. A "challenge first" test might be favoured, since if it is normal, then the baseline study can be omitted. On the other hand, performing the baseline study in advance of the challenge study can be helpful if large perfusion defects are present, suggesting the need for caution during the challenge infusion of acetazolamide.

One-day protocols using split-dose techniques (second dose at least twice the first dose) require more sophisticated evaluation and data processing, and therefore are less favoured.

J. Epilepsy focalization

J.1 Ictal SPECT studies

The tracer should be injected as soon as the patient begins seizing (via intravenous line placed previously). It is recommended that prepared syringes be stored in the epilepsy monitoring unit to ensure the quickest possible injection time. Patients should have continuous video-EEG monitoring in order to relate the injection time exactly to the time point of the behavioural and electrical seizure onset and end.

J.2 Interictal SPECT studies

The conditions for tracer injection are the same as for the Ictal SPECT scan, but additionally continuous EEG monitoring should be performed from at least 2 hours before until 15 minutes after injection to exclude the possibility that seizures occurred shortly before and during the uptake period of the radiopharmaceutical. Interictal studies may add useful information to ictal studies.

K. Interpretation criteria

K.1 Visual interpretation

Images should be read on computer screen with a similar colour table used for all patients.

Ideally interpretation will be correlated with CT or MRI anatomic studies, or if possible, with the use of a hybrid imaging system such as SPECT-CT. If there are anatomic abnormalities, the SPECT study should be interpreted relative to the observed morphological changes, including atrophy and partial volume changes. If available, image fusion software may be useful to help clarify the rCBF changes against the anatomic changes.

L. Reporting

L.1 General Reports should include all pertinent information, including the name of the patient and other identifiers, such as birthdate, name of the referring physician, type and date of examination, type of equipment, radiopharmaceutical including the administered activity, and patient history, including the reason for requesting the study and any potentially interfering medications.

L.2 Body of the report

L.3 Procedures and materials:

Include in the report a brief description of the imaging procedure (including the type of attenuation/scatter correction used) and assessment of scan quality (if compromised, give the reason, e.g., motion artifacts, interstitial injection, poor radiopharmaceutical preparation.

If sedation is performed, briefly describe the procedure, including the type and time of medication given in relation to the time of radiotracer injections.

If interventions are performed, briefly describe the protocol applied.

L.4 Findings

Describe whether or not the SPECT pattern is normal or not. If findings are abnormal, describe the location and intensity of abnormal tracer uptake. Description of the anatomic location of the abnormalities (i.e., based on Brodmann areas) can be useful.

The vascular anatomy might also be useful if relating the lesions to vascular origins. The criteria used (visual assessment, quantitative or semi-quantitative measurements, or comparison with normal database) should also be reported.

L.5 Limitations

Where appropriate, identify factors that could have limited the sensitivity and specificity of the exam, such as patient motion or lesions below the resolution of the detector.

L.6 Clinical issues

The report should answer any clinical issues raised in the examination history or imaging request.

If the patient is traveling on the day of injection, they should be informed that they may set off radiation detection devices at international airports.

L.7 Comparative data

Comparisons to previous examinations and reports, if available, should be entered into the report. Results of anatomic imaging studies (CT, MRI) if available, image fusion results, should also be discussed where relevant.

L.8 Interpretation and conclusions:

To the extent possible, provide a differential diagnosis based on generally accepted disease- specific patterns. If no such pathognomonic patterns exist, the interpretation should be considered as requiring confirmation with other tests, follow-up or additional studies, or referred to as "consistent with" or "not consistent with" the reasons for ordering the studies.

M. Quality Control

See procedure guidelines of the EANM

N. Sources of error

1. Unintended cerebral activation
2. Artifacts (patient movement, camera problems, computer software malfunction)
3. Interference with drugs
4. Normal variation
5. Level of contrast or background subtraction
6. Inappropriate thresholding can result in artifact. Thresholding should only be used based upon knowledge of a normal database
7. Colour table: Use of non-continuous colour tables may overestimate changes due to abrupt colour changes.

O. Technological developments

New SPECT cameras are being developed with improved detector efficiency and spatial resolution, such as those using solid state detectors, such as CZT (Cadmium Zinc Telluride) or dedicated multi-pinhole detectors, continuous or discontinuous rings, or SPECT-CT for attenuation correction. MRI-SPECT fusion is available by several software vendors. Certain novel cameras allow for dynamic 4-D SPECT acquisitions, as well as PET-resolutions.

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