LE PATIENT

LE SEUL MAGAZINE DE TOUS LES PROFESSIONNELS DE LA SANTÉ

THÉRANOSTIQUE

IMAGERIE DES TUMEURS NEUROENDOCRINES

LA MÉDECINE NUCLÉAIRE

LES AVANCÉES MÉDICO-PHARMACOLOGIQUES

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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.

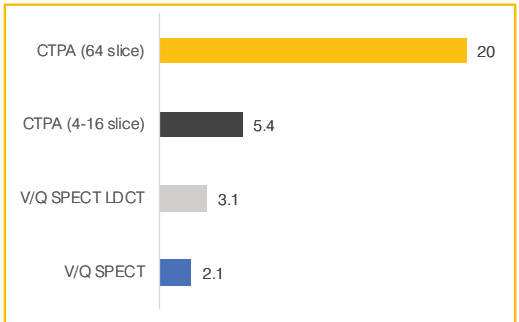

Table 1: Radiation exposure [8] (mSv)
(adapted from CANM guidelines, 2018)

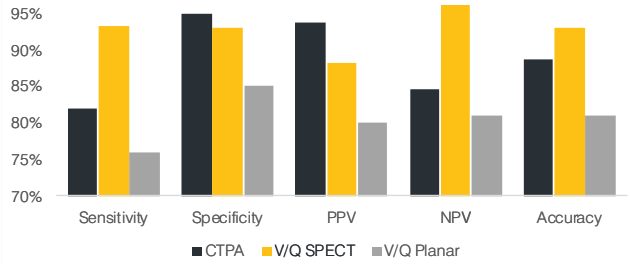

Table 2: Diagnostic ability of CTPA, V/Q SPECT and V/Q Planar to detect PE (adapted from Hess et al, 2016)

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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8. Leblanc M , et al. CANM Guidelines 2018; published Nov 2018

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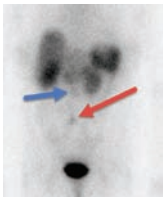

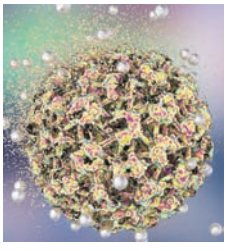

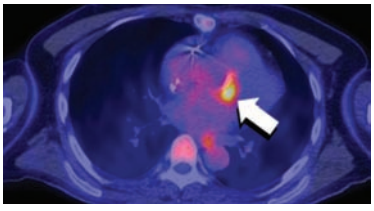

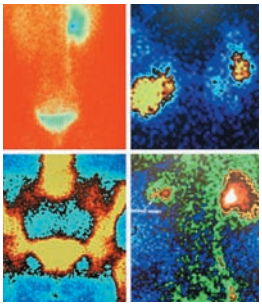

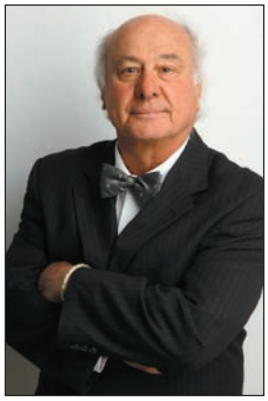

François Lamoureux,
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LES AVANCÉES MÉDICO-PHARMACOLOGIQUES

LA NOUVELLE ÈRE SUPERSONIQUE DE LA MÉDECINE

L'Homme est un être extrêmement complexe, une machine moléculaire d'une dimension qui dépasse tout ce que, jusqu'à maintenant, on a pu imaginer.

On n'a pas encore atteint l'immortalité mais on repousse continuellement les frontières de son irrémédiable arrêt. Aujourd'hui vivre presque jusqu'à 100 ans, c'est possible.

La médecine a fait des progrès immenses pour assister, protéger et surtout guérir et assurer pour plusieurs années la survie de l'Homme sur cette Terre.

Jusqu'au début du siècle dernier, on devait procéder à des interventions chirurgicales effractives pour inventorier l'intérieur du corps humain afin de débusquer les pathologies et les agresseurs et tenter de les neutraliser et de les extirper de ce corps envahi.

Aujourd'hui, le médecin du 21e siècle a à sa disposition tout un armamentarium des plus sophistiqués et en continuel développement.

La première avancée fut incontestablement l'usage de la radiation comme source externe pour générer des images des organes du corps humain sans effraction physique; ce fut la naissance de la radiologie. Puis, très rapidement s'est ajouté l'usage de la radiation, mais cette fois par l'introduction dans le corps humain d'une molécule radioactive pratiquement indétectable par le corps humain. Au moyen d'une caméra externe spéciale, appelée Gamma-Caméra, on reproduit l'image moléculaire et anatomique des organes. La médecine nucléaire diagnostique venait de naître.

L'Homme pouvait être investigué sans effraction, sans douleur et sans effets secondaires significatifs.

Un immense pas venait d'être franchi. Le chirurgien ou le médecin pouvait alors envisager le problème et planifier le traitement approprié, mais surtout avec un minimum d'effets secondaires.

On utilise aussi couramment, comme à l'image des sous-marins, des ultra-sons ou encore on stimule les champs magnétiques des atomes d'hydrogène du corps humain pour produire des ondes radio et générer des images tri-dimensionnelles des organes du corps humain : c'est la technique de la résonance magnétique.

Les médecins nucléistes et radiologistes utilisent au jour le jour de puissants ordinateurs couplés à des

écrans à haute résolution pour exploiter ces supers machines.

C'est un véritable et fantastique voyage *in vivo*.

Les moindres recoins de l'être humain sont maintenant accessibles à la médecine pour débusquer les dysfonctionnements ou les pathologies.

À ces techniques s'ajoute l'intelligence artificielle comme précieuse aide pour les médecins nucléistes et radiologistes. Les robots prêtent de plus en plus main forte aux chirurgiens.

Mais le summum actuel, c'est l'utilisation de l'antimatière, des positons ou des électrons plus (e+), pour reproduire une image complète de l'intérieur du corps humain en trois dimensions, en couleur et accompagnée de données quantitatives. Ici la médecine nucléaire a franchi un nouveau pas de géant dans le débusquage des pathologies à leur début.

Plus encore, cette médecine nucléaire s'attaque maintenant au traitement de certaines maladies en utilisant des molécules ou des anticorps radioactifs pour cette fois, non seulement diagnostiquer certaines pathologies, mais amorcer également leur traitement, c'est un véritable scalpel nucléaire, c'est la théranostique. Cette nouvelle médecine bien qu'embryonnaire est et sera une partie importante de la médecine de tous les jours.

Voilà pourquoi l'Homme peut espérer vivre au moins jusqu'à près de 100 ans et réaliser combien les médecins nucléistes et radiologistes apportent une contribution inestimable à cette avancée.

La médecine nucléaire et la radiologie sont des spécialités bien en selle pour le futur et combien gratifiantes. ■

« Les moindres recoins de l'être humain sont maintenant accessibles à la médecine pour débusquer les dysfonctionnements ou les pathologies. »

« La médecine nucléaire et la radiologie sont des spécialités bien en selle pour le futur et combien gratifiantes. »

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THERANOSTICS

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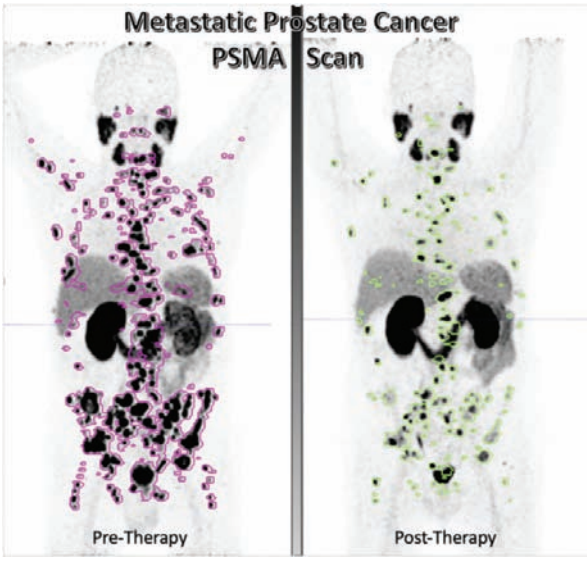
INTRODUCTION

Over the past 30 years, there have been colossal advances in the way we have lived life through the development and innovation of scientists worldwide. From the creation of the internet, to the development of the smart phone, accessible Wi-Fi, and more recently to self-driving cars and smart home systems. When people think of the word technology, Steve Jobs's Apple devices, or Elon Musk's Tesla comes to mind. Although healthcare is not the first field that pops into people's minds when innovation and technology are asked about, healthcare advances are important to consider. In 1950, the global average life expectancy was 46 years; in contrast, the WHO reports that the global life expectancy in 2019 is 73.4 year. This 27-year increase in life expectancy can be attributed to the development of our healthcare system and the newer therapies that are available.

Within healthcare, cancer has been one of the longest studied diseases. It is well known that cancer is one of the most important health problems that we face as it is a leading cause of death worldwide, accounting for nearly 10 million deaths per year, or nearly one in six deaths. As much as cancer prevention is important, finding new scientific ways to treat this nasty disease has been a goal for many top researchers all over the world over many decades now. This article will briefly explain a relatively new smart way of cancer treatment that has the potential of being applied to many types of cancer in different age groups. This concept is called theranostics



WHAT IS CANCER?

Cancer is a generic term for a large group of diseases that can affect both sexes at different ages and may affect any part of your body. It is caused by the transformation of normal body cells into tumour cells. These usually arise from random unpredictable DNA mistakes that happen on a cellular level. These mistakes, or what we call mutations, lead to unregulated cell division and much faster growth compared to normal cells associated with cell death inhibition. Eventually, this leads to the formation of large masses that replaces normal body tissue. This causes disruption of the normal function of the organs they occupy, which leads to multiple complications and, if untreated, death.

It is believed that the cause of cancer is multifactorial where genetic factors play an important role, as well as environmental exposure to certain agents that we call carcinogens. These could be chemical (tobacco and alcohol for example), physical (like ultraviolet and ionizing radiation), and biological (like infections).

RADIONUCLIDIC THERAPY

The main known therapeutic options for cancer are: surgery, drug therapy (including chemotherapy, immunotherapy and hormonal therapy), and radiation therapy. Radiation therapy uses beams of intense energy to kill cancer cells by destroying the genetic material (DNA) that controls how cells grow and divide. Radiation kills healthy cells as well as cancer cells, but cancer cells are easier to kill because they are dividing faster.

External radiation therapy is the most common type of radiation therapy to treat cancer. It uses external radiation aiming at specific organ or part of the body where the cancer is. The main disadvantage is the direct damage to the surrounding tissue as it is not specifically targeting the cancer cells and all the cells in the path of radiation will be affected.

Another radiation-based treatment option available for certain types of cancer is the use of targeted

radionuclide therapy, where a radioactive substance is administered to patients. This type of therapy is a systemic treatment, reaching cells throughout the body by travelling through the bloodstream. However, it is smart enough to target mainly the tumor cells, unlike chemotherapy which targets all rapidly dividing cells leading to many undesirable side effects.

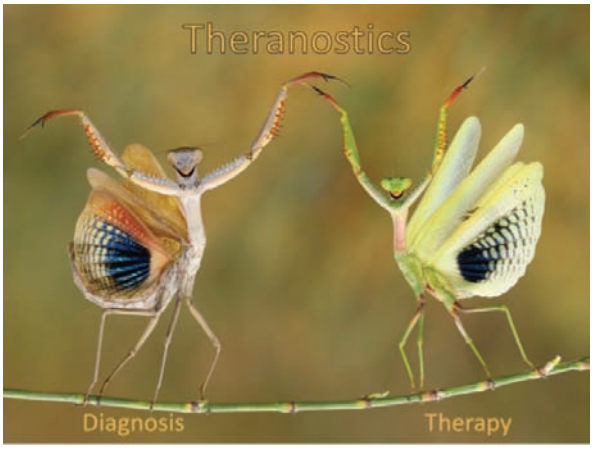
Targeting cancer cells specifically can be achieved by using a specific molecule that would target a specific receptor that is found on the membranes of cancer cells. The tumor cells in this case are rather more differentiated and have partially preserved the characteristics of the original cells that they develop from. The key molecule that is usually injected into the patient has an accessary radioactive isotope attached to it which emits radiation that can be imaged to localize the tumor cells, and/or to destroy these cancer cells. Of all the disciplines in medicine, nuclear medicine is the best suited to achieve these goals.

Different types of radioactive isotopes can be used depending on whether these are needed for diagnosis to localize the tumor; or for therapy where more intense and more damaging effect is required to kill the cancer cells. This selectivity in targeting the tumor cells will significantly reduce the undesirable collateral damage of normal tissue that is difficult to avoid with other types of radiation or chemotherapy.

THE CONCEPT OF THERANOSTICS

The word **"Theranostics"** is a combination of two words: **Therapy** and **Diagnosis**. It is a transition from conventional therapy to a contemporary, personalized, and precise approach in cancer therapy. It combines specific targeted therapy based on specific targeted diagnostic tests improving both patients' outcome and safety at the same time. In other words, using a specific key molecule attached to a diagnostic radioisotope to detect and assess the phenotype of the cancer (Diagnosis), and if positive, then use a similar key molecule attached to a therapeutic more damaging radioactive isotope to selectively damage the cancer cells (Therapy). Consequently, this ensures that the radioactivity will target the desirable sites of tumor spread. It is important to monitor the effects and response to this smart therapy, and for that we can use the diagnostic functional imaging repeatedly. A distinctive advantage of molecular targeted radiotherapy is having the radiation dose distributions available before initiating the therapy for a patient. This can be used to select the preferred drug at the appropriate dose for a patient, thereby maximizing the desirable tumor damaging effect and minimizing the undesirable potential side effects.

It is the nature of cancer cells to gain aggressiveness and build resistance to different types of therapies overtime. It is well known that different clones of the same cancer can co-exist in the same patient with



variable levels of aggression. This heterogeneity of tumor cells is an important factor that will affect prognosis and overall survival. Nuclear medicine and molecular imaging can play an important role in detecting this heterogeneity and further characterization by combing different tumor targeted agents, for example adding radioactive glucose F18-FDG imaging which can detect the most aggressive clones of cancer within the body. This will help guiding management and plan future therapies that will target the most aggressive phenotype and eventually prolong survival and improve quality of life.

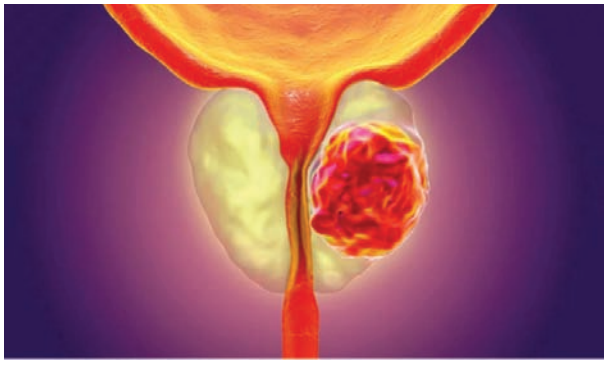
EXAMPLES OF THERANOSTICS

IODINE THERAPY FOR THYROID DISEASE

Radioactive iodine (RAI) is known to be the first theranostic agent that is still considered an essential component of thyroid disease management. It is used to treat both hyperthyroidism and differentiated thyroid cancer (DTC). Iodine-130 and I-131 were first employed to treat thyrotoxicosis in 1941, and thyroid cancer in 1943. The RAI treatment of DTC is based on the principle of the sodium-iodide symporter that is expressed on the differentiated thyroid cancer cells and have the ability of trapping circulating RAI. As such, it is also effective in the treatment of residual and metastatic disease.

PEPTIDE RECEPTOR RADIONUCLIDIC THERAPY (PRRT) FOR NEURO ENDOCRINE TUMORS (NET)

Neuroendocrine neoplasms represent a diverse group of tumors which most commonly arise from gastroenteropancreatic structures. Although neuroendocrine tumors are considered rare, there is a global rise in incidence. The relatively differentiated nature of the disease, with specific expression of somatostatin receptors (SSTR), and its indolent course, make this disease perfect to be targeted by peptide receptor radionuclidic therapy (PRRT) using therapeutic radionuclides (beta- or alpha-emitting radioisotopes). PRRT binds to those receptors on the tumor cells and destroys them with radioactivity. It is



not a cure, but PRRT can effectively slow or stop tumor growth. This can be achieved by applying the concept of theranostics and assess the receptor status of the tumor cell before the actual therapy utilizing positron emission tomography/computed tomography (PET/CT) using Ga-68-labeled somatostatin analogs. This diagnostic tracer binds specifically to those somatostatin receptors and allow the molecular imaging and characterization of NETs with a very high sensitivity and specificity for early identification of metastases.

PROSTATE SPECIFIC MEMBRANE ANTIGEN (PSMA) TARGETED THERAPY FOR PROSTATE CANCER

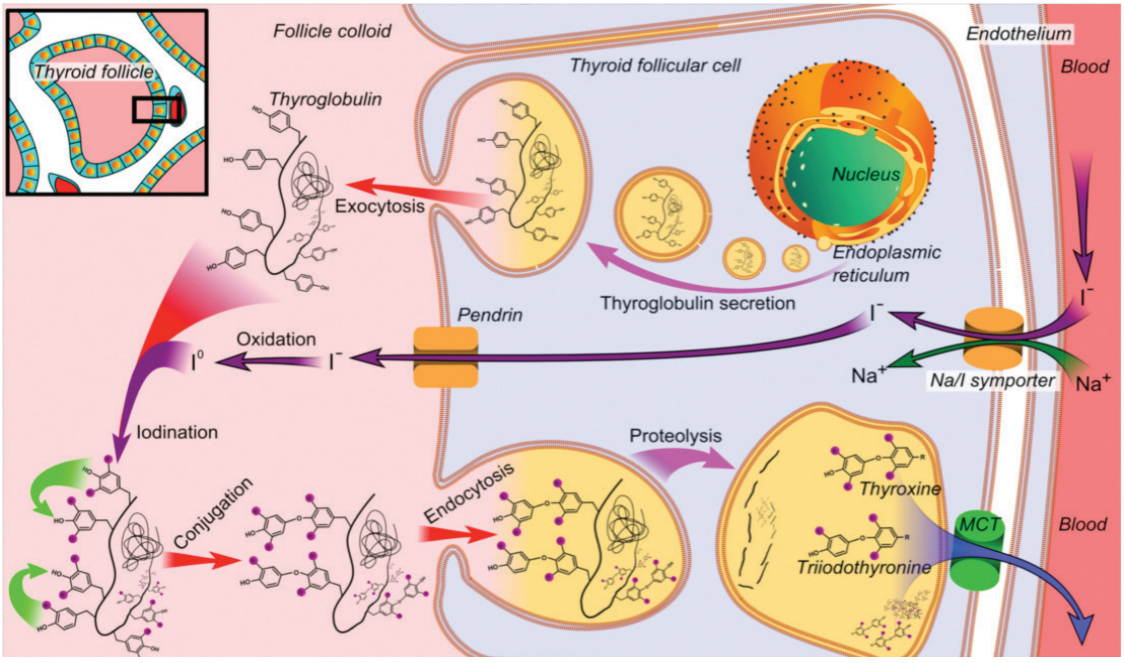
Prostate cancer is the second most frequently diagnosed cancer in men worldwide and the fifth leading cause of cancer caused death. Prostate-specific membrane antigen (PSMA) is expressed on the cell surface in normal prostate tissue and is overexpressed in prostate cancer by several orders of magnitude. Targeted radionuclide therapy with prostate-specific membrane antigen (PSMA)-targeting ligands is a novel therapy that revolutionized the role of nuclear medicine in prostate cancer management. Both lutetium-177 PSMA, the therapeutic agent, and gallium-68 PSMA, the diagnostic agent, were approved by the FDA in early 2022. This targeted therapy appears to be the first of many future agents that will help fulfil a major clinical need in the treatment of patients with metastatic castration-resistant prostate cancer (mCRPC).

Interestingly, PSMA-targeted approaches are expected to move into earlier mCRPC and mHSPC (metastatic hormone sensitive prostate cancer), due the frequent expression of PSMA in early disease, in addition to the acceptable safety profile of this therapy. PSMA-targeted therapy proved to significantly improve prostate cancer survival rates and quality of life, as well as extend the time it takes for the disease to progress.

FUTURE DIRECTIONS

Targeted radionuclide therapy is an excellent example of theranostics. Molecular imaging and therapy are part of a paradigm shift to individualize or personalize patient care. Radionuclidic therapies are not restricted to the previously mentioned examples. Multiple other indications are currently being explored including tumors other than NET that express SSTR (like breast, small-cell lung cancer, pheochromocytoma, and meningioma); as well as other PSMA-expressing tumors like hepatocellular carcinoma and renal cell carcinoma. On the other hand, other molecular targets are being investigated like fibroblast activation protein (FAP) which is up-regulated by cancer-associated fibroblasts, among many other potential targets.

In summary, radiotheranostics is still in its early stages and interdisciplinary efforts are needed to overcome various challenges. Moving forward, the main goal is to integrate radiotheranostics with other cancer therapies like chemotherapy and immune modulation to support precise and personalized cancer therapy in both palliative and curative settings. ■



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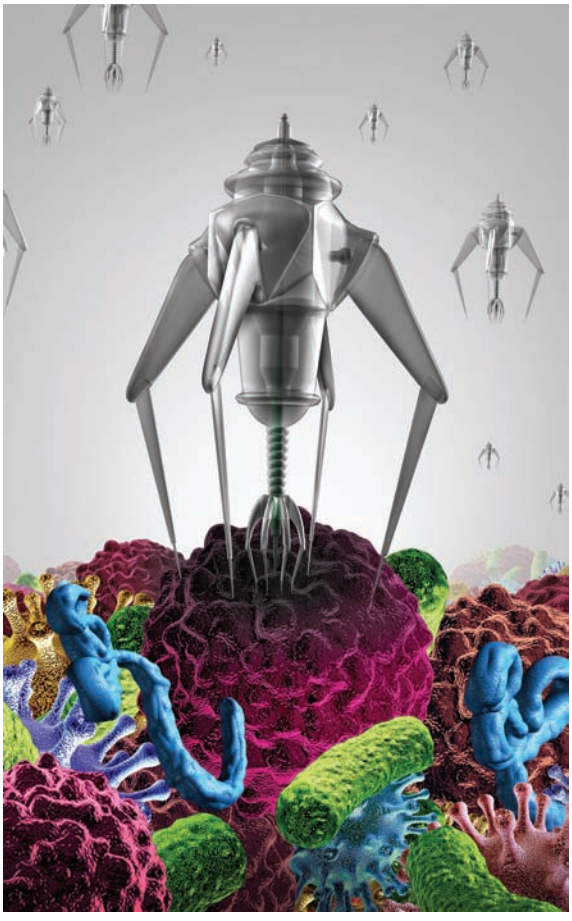
LA THÉRANOSTIQUE AU SERVICE DES TUMEURS NEUROENDOCRINES



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

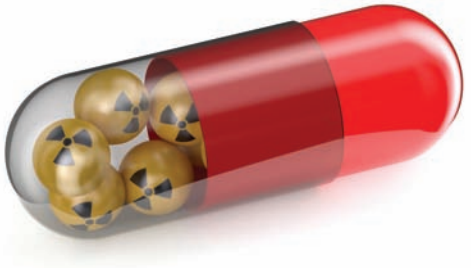
Ce traitement s'adresse aux patients symptomatiques et/ou avec une maladie progressive. Un médecin spécialiste en médecine nucléaire s'assurera que le traitement sera sécuritaire et adéquat pour le patient. Notamment, il est important de s'assurer que toutes les lésions connues surexpriment suffisamment 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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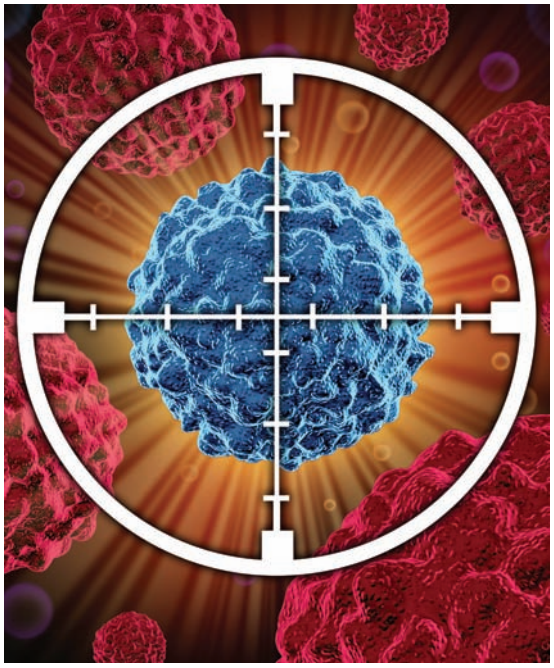
IMAGERIE DES TUMEURS NEUROENDOCRINES EN CIBLANT LES RÉCEPTEURS À LA SOMATOSTATINE



TUMEURS NEUROENDOCRINIENNES

Bien que l'on pense que les tumeurs neuroendocrines (TNE) soient rares, les statistiques nationales et mondiales démontrent que leur incidence est en augmentation (5 cas par 100 000). Cette croissance s'explique par une réelle augmentation de l'incidence mais également par une connaissance accrue des médecins qui sont de plus en plus familiers avec les manifestations cliniques peu spécifiques, dus fréquemment à leur activité hormonale, ainsi que par les avancées des moyens diagnostiques biochimique et d'imagerie.

Le diagnostic des TNE se fait à l'aide de techniques endoscopiques, radiologiques et de médecine nucléaire. Un grand nombre de ces tumeurs sera visible par TDM et IRM avec une sensibilité variant entre 30-40 %. La capacité de déterminer avec précision la localisation et l'étendue de la tumeur est d'une importance capitale car le seul geste curatif existant est la résection chirurgicale. Dans la vague de la médecine spécialisée, la médecine nucléaire s'est démarquée en offrant un test d'imagerie visant une caractéristique biologique des TNE, soit l'expression du récepteur à la somatostatine. Le concept de l'imagerie des récepteurs à la somatostatine est apparu en 1994, par l'introduction d'un agent de médecine nucléaire appelé Octréoscan (Mallinckrodt Pharmaceuticals). Cet agent a marqué le début d'une révolution de l'imagerie des récepteurs permettant d'identifier, par un test non invasif, l'étendue des tumeurs sur-exprimant le récepteur à la somatostatine, presque indétectables par les autres modalités d'imagerie.

« Le diagnostic des TNE se fait à l'aide de techniques endoscopiques, radiologiques et de médecine nucléaire. Un grand nombre de ces tumeurs sera visible par TDM et IRM avec une sensibilité variant entre 30-40 %. »

SCINTIGRAPHIE A L'OCTREOSCAN

L'Octréoscan (Indium-111 pentréotide) est disponible depuis plusieurs années dans tous les centres de médecine nucléaire du Québec et ailleurs dans le monde et offre une sensibilité variant de 52-92% et spécificité de 92 % pour la détection des TNE (Figure 1. A et B). Il s'agit d'une séquence de huit acides aminés similaire à l'octréotide à laquelle un groupement chélateur a été ajouté afin de pouvoir y insérer un isotope radioactif, l'indium-111. Cet isotope est essentiel pour suivre la distribution du radiopeptide qui, une fois injecté en intra-veineux, ciblera spécifiquement l'expression du récepteur à la somatostatine à la surface cellulaire. Des cinq sous-types de récepteurs à la somatostatine connus,

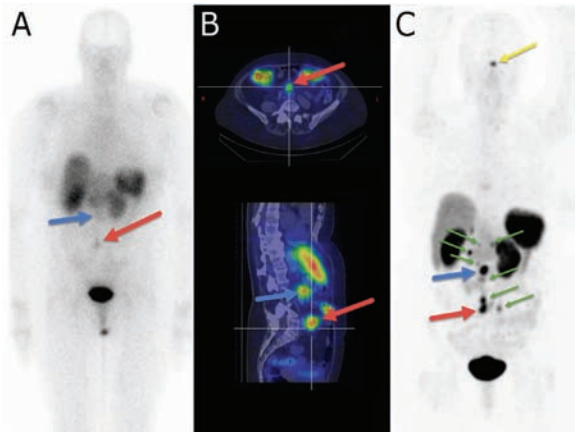


Figure 1. Images obtenues à l'Octréoscan (A et B) et à l'Octréotate chez le même patient à un mois d'intervalle. Scintigraphie à l'Octréoscan (A): La flèche rouge pointe une lésion sur-exprimant les récepteurs à la somatostatine et la flèche bleu une lésion équivoque abdominale. SPECT-TDM à l'Octréoscan (B): deux lésions sont clairement visibles (flèche rouge et bleue). TEP-Octréotate (C) : confirme que les deux lésions visibles à l'Octréoscan sur-expriment les récepteurs à la somatostatine en plus de sept autres lésions (flèches vertes). Captation hypophysaire physiologique (flèche jaune).

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+/-2% of the measurement dose, exclusive of dose calibration factor[3]

[1] Bayer V&V Testing Results
[2] Del Sole A, Lecchi M, Lucignani G. Radiat Prot Dosimetry. 2016: 168 (3):337-42. [Epub ahead of print]
[3] Source: IRRIS Database (5/21/2013). Data on file. IRRIS – Intego Radiation Reduction Initiative & Survey.

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Grande précision de la dose administrée par rapport à la dose prescrite
1re puce : +/-2 % de la dose mesurée,sans tenir compte du facteur d'étalonnage de dose[3]

[1] Résultats d'épreuves de vérification et validation réalisées par Bayer.
[2] Del Sole A, Lecchi M, Lucignani G. Radiat Prot Dosimetry. 2016: 168 (3):337-42. [publication en ligne avant l'impression]
[3] Source : Base de données IRRIS (21 mai 2013). Données internes. IRRIS – Intego Radiation Reduction Initiative & Survey.

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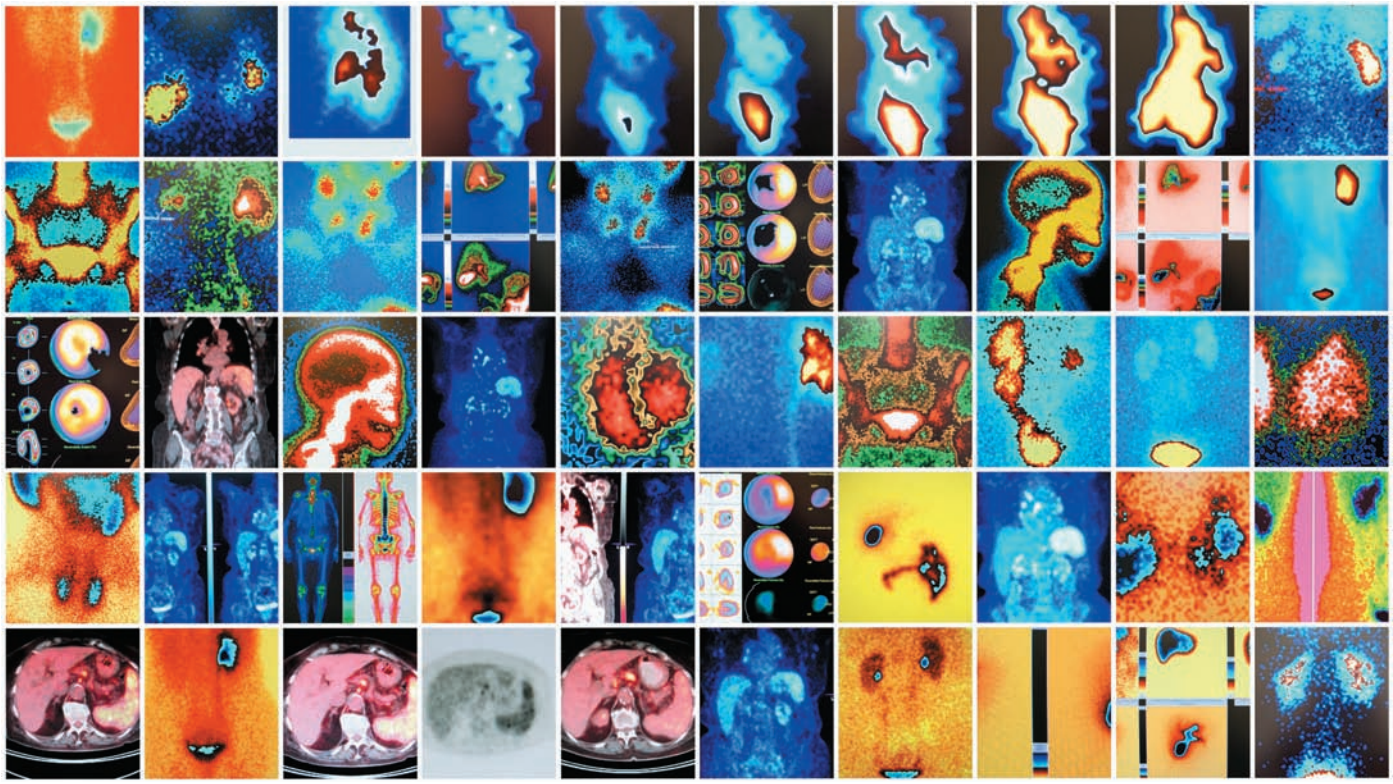

l'Octréoscan cible préférentiellement les récepteurs SSTR-2, 3 et 5. Au niveau des TNE gastroentéropancréatiques, le récepteur SSTR-2 est le plus fréquemment exprimé comparativement au SSTR-4 qui ne l'est que très rarement. L'ensemble des TNE exprime différemment les cinq sous-types de récepteurs et l'expression du récepteur n'est pas spécifique aux TNE car des lésions bénignes (ex : adénomes hypophysaires, méningiomes, hémangiomes) et néoplasiques (ex : sein, poumon, lymphome) peuvent également exprimer le récepteur. Également, lors de la progression d'une tumeur d'un état différencié vers l'indifférencié, l'expression du récepteur diminue jusqu'à sa disparition. Ces facteurs sont donc à tenir compte pour garantir l'efficacité de l'imagerie des récepteurs à la somatostatine.

TABLEAU 1 : Avantages et inconvénients de l'imagerie TEP à l'Octréotate comparativement à l'Octréoscan

Avantages:

- S'effectue en 25 minutes en une seule journée plutôt que de deux à trois jours
- Dosimétrie inférieure, avantageuse pour la population pédiatrique (2,1mSv/100MBq vs 8mSv/100MBq)
- Résolution de 5mm comparativement à 1-1,5cm, plus sensible
  - Localise d'avantages de lésions, insoupçonnées
  - Modification de la prise en charge chez >50 % des patients
- Coût avantageux, inférieur au coût de l'Octréoscan pour les installations pouvant imager à haut débit
- Disponible tous les jours. L'Octréoscan doit être commandé une semaine avant son utilisation.

Inconvénients :

- La demi-vie du radiotraceur, 68 minutes, rend l'exportation impossible
  - Les patients doivent se déplacer vers le centre d'imagerie
- Doit être synthétisé sur place, quelques minutes avant l'utilisation
  - Équipe expérimentée doit être disponible
  - Une synthèse possible par période de six heures
- Faux-positifs également plus visibles: Hémangiome hépatique et osseux

NOUVEAU STANDARD, LA TOMOGRAPHIE D'ÉMISSION PAR POSITRONS A L'OCTREOTATE

De nos jours, plusieurs départements de médecine nucléaire au Québec ont été rehaussés pour intégrer un tomographe d'émission par positrons (TEP) dans leur parc d'équipement. Ces appareils de très haute technologie, plus sensibles et rapides que les appareils conventionnels de médecine nucléaire, offrent de très grands avantages en ouvrant les portes de l'imagerie moléculaire personnalisée. Ces appareils sont toutefois incompatibles avec les isotopes couramment utilisés en médecine nucléaire conventionnelle. Par conséquent, une gamme différente de radiotraceurs est utilisée.

L'Octréotate (DOTATATE) est une version TEP améliorée de l'Octréoscan. Comme l'Octréoscan, l'Octréotate est une séquence de huit acides aminés associés avec un chélateur qui permettra d'insérer un isotope TEP, le Gallium-68, au peptide. Cependant, la séquence des acides aminés est différente de l'octréotide. Comparativement à l'Octréoscan, la TEP-Octréotate

(Figure 1. C) possède une sensibilité variant entre 81-94 % et spécificité entre 82 et 90 %. Cette augmentation en précision comparativement à l'Octréoscan s'explique par une affinité 12 fois plus élevée de l'Octréotate pour les récepteurs à la somatostatine SSTR-2 ainsi qu'un gain en sensibilité des appareils TEP pouvant imager des lésions aussi petites que 5 mm.

L'imagerie TEP à l'Octréotate possède des avantages considérables pour le patient puisque l'imagerie s'effectue en une seule journée et ne prend que 25 minutes. L'inconvénient principal de l'Octréotate est sa disponibilité en raison de sa demi-vie physique de 68 minutes comparativement à l'Octréoscan de 2,8 jours. Cette limitation est une conséquence reliée uniquement à l'utilisation du Gallium-68 comme isotope et qui ne peut être remplacé. Conséquemment, l'Octréotate doit être synthétisé sur place par une équipe expérimentée, ne peut être transporté que sur une courte distance et doit être utilisé dans les minutes qui suivent la synthèse. Le tableau 1 résume les avantages et inconvénients de la TEP-Octréotate versus l'imagerie conventionnelle à l'Octréoscan pour le patient et le clinicien. Le tableau 2 résume les indications de la TEP-Octréotate. ■

Tableau 2 : Indications pour lesquelles l'Octréotate remplace l'Octréoscan

- Localiser une TNE ou une tumeur exprimant le récepteur à la somatostatine et ses métastases :
  - Tumeurs gastro-entéro-pancréatiques : carcinoide, gastrinome, insulinome (50%), glucagonome, VIPome, bronchique, carcinome à petites cellules
  - Tumeurs du système sympathique (phéochromocytome, paragangliome, neuroblastome, ganglioneurome)
  - Médulloblastome
  - Ostéomalacie oncogénique
  - Tumeur de Merkel
  - Carcinome médullaire de la thyroïde
  - Autres tumeurs : sein, lymphome, hypernéphrome, hépatome, adénome hypophysaire, méningiome
- Mesurer la réponse aux traitements
- Déterminer le degré d'expression des récepteurs à la somatostatine afin de caractériser une lésion difficilement biopsiable
- Localiser les sites de récurrence chez les patients symptomatiques
- Sélectionner les patients chez qui la tumeur progresse et pourraient bénéficier d'une thérapie radiopeptidiques (Lutétium ou Yttrium)
- Caractérisation d'une lésion cérébrale suspecte de méningiome, non biopsiable, en prévision de radiothérapie

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HIDA Hepatic Uptake
Gallbladder Ejection Fraction
Remnant Liver Function
SeHCAT Analysis

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Relative Function
Urinary Tract Obstruction
Renal Transplant

Rutland Patlak Method
Duplex Kidney
DMSA
Renogram
Advanced Renal Analysis

Endocrinology

Hyperthyroidism
Hyperparathyroidism
Thyroid Nodules

Thyroid Uptake
Parathyroid Subtraction
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Pneumology

Pulmonary Embolism
COPD
Surgical Planning

Lung V/Q SPECT(/CT)
Lung Lobe Quantification
AI Lung Lobe Segmentation
Planar Reprojection

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Cedars-Sinai QGS/QPS
FUGA/MUGA
Cardiac MPI Splash
AI Myocardium Detection
AI Motion Correction
First Pass Shunt

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Alzheimer's Disease
Epilepsy Focus

FDG vs Normal
DaTSCAN vs Normal
Ictal/Interictal
Amyloid SUVR (Amyvid™, Vizamyl™, Neuraceq™)

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CLINICAL USEFULNESS OF VENTILATION/PERFUSION LUNG SCINTIGRAPHY (V/Q scan) IN DETECTION OF PULMONARY EMBOLISMS

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Pulmonary embolism (PE) is a blockage in one or more of the pulmonary arteries of the lungs. Most of the time, PE results from blood clots travelling to the lungs and originating from deep veins in the legs (deep vein thrombosis) or, sometimes, from veins in other parts of the body. The lungs act as "filters" to these blood clots which can block the blood flow to the lungs. Blockage of the lung arteries can occasionally be secondary to fat from the marrow after a bone fracture, air bubbles or tumor. Depending on the size of the clots, the area of the lung involved and any underlying lung or heart diseases, PE can be a life-threatening condition, necessitating a rapid diagnosis. Prompt anticoagulant therapy (use to dissolve the blood clots) greatly reduces the risk of death and future chronic lung complications (such as chronic pulmonary hypertension).

The symptoms of PE can be quite variable, making the diagnosis of PE based only on the signs and symptoms more difficult. Most common signs and symptoms of PE include a sudden shortness of breath which gets worse with exertion or inspiration, a chest pain (sometimes mimicking a heart attack), cough (sometimes with bloody sputum), irregular heartbeat, leg pain, leg swelling or fever, to name only the most frequent ones. Various risk factors are associated with PE such as recent surgery, estrogen supplement, pregnancy, prolonged immobility, cancer, family history, COVID-19, heart disease, smoking, and overweight are the most frequent ones.

As the clinical assessment alone is not reliable in the diagnosis of PE, objective demonstration of the presence of PE is essential. About one-third of patients with undiagnosed and untreated PE will not survive. On the other hand, incorrect diagnosis of PE unnecessarily exposes the patient to the risk of anticoagulant therapy such as potentially fatal hemorrhage. Therefore, various blood tests and imaging procedures have been developed to objectivate the presence of PE.

Discussion on all the different procedures used in the diagnosis of PE is beyond the scope of this article. Only those directly involved in the diagnosis of PE in clinical practice are presented. Various D-dimer blood tests have been developed. This is a substance derived from the coagulation process which shows increased levels in PE. This is a very sensitive test to detect PE but unfortunately increased in D-dimer blood levels is not specific to PE as it can be seen also in inflammation, cancer or aging. However, a negative D-dimer test almost completely rules-out PE.

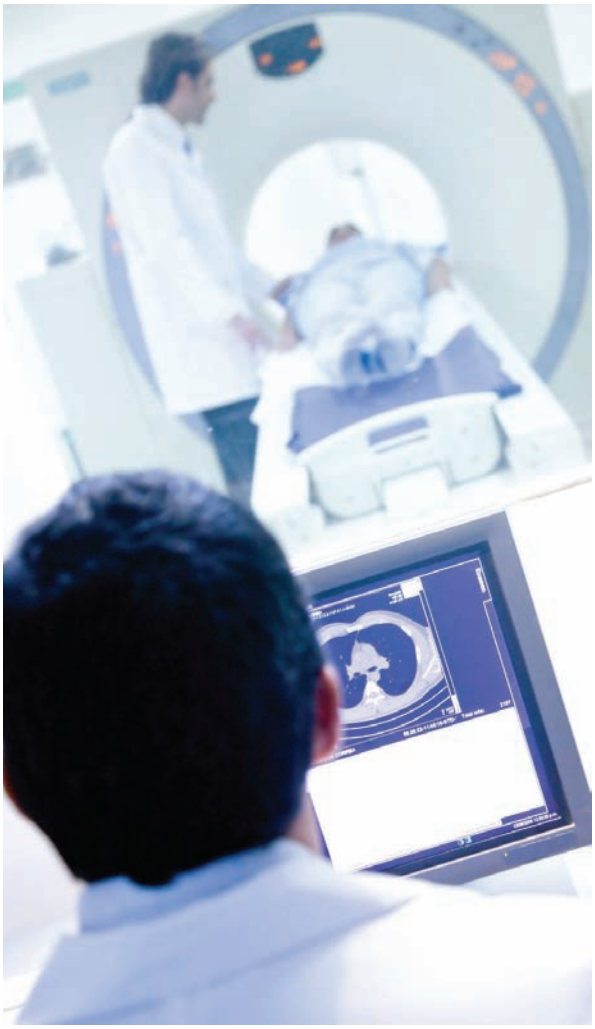
The gold-standard method for diagnosis of PE is the pulmonary angiography which consists of injecting a contrast dye directly into the pulmonary arteries. Unfortunately, this quite invasive procedure is associated with serious side effects with a mortality rate of about 0.5%, is costly, technically challenging and sometimes difficult to interpret. The actual radiologic procedure mostly used in the diagnosis of PE is the multirow-detector computed tomographic pulmonary angiography (MD-CTPA). This consists in the use of a CT scan (Computed Tomography) with an injection of a radiologic contrast medium. This procedure can allow to visualize the main arteries as well as the lobar and segmental lung arteries. However, the diagnostic accuracy to detect sub-segmental pulmonary lesions is rather low. The major advantage of CTPA is the ability to provide valuable information on diseases other than PE such as

pneumonia, pleural effusion, aortic aneurysm or dissection, or tumor. Unfortunately, a significant number of patients are not illegible for CTPA due to allergy, kidney failure, critical illness, ventilator support, or recent myocardial infarction. Furthermore, up to 15-20% of CTPA are limited due to technical artifacts such as dilution effect of the contrast medium or respiratory motion artifacts. Therefore, other imaging modalities are frequently needed.

One of the most commonly used procedure nowadays in clinical practice is the ventilation/perfusion lung scintigraphy also known as V/Q scan performed in nuclear medicine. This procedure has been the witness of dramatical technical improvements in the last decade which can explain its constantly increased clinical demand. Interpretation criteria for the presence of EP has also contributed to its clinical usefulness. Many scientific societies have established criteria and technical guidelines for the realization of V/Q scans under strict conditions to allow for optimal results. The three major improvements can be summarized as follows: 1- The routine use of SPECT (Single Photon Emission Computed Tomography), 2- The use of 99mTc-Technegas for the ventilation part of the study, 3- Modifications of interpretation criteria for an abnormal V/Q lung study.

1- Routine clinical use of SPECT:
The first technical improvement includes the routine use of SPECT (Single Photon Emission Computed Tomography) for both ventilation and perfusion studies. This technique allows for a better image resolution and images of multiple slices of the lung, therefore providing better details and significant improvement in overall accuracy in comparison to the "standard" planar imaging acquisition used in the majority of published studies. In more complex cases, it is also possible to add the CT portion to the SPECT acquisition which is called SPECT-CT. The combination of these two modalities allows for simultaneous evaluation of the function with V/Q scan and the anatomical increased resolution of the CT.

2- Use of 99mTc-Technegas for the ventilation study:
Ventilation study is preformed first (duration of approximately 15-20 minutes) using the best widely available agent in Canada, 99mTc-Technegas (Cyclomedia), which consists of an aerosol of carbon nanoparticles. This radiotracer is distributed in the lungs almost like a gas (because of its very small particle size varying from 5 to 200 nm) and deposited in alveoli by diffusion where it remains stable for the duration of the lung scan using SPECT imaging. The patient rapidly inhales the 99mTc-Technegas for 2-5 deep inspirations. The administered dose varies from



0.8 to 1.4 mCi. Once the ventilation part of the study is completed, the perfusion part immediately follows. 99mTc-macroaggregated albumin (MAA) are used to perform the lung perfusion study. Approximately 400,000 albumin particles with an average size of 10-90 um are slowly injected into a vein, usually of the arm. This particle size allows them to lodge into the pulmonary small capillaries and provides a good definition of the entire lung perfusion. The standard dose is approximately 3.0-6.0 mCi of 99mTc-MAA (the activity ratio between perfusion and ventilation should be at least 4:1, preferably more). A second SPECT acquisition immediately starts and will last approximately 15-20 minutes although this time may vary according to the type of gamma camera used and the clinical situation. For example, in pregnant or lactating patient, the dosage will be significantly decreased in order to limit the radiation dose to the patient and the acquisition time will be increased in order to obtain still high quality images. 99mTc-Technegas provides a more uniform and a better overall ventilation scan in comparison to the previously used 99mTc-DTPA aerosols. Almost all the ventilation studies performed actually in Canada used 99mTc-Technegas.

3- Modifications of the diagnostic criteria for the V/Q study:

In the majority, if not all previous large studies comparing clinical assessment, radiologic procedures and nuclear medicine V/Q scans in the diagnosis of PE, interpretation criteria were based in probabilistic terms (normal, low, intermediate, and high probability) which are now unacceptable in clinical practice. Technological improvements in ventilation studies and the use of SPECT acquisition can now allow the interpreter to be more decisive, that is presence of PE or absence of PE, without gradation of probability which was very confusing to the referring physician. Equivocal or non diagnostic studies may still be possible but should not be more than 5% of all the cases.

Interpretation criteria:
Different criteria have been proposed since the early ages of V/Q scan, the detailed discussion of which is beyond the scope of this article, but most diagnostic algorithms are derived from the same premisses. The basic principle of the lung scintigraphy is to compare the ventilation and the perfusion status of each pulmonary lobes, segments and subsegments, side by side. In a normal study, both perfusion and ventilation are homogeneous and similar (Figure 1). However, when PE occurs, only the lung perfusion is impaired by the blood clots blocking local blood circulation and preventing the radiotracer (99mTc-MAA) to travel beyond the clot, creating a "perfusion defect" on the perfusion images, while the ventilation remains normal since it is not affected by the venous clot (Figure 2). This is called vascular mismatched defects with usually clear borders, wider at the periphery of the lung and narrower more centrally, respecting the pulmonary vascular anatomy.

V/Q scans are frequently prescribed to rule-out PE in patients with chronic obstructive pulmonary disease (COPD) in whom the incidence of PE is increased and clinical presentation is very often confounding. Typically, V/Q lung scans in these COPD patients show impaired ventilation proportional to the severity of COPD (often underestimated clinically) which can be similar to perfusion defects or more prominent. Usually, both ventilation and perfusion defects are matched, meaning that they both have similar extension, pattern and localization (Figure 3).

The combination of 99mTc-Technegas for the ventilation part of the study, combined with SPECT acquisition of both ventilation and perfusion and new interpretation criteria have led to significant improvement in the overall diagnostic accuracy of

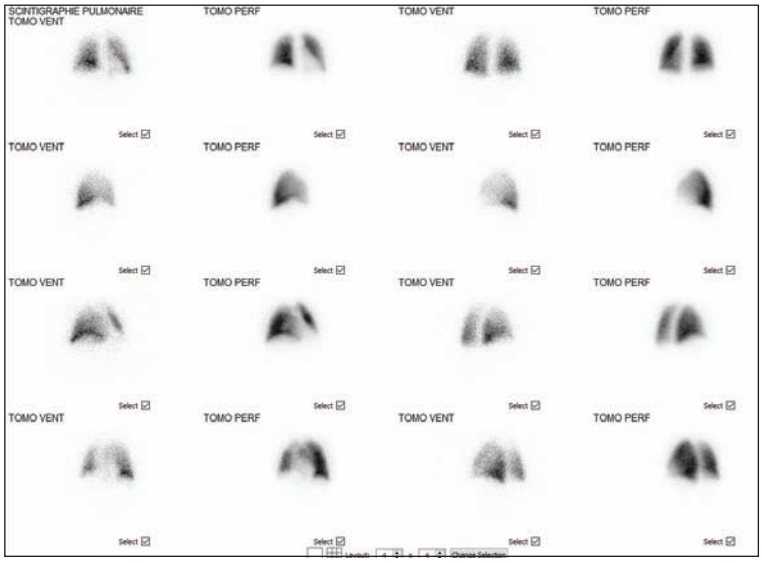


Figure 1.
Normal V/Q lung scan. The first and third column represent the ventilation study with 99mTc-Technegas while the second and fourth column represent the corresponding perfusion study performed with 99mTc-MAA in various imaging incidences. The distribution of both radiotracers is similar and relatively homogeneous.

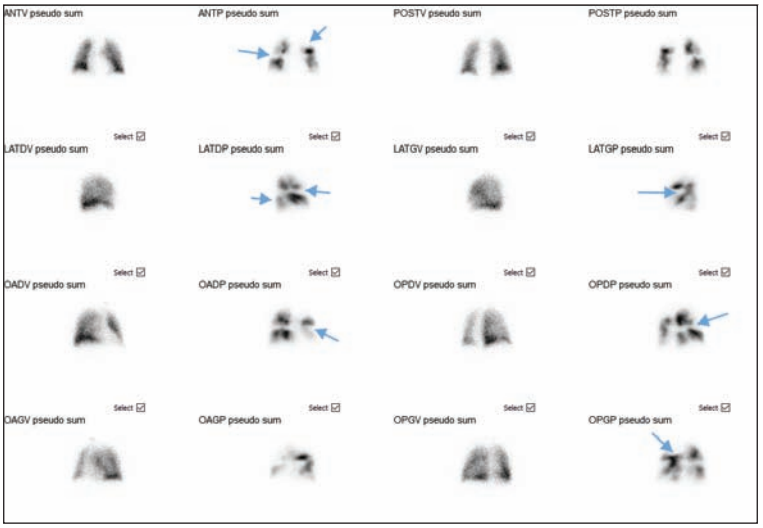


Figure 2.
Patient with multiple perfusion defects (blue arrows) on perfusion images with corresponding normal ventilation, typical of segmental and sub-segmental acute PE (mismatches).

V/Q scan for acute PE detection. The sensitivity of V/Q scan in the detection of PE varies from 90-95% with a similar specificity. The very high negative predictive value of V/Q scan varies between 97-99%, indicating that if a V/Q study is normal, combined with a normal D-dimer test virtually exclude the presence of PE. V/Q scan is highly sensitive for detection of chronic PE (90-95%) in comparison to CTPA (50-60%).

Radiation Exposure.
One of the most frequent and comprehensible concern when comes the time to inject a radiotracer to a patient, especially in young patients, or in breast-feeding or lactating patients, is the risk of radiation exposure to the patient. In medicine (either radiology or nuclear medicine) the millisievert (mSv) is used as a radioprotection unit which measures the radiation dose received by a specific medical procedure. While discussing the risk of radiation exposure, it is very important to consider the relative overall picture. For example, natural radioactivity occurring from cosmic rays or radon in the ground, generates between 2 to 10 mSv a year, depending on the location on the planet. Internal radioactivity from a human body generates approximately 0.25 mSv. Besides natural radioactivity and radioactivity from general medical imaging procedures, regulations in almost countries in the world limit exposures related to other causes to less than 1.0 mSv per year for the general public. A trans-atlantic flight from Montreal to Paris results in a dose of 0.03mSv.

The radiation exposure from a V/Q SPECT study is approximately 2.1 mSv while for CTPA it varies from 5 to 15 mSv, depending of many technical factors. The fetal exposure in a pregnant patient is relatively the same for both procedures while the breast exposure for the CTPA is increased by a factor of 5-20 in comparison to the V/Q scan.

CONCLUSION
V/Q lung scan with its high sensitivity and specificity, low radiation exposure and no adverse reactions can be considered as a first line investigation procedure in suspected acute or chronic PE, in pediatric population, in pregnant or breast-feeding female patients or in patients with COPD. ■

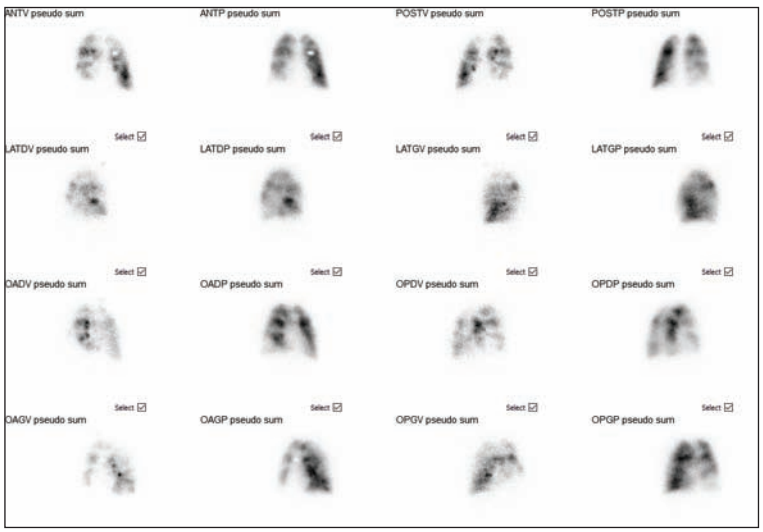
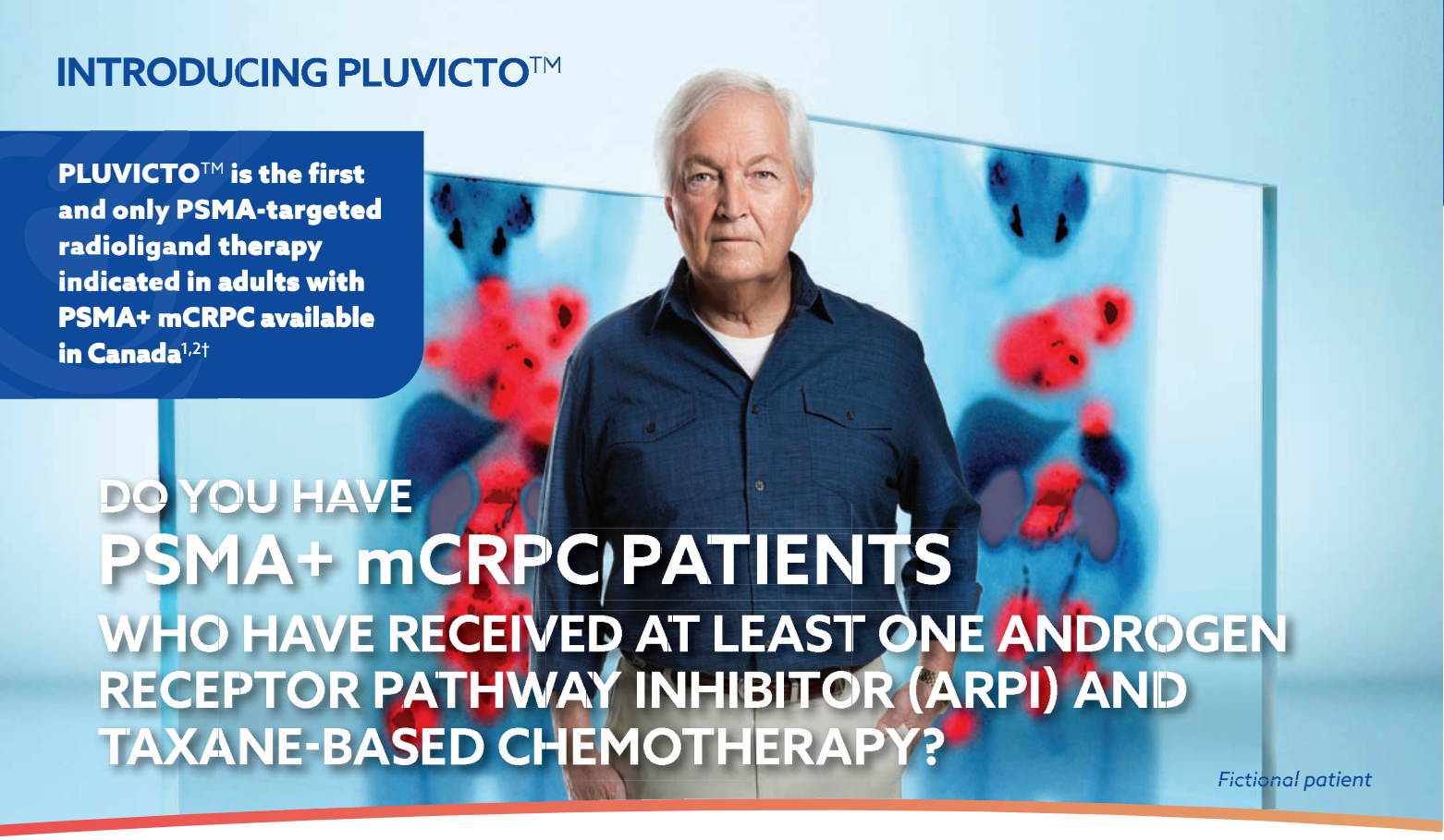


Figure 3.
Patient with moderate to severe COPD. Both ventilation and perfusion studies show similar and corresponding matched defects.

INTRODUCING PLUVICTO™

PLUVICTO™ is the first and only PSMA-targeted radioligand therapy indicated in adults with PSMA+ mCRPC available in Canada[1,2†]



DO YOU HAVE PSMA+ mCRPC PATIENTS WHO HAVE RECEIVED AT LEAST ONE ANDROGEN RECEPTOR PATHWAY INHIBITOR (ARPI) AND TAXANE-BASED CHEMOTHERAPY?

Fictional patient

PLUVICTO™ (lutetium [^{177}Lu] vipivotide tetraxetan injection) is indicated for the treatment of adult patients with PSMA-positive mCRPC who have received at least one androgen receptor pathway inhibitor (ARPI) and taxane-based chemotherapy.

The VISION trial demonstrated a statistically significant improvement in both major efficacy outcome measures of OS and rPFS by BICR with PLUVICTO™ plus BSoC compared to treatment with BSoC alone, respectively.[1‡]

- OS: estimated 38% reduction in the risk of death based on the HR (HR=0.62; 95% CI: 0.52, 0.74; *P*<0.001); median OS 15.3 months vs. 11.3 months[1]
- rPFS: HR for progression or death, 0.40; 99.2% CI, 0.29 to 0.57; *P*<0.001 (significance level, 0.008); median rPFS 8.7 months vs. 3.4 months[3]

Interpretation of the magnitude of the rPFS effect was limited due to a high degree of censoring from early drop out in the control arm.[1]

Refer to the page in the bottom-right icon for additional safety information and for a web link to the product monograph discussing

- Most serious warnings and precautions regarding healthcare professional qualifications pertaining to use of radiopharmaceuticals; severe and life-threatening myelosuppression and renal toxicity including severe renal injury
- Other relevant warnings and precautions regarding location of use; compliance with regulations and good safety practices related to radiopharmaceuticals; contamination including special precautions such as bladder catheterization in incontinent patients; radiation exposure including long-term cumulative radiation exposure and increased risk for cancer; patient counselling on consumption of oral fluids and voiding to reduce bladder radiation; patient education regarding minimizing radiation exposure; hematology laboratory tests to assess myelosuppression; dose adjustments and discontinuation related to severity of myelosuppression; renal toxicity; kidney function laboratory tests; dose adjustments and discontinuation based on the severity of renal toxicity; male reproductive health; risk of temporary or permanent infertility; use effective contraception; no indication in pregnant women and risk of fetal harm in pregnant women
- Conditions of clinical use, adverse reactions, drug interactions, and dosing instructions.

In addition, the page contains the reference list and study parameters relating to this advertisement.

PSMA=prostate-specific membrane antigen; mCRPC=metastatic castration-resistant prostate cancer; BSoC=best standard of care; BICR= blinded independent central review; HR=hazard ratio; OS=overall survival; rPFS=radiographic progression-free survival

† Comparative clinical significance has not been established.

PLUVICTO™
lutetium (^{177}Lu) vipivotide tetraxetan injection

Indication and clinical use:

PLUVICTO™ (lutetium [^{177}Lu] vipivotide tetraxetan injection) is indicated for the treatment of adult patients with PSMA-positive mCRPC who have received at least one androgen receptor pathway inhibitor (ARPI) and taxane-based chemotherapy.

Pediatrics (<18 years of age): No data are available to Health Canada; therefore, Health Canada has not authorized an indication for pediatric use.

Geriatrics (≥65 years of age): No clinically relevant differences in efficacy were observed between patients ≥65 years and those younger than 65 years.

Most serious warnings and precautions:

Healthcare professional qualifications: Radiopharmaceuticals should be used only by those health professionals who are appropriately qualified in the use of radioactive prescribed substances in or on humans.

Myelosuppression can occur in patients treated with PLUVICTO™. PLUVICTO can cause severe and life threatening myelosupression including anemia, thrombocytopenia, leukopenia and neutropenia.

Renal toxicity can occur in patients treated with PLUVICTO™. Cases of severe renal injury have been reported.

Other relevant warnings and precautions:

- Location of use; compliance with regulations and good safety practices related to radiopharmaceuticals
- Contamination: the following measures should be taken for 2 days after receiving the radiopharmaceutical product:
  - Toilet should be used instead of urinal
  - Toilet should be flushed several times after use
  - Contamination: special precautions such as bladder catheterization should be taken following administration to incontinent patients to minimize the risk of radioactive contamination
- Radiation exposure including long-term cumulative radiation exposure is associated with an increased risk for cancer
- Radiation exposure to patients, medical personnel, and household contacts should be minimized during and after treatment
- Encourage patients to increase consumption of oral fluids and voiding to reduce bladder radiation
- Patient education regarding minimizing radiation exposure to patient and others including instruction about close contact, sexual activity and sleeping location
- Hematology laboratory tests before and during treatment to assess myelosuppression; PLUVICTO™ should be withheld, dose reduced, or permanently discontinued and patients should be clinically managed as deemed appropriate based on the severity of myelosuppression
- Renal toxicity; maintain hydration; frequent urination before and after administration; perform kidney function laboratory tests before and during treatment; withhold, reduce dose or permanently discontinue based on the severity of renal toxicity
- Male reproductive health; risk of temporary or permanent infertility; use effective contraception during treatment with PLUVICTO™ and for 14 weeks after the last dose
  PLUVICTO™ is not indicated in females; risk of fetal harm if used in pregnant women

For more information:

Consult the Product Monograph at **https://www.adacap.com/wp-content/uploads/pluvicto-pm-20220825-en.pdf** for adverse reactions, drug interactions and dosing information which have not been discussed in this piece. The Product Monograph is also available by calling 1-800-363-8883.

‡ VISION was an international, prospective, open-label, multicenter, randomized phase 3 clinical trial evaluating PLUVICTO™ in 831 adult patients with PSMA-positive mCRPC previously treated with at least 1 ARPI and 1 or 2 taxane regimens. Participants were randomized in a 2:1 ratio to receive PLUVICTO™ (7.4 GBq every 6 weeks for up to 6 cycles) + BSoC or BSoC alone.

References: 1. PLUVICTO™ Product Monograph. Advanced Accelerator Applications USA, Inc. August 25, 2022. **2.** Data on file. **3.** Sartor O et al. Lutetium-177–PSMA-617 for Metastatic Castration-Resistant Prostate Cancer. *NEJM* 2021;385:1091-103.

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MEMBER OF INNOVATIVE MEDICINES CANADA

PLUVICTO™
lutetium (^{177}Lu) vipivotide tetraxetan injection

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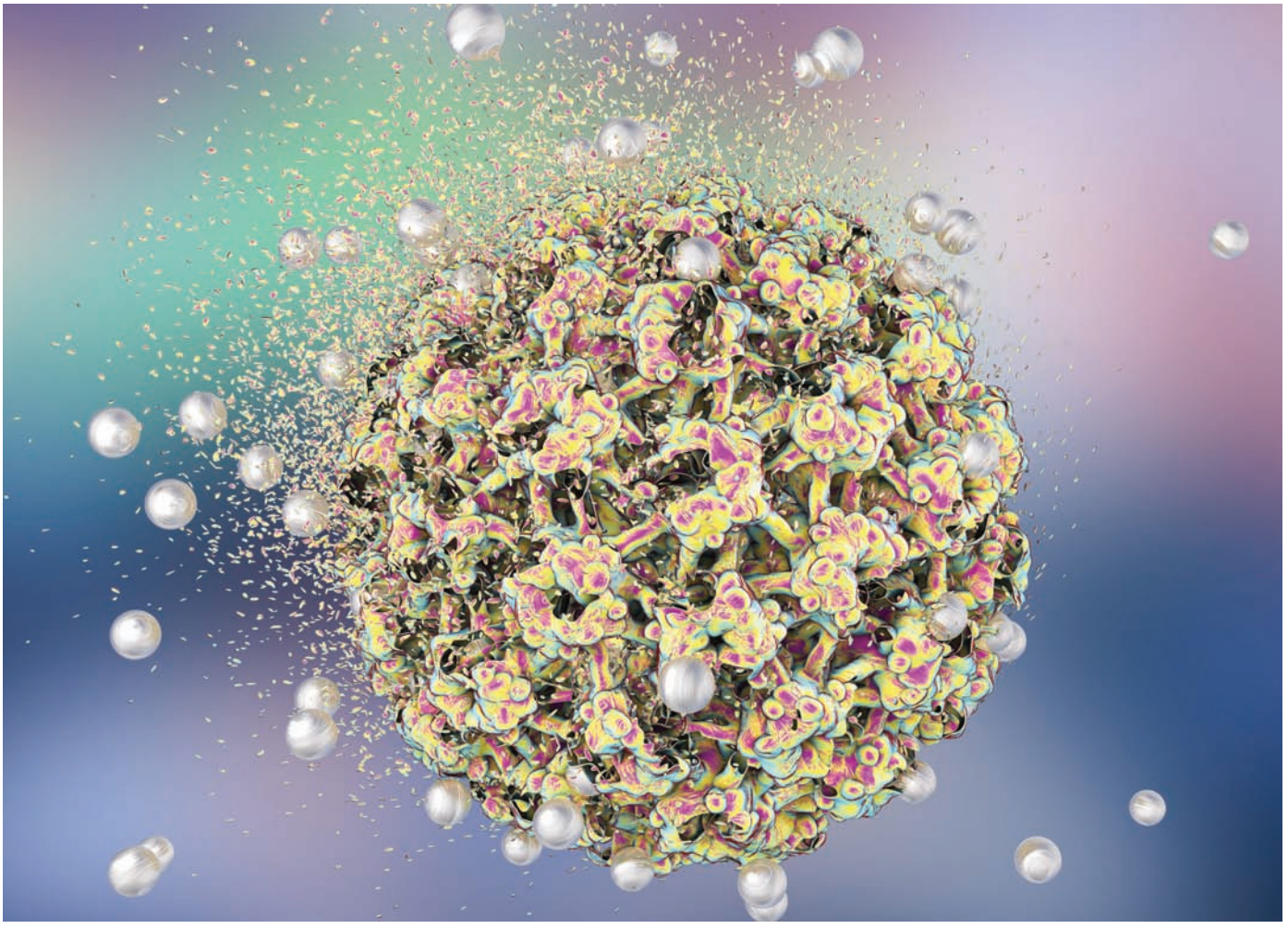
CARDIAC AMYLOIDOSIS

Amyloidosis is a group of diseases characterized by deposition of protein-based infiltrates with beta-pleated sheets in various body tissues, eventually leading to organ dysfunction. Cardiac amyloidosis involves the abnormal deposition of these protein-based infiltrates in the heart tissue which can lead to chamber wall hypertrophy, valvular disease, arrhythmias and heart block, as well as heart failure. Cardiac amyloidosis is frequently misdiagnosed as its clinical presentation is similar to other cardiac diseases however through increased awareness of this entity and improved imaging techniques this will likely change.

There are many forms of amyloidosis which is determined by the type of protein deposited. The most common subtypes involving cardiac tissue include immunoglobulin light chain (AL) and transthyretin (ATTR).

AL cardiac amyloidosis results from derangements of the immune system leading to mutations that alter the light chain structure. The amyloid deposits in this process can involve any organ but typically involve kidneys, liver, gastrointestinal tract, tongue and nerves. The annual incidence of AL is approximately 6-10 cases per million in North America and occurs in 12-15% patients with myeloma. Treatment for AL includes chemotherapy and autologous hematopoietic cell transplantation.

ATTR cardiac amyloidosis involves transthyretin (prealbumin), a protein produced by the liver that functions as a transporter for thyroxine and retinol. The misfolded form of transthyretin results in amyloid deposits. There are two main subtypes of ATTR: a wild-type ATTR and mutant hereditary ATTR. The wild-type ATTR, previously known as senile amyloidosis, tends to occur with advancing age where the misfolded transthyretin deposits gradually over time including carpal tunnel, vasculature, and the heart. The wild type ATTR is grossly underestimated and one study showed it affected one quarter of elderly patients at autopsy. The mutant ATTR involves a hereditary mutation that



results in a misfolded complex with accelerated amyloid deposition, most commonly heart and nerves. This form is rare with approximately 3000 reported cases ATTR hereditary form in North America annually. Novel treatments for ATTR cardiac amyloidosis include TTR stabilizers, such as diflunisal, tafamidas and G10; amyloid degrading agents such as doxycycline, tauroursodeoxycholic acid, and monoclonal anti-serum amyloid P antibodies.

Mortality remains high for those with advanced cardiac involvement and therefore early disease detection and classification are crucial. Cardiac amyloidosis may be identified by inappropriately low voltages on electrocardiogram (ECG). Laboratory tests include free light-chain assays.

Definitive diagnosis ultimately involves biopsy with subtyping by immunofluorescence or mass spectrometry. Ideally this is performed by biopsy of the clinically involved organ such as an endomyocardial biopsy. Due to the risks associated with biopsy, this is sometimes achieved by biopsy at other locations such as abdominal fat pad.

Advancements in diagnostic imaging including nuclear medicine has resulted in improved identification of this disease and has even helped with subtyping, thus potentially reducing the need for endomyocardial biopsy. Echocardiography and MRI been useful in identifying morphological changes in the heart and evaluating function.

Echocardiography features include increased ventricle wall thickening, atrial septal thickening, non-specific granular sparkling appearance of the myocardium as well as restrictive filling patterns. Typically, the LV ejection fracture in preserved or mildly reduced until end stage disease and there is a decrease in the LV end-diastolic volume. Increased atrial volumes with reduced function and reduced atrial strain are also noted. The left ventricle longitudinal strain can be impaired, worse at the base and mid ventricle with sparing of the apex.

Cardiac MRI can show left ventricular wall thickening, decrease in T1 and T2 signal intensity myocardium, diastolic dysfunction with restriction of diastolic filling, subendocardial shortened T1 relaxation time and diffuse heterogeneous increased signal on delayed gadolinium enhancement inversion recovery T1-weighted images. Differentiation between ATTR and AL is difficult on MRI however some note transmural late gadolinium enhancement appearance seen more in ATTR than AL.

Advancements in Nuclear Medicine has created an emerging role in the workup of cardiac amyloidosis: differentiating ATTR from AL cardiac amyloidosis. For decades, bone-seeking radiotracers 99mTc-Methylene Diphosphonate and 99mTc- Pyrophosphate (99mTc-PYP) have been known to have an affinity for amyloid protein with myocardial uptake seen on whole body planar imaging. This myocardial uptake can be seen in other causes such as myocardial infarction or pericarditis, but researchers were interested in its role in cardiac amyloidosis. These studies have shown that 99mTc-PYP tends to accumulate in myocardium in patients with ATTR but does not significantly accumulate in the myocardium of those with AL. The mechanism as to why these bone seeking radiotracers accumulate in the myocardium in patients with ATTR cardiac amyloidosis and not AL cardiac amyloidosis is still unknown but may relate to high calcium levels in the amyloid deposits in ATTR.

A semi-quantitative and a quantitative analysis of 99mTc-Pyrophosphate (99mTc-PYP) have been proposed by several authors. The semi-quantitative visual scoring of cardiac retention compared to bone using Grade 0 to Grade 3 has been put forth. The quantitative analysis of heart retention involves calculating a Heart to Contralateral Ratio calculated by drawing a region of interest over the heart and a second region of similar size mirrored over the contralateral chest. A ratio greater than 1.4 would be consistent with ATTR.

SPECT imaging can also be performed with some studies noting the pattern of myocardial uptake in ATTR tends to spare the

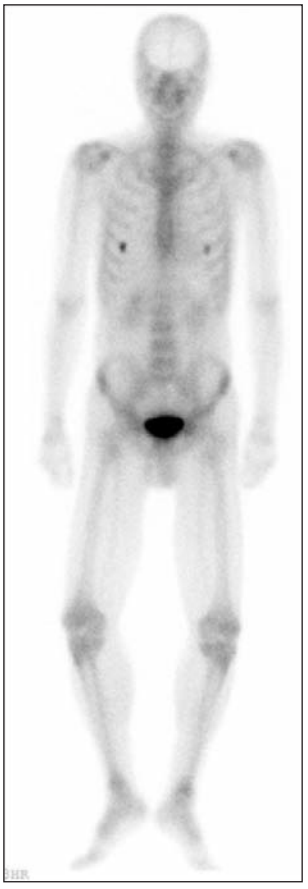


Figure 1: Patient with cardiac amyloidosis. 99mTc-Pyrophosphate scan with no significant radiotracer uptake consistent with AL subtype.

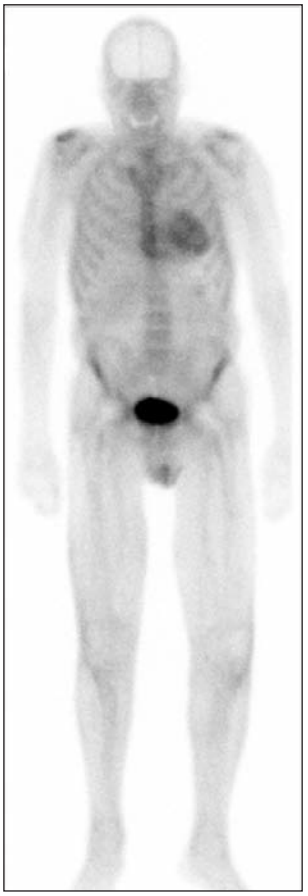


Figure 2: Patient with cardiac amyloidosis. 99mtc-Pyrophosphate scan with increased radiotracer uptake consistent with ATTR subtype.

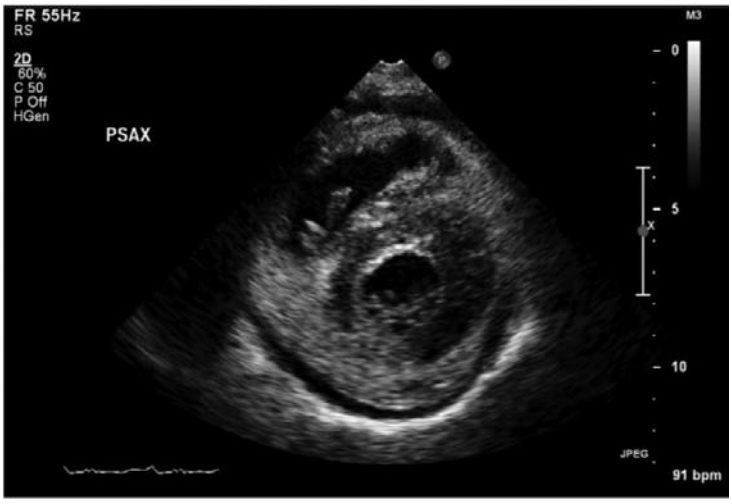


Figure 3: Echocardiogram showing concentric left ventricular wall thickening and small pericardial effusion in a patient with cardiac amyloidosis.

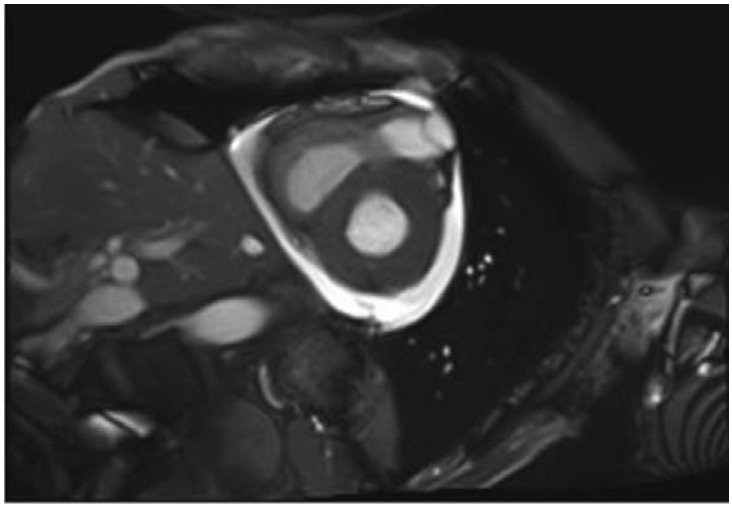


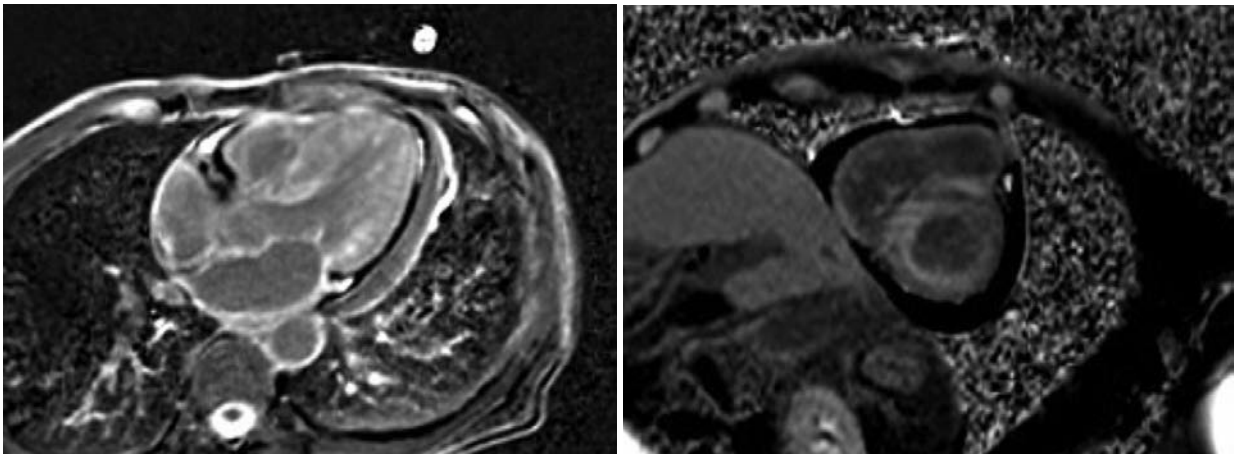
Figure 4: Cardiac MRI showing moderate sized pericardial effusion and concentric left ventricle wall hypertrophy in a patient with cardiac amyloidosis.

apex until advanced disease. This is similar to pattern of impaired longitudinal strain seen on echocardiography. There has been greater interest in evaluating the pattern of uptake in hopes of aiding prognostication and further studies would be needed to clarify its role in this regard. Additionally, further studies evaluating changes in degree of radiotracer uptake following treatment is needed.

A similar tracer 99mTc-3,3-diphosphono-1,2-propanodicarboxylic acid (99mTc-DPD) is currently available for clinical use in Europe. Studies have shown this tracer also shows uptake in the heart in patients with ATTR-CA with minimal uptake in AL-CA. 123I-mIBG while not specific for cardiac amyloidosis has also been useful in identifying sympathetic denervation in the heart, a finding identified in the early stage of cardiac amyloidosis, particularly ATTR type.

Cardiac amyloidosis can cause significant morbidity to patients and yet remains a relatively underdiagnosed cause of cardiac dysfunction. However increased awareness of this disease with improved diagnostic tools is slowly changing the landscape of this disease. The importance of differentiating ATTR and AL cardiac amyloidosis is crucial in guiding patient management, information 99mTc-pyrophosphate scans can provide. Additional studies are still needed to evaluate whether 99mTc-pyrophosphate scans can be used for prognostication and treatment response evaluation. Although 99mTc-pyrophosphate may be an old, forgotten radiotracer, it still remains very much relevant today.

Figure 5: Cardiac MRI showing heterogeneous late gadolinium enhancement subendocardial regions within the basal left ventricle wall, parts of the right ventricle and left atrial walls with hypertrophy of the left ventricle wall in a patient with cardiac amyloidosis.



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Apporter un nouvel espoir aux patients atteints de cancer

Des soins personnalisés avec la théranostique

GROWTH IN NUCLEAR MEDICINE

Kristy Owen, RTNM
Co-Program Head and Faculty, Nuclear Medicine Technology, BCIT
BC Director, CAMRT

The rapid expansion of theranostics is resulting in an unprecedented and exciting evolution in the field of Nuclear Medicine. With plans for many new sites to be built, ongoing research and development of novel therapeutic agents as well as safer, more efficient equipment available, it is clear there is a Canada-wide need for skilled Nuclear Medicine Technologists, both immediately and in the future. While the post-pandemic health human resource (HHR) shortage is not limited to Nuclear Medicine Technologists, we have a unique challenge in that planning for these shortages must also consider the significant rate of growth in our sector. Forecasting HHR needs typically involves comparing the current resources that are available to serve the province or country with the required number of resources necessary to meet the demand of the population, while also estimating growth or change expected for the future. Due to the ongoing exponential progression in this specialty, Nuclear Medicine's advancement will be significantly accelerated compared to many other imaging modalities. HHR planning must consider this as soon as possible to ensure the imaging departments, equipped with multiple million-dollar pieces of equipment are not sitting empty due to lack of competent technologists. This dire situation already exists in many places across Canada.

" With plans for many new sites to be built, ongoing research and development of novel therapeutic agents as well as safer, more efficient equipment available, it is clear there is a Canada-wide need for skilled Nuclear Medicine Technologists, both immediately and in the future. "

THE CAUSALITY DILEMMA

As an educator, I can speak first hand to the fact that there is no easy solution to this HHR problem. First, we must understand the scope of the situation. Within Nuclear Medicine departments in hospitals or private clinics, it is evident that our small and connected community is officially feeling the weight of post-pandemic wait lists and resource limitations. Technologists who once had the determination and ambition to take extra shifts, work overtime and add on extra patients are now feeling discouraged with unchanging extended waitlists and increased workload. The extra efforts taken by them to compensate for the current shortage is not making a noticeable difference, and technologists are turning inward to preserve their own health and well-being. The growth, expansion and increased scope of the field has also added to this pressure.

"But wait!" you say, the flip side is the increased number of jobs available, signing bonuses, relocation expenses, exciting new treatments and ways to positively impact patient outcome. Many of these perks have never even been seen before in this industry. Yes, this is true and it is evident that there is a bright and busy future ahead in Nuclear Medicine. We must future-proof our workforce in order to protect these promising opportunities, and this begins with facing and managing the HHR crisis. How do we get our future technologists interested in this profession? Nuclear Medicine has never been a well-known imaging modality, and when you ask graduates how they first heard about it, it is typically by random chance. Many associations in Canada such as the Canadian Association of Medical Radiation Technologist (CAMRT) and the Canadian Association of Nuclear Medicine (CANM) have been working extremely hard to bring awareness to medical radiation technologists (MRT's) and the Nuclear Medicine industry, which undoubtedly helps. However, applicant numbers continue to be low across the board for many MRT training programs throughout Canada. Students who do enroll in these programs then face another battle. Typically, a student is assigned to a variety of clinical placement sites to gain hands-on experience and skills required to become an entry-level technologist. However, we are seeing clinical sites who desperately need trained technologists, reject or restrict student placements due to staffing shortages and safety concerns over lack of supervision. These same clinical sites are having their own vacation cancelled in order to avoid operating understaffed. In this causality dilemma, the question then becomes, do we prioritize training new technologists or support the infrastructure that exists currently in order to make space for future training opportunities? Realistically, the solution must come from all angles to create the greatest impact. Active recruitment, bursaries, awareness campaigns and incentives will be required from health authorities, ministries, unions, educational facilities, associations and government. Meaningful support to existing technologists via funding from provincial and federal

government bodies and/or negotiations for improved wages with unions over the next few years will also be necessary. This current snapshot of our healthcare system, is only that, a blip in time that we will look back on and be proud to have overcome.

A special consideration must also be given to our existing and future students. The profile of this student has changed and to attract today's learners, educational facilities need to adjust. For example, students of today might prioritize the following when in school: the need for an active learning approach with many opportunities to practice hands-on skills, flexible learning (with regards to pace and timing of delivery, virtual vs. in-person, the learning environment itself), passionate educators who do not "impart" knowledge but facilitate knowledge transfer in an interactive way, learning through media such as video, audio, virtual reality or other interactive technology, and a priority for their own mental health and wellness is key. This isn't an inclusive list, but it does demonstrate a variance when compared to 10 or 15 years ago. As a result, our Nuclear Medicine Program at British Columbia Institute of Technology (BCIT) is undergoing a major curriculum change and restructuring, to address both the needs of the industry as well as how the current student prefers to learn. More applied hands-on skill building opportunities, balanced and decreased workload, a focus on essential skills, learning and assessment flexibility and simulation education will be used to ensure our students are ready to hit the ground running into this exciting career.

BRIGHT FUTURE

Undoubtedly, Nuclear Medicine is paving its way to an impressive future. There has never been more expansion in this field of "personalized medicine" with added equipment efficiencies, ongoing research, and the development of novel diagnostic and theranostic radiotracers which will grossly impact the lives of millions of patients globally. Positron emission tomography/computed tomography (PET/CT) and single photon emission computed tomography/computed tomography (SPECT/CT) systems are rapidly enhancing the field with regards to faster images, lower dose algorithms, efficiencies in collimation and whole-body three-dimensional imaging. Analysis and interpretation of images is sure to be further advanced with implementation of AI. Technologists within these imaging and treatment facilities are more skilled than ever with increased training and access to advanced radiation protection equipment. Safe use and accurate delivery of both diagnostic and therapeutic radiopharmaceuticals is supported with more efficient shielding systems for dose shipping and delivery, shielded injectors and hot cells, and sensitive yet robust measurement tools. Collectively, these recent enhancements in equipment improves patient throughput, accuracy and precision of disease management, as well as optimizes the technologist's workflow. Efficiency of the equipment only supports the exciting new developments in disease detection and management. Recently, Health Canada approved Lutetium-177 (Lu-177) prostate-specific membrane antigen (PSMA) therapy for the treatment of PSMA-positive metastatic castration-resistant prostate cancer. Being the most common cancer in men across Canada, this approval will undoubtedly improve patient outcome and disease management. Multiple theranostic agents are currently being developed in the field of oncology for a variety of cancers such as hematologic malignancies like lymphoma, myelomas and leukemia's, breast cancers, neuroendocrine tumors, soft tissue sarcomas and pancreatic cancers. AI algorithms will have the potential to aid in evaluation and extent of disease. However, developments are not limited to oncology. Effective diagnosis and possible treatments of neurodegenerative disorders like Alzheimer's and Parkinson's, as well as neuroinflammatory imaging for psychiatric conditions are among a few being researched at present. In cardiology there are advancements in detection and differentiation of cardiac amyloidosis, in addition to assessment of myocardial function, perfusion and viability.

Finally, it is without a doubt that this impactful and exciting industry is evolving at an accelerated pace both with advancements of novel therapeutic radiopharmaceuticals and equipment to support and optimize their use. With creative planning and careful thought given to managing our current HHR needs both within the existing workforce and recruitment into educational training programs that consider today's learner, we will successfully advance disease management, treatment and most importantly, patient outcome in Canada. ■

"Many associations in Canada such as the Canadian Association of Medical Radiation Technologist (CAMRT) and the Canadian Association of Nuclear Medicine (CANM) have been working extremely hard to bring awareness to medical radiation technologists (MRT's) and the Nuclear Medicine industry, which undoubtedly helps."

"Undoubtedly, Nuclear Medicine is paving its way to an impressive future. There has never been more expansion in this field of "personalized medicine" with added equipment efficiencies, ongoing research, and the development of novel diagnostic and theranostic radiotracers which will grossly impact the lives of millions of patients globally."

CARDIAC FDG PET: REVOLUTIONIZING CARDIOVASCULAR DIAGNOSIS AND TREATMENT IN CANADA

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Cardiovascular disease (CVD) has long been a leading cause of morbidity and mortality worldwide and is likely to remain so for years to come. According to the Canadian Heart and Stroke Foundation, more than 1.6 million Canadians are afflicted by CVD leading to an estimated 70,000 deaths each year. In Canada alone, CVD is estimated to cost $22.2 billion dollars each year in health care costs and decreased productivity. Early diagnosis and intervention can play an important role in improving outcomes while also decreasing the morbidity and financial burdens of CVD. Medical imaging has been playing an increasingly important role in the diagnosis and management of heart disease. In particular, the last few years have seen cardiac fluorodeoxyglucose positron emission tomography (FDG PET) emerge as a valuable tool for the evaluation of patients with suspected or known CVD in Canada.

WHAT IS CARDIAC FDG PET?

Cardiac FDG PET is a non-invasive imaging technique that uses a radioactive tracer called fluorodeoxyglucose (FDG) which allows for the visualization of the metabolic activity in the heart and major blood vessels. FDG is a glucose analogue and is taken up by cells in proportion to their glucose utilisation. The degree of FDG uptake reflects the metabolic activity of the myocardium, which can provide insights into various cardiac conditions. FDG is also taken up by immune cells which makes it a useful test for the assessment of cardiovascular infection and inflammation.

Following injection of FDG, the patient is then imaged using a PET scanner, which detects the radioactive emissions from the FDG and creates a 3D image of the entire body, including the heart, based on the patterns of radiation. The images generated from the PET scan are then combined with computed tomography (CT) or magnetic resonance imaging (MRI) in order to provide detailed anatomical information about the heart.

APPLICATIONS OF CARDIAC FDG PET

Cardiac FDG PET has a wide range of applications in the diagnosis and management of CVD. Some of the most common applications are:

1. Coronary artery disease (CAD): CAD is a common condition - affecting approximately 1 in 12 Canadians over the age of 20 - in which the coronary arteries that supply blood to the heart become narrowed or blocked by coronary plaque, leading to reduced blood flow and oxygen supply to the heart muscle. The coronary plaques contain numerous inflammatory cells and cardiac FDG PET can be used to assess the inflammatory activity in the plaques of patients with suspected or known CAD.

2. Myocarditis evaluation: Myocarditis is a condition that causes inflammation of the heart muscle, often as a result of a viral infection. The inflammation can cause damage to the heart muscle and lead to symptoms such as chest pain, shortness of breath, and heart failure. FDG PET can be used to visualize the metabolic activity in the heart muscle and detect areas of increased activity that may indicate inflammation. In some cases, FDG PET may be used to guide the biopsy of affected tissue, which can aid in the diagnosis of myocarditis.

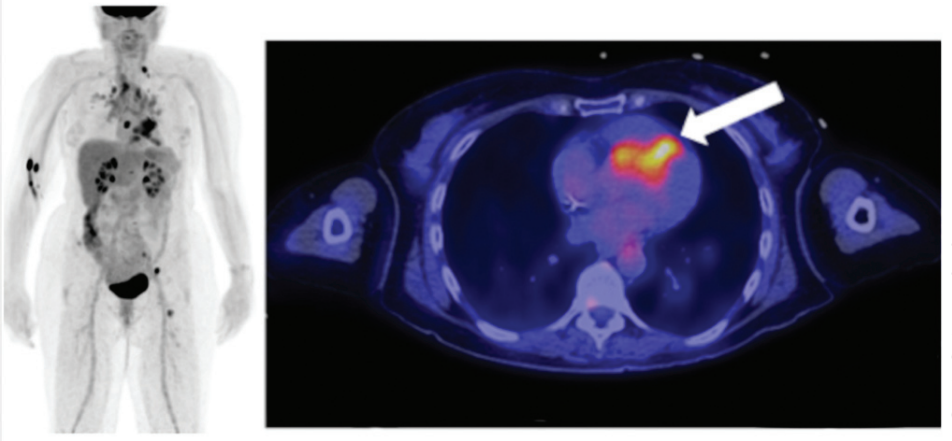


Figure 1. An example of FDG PET in a patient with cardiac sarcoidosis. In addition to being able to detect myocardial inflammation, whole body FDG-PET can detect extra-cardiac sites of involvement and provide a better picture of the disease stage.

3. Sarcoidosis evaluation: Sarcoidosis is a condition in which abnormal tissue growth (granulomas) form in various organs, including the heart. The use of cardiac FDG PET scans for cardiac sarcoidosis is particularly significant because the disease can be difficult to diagnose. The symptoms of cardiac sarcoidosis are often vague and can be mistaken for other conditions, such as heart failure or myocarditis. Additionally, traditional imaging techniques, such as echocardiograms and MRIs, may not be able to detect the early stages of the disease. The granulomas seen in sarcoidosis can often be highly inflammatory which allows for their detection using cardiac FDG PET. Beside being helpful in diagnosis, cardiac FDG PET has also been shown to be helpful in guiding therapy in these patients. The use of cardiac FDG PET scans for cardiac sarcoidosis is still relatively new in Canada, with only a few healthcare facilities offering the procedure. However, the number of institutions offering the scan is steadily increasing, as physicians recognize the significant impact it can have on patient care.

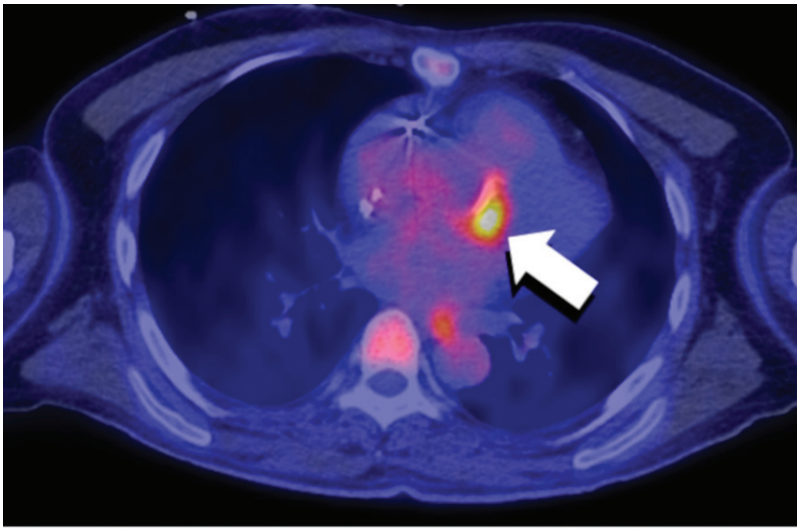


Figure 2. FDG PET is particularly useful for the assessment of prosthetic valve endocarditis. In this patient with a prosthetic aortic valve, an intense focus of uptake indicates the site of active infection.

4. Large vessel vasculitis: Large vessel vasculitis is a group of disorders characterized by inflammation of the blood vessels, primarily affecting the large arteries. These conditions can cause symptoms such as fever, fatigue, and pain or stiffness in the shoulders, hips, and neck. FDG PET can be used to visualize the metabolic activity in the blood vessels and detect areas of increased activity that may indicate inflammation. By comparing the level of FDG uptake in the blood vessels to that in normal healthy tissue, physicians can identify areas of inflammation and assess the extent of damage to the blood vessels. FDG PET can also be used to monitor the progression of large vessel vasculitis and the effectiveness of treatment. It can help identify early relapse of the disease, and assess the need for changes in treatment plans. Overall, FDG PET is a useful tool in the diagnosis and management of large vessel vasculitis because it can provide valuable information about the extent and severity of inflammation in the blood vessels, as well as guide treatment decisions and monitor the effectiveness of therapy.

5. Endocarditis: Endocarditis is a condition where the inner lining of the heart, including the valves, becomes inflamed due to an infection. The infection can lead to the formation of clumps of bacteria and blood cells, called vegetations, on the heart valves. These vegetations can damage the valves and lead to complications such as heart failure, stroke, and sepsis. FDG PET can be used to detect infection of the heart valves. FDG PET can also be used to monitor the progression of endocarditis and the effectiveness of treatment. It can help identify early relapse of the disease and assess the need for changes in treatment plans.

6. Cardiac viability: When a person experiences a heart attack, blood flow to the heart muscle is reduced, which can result in damage to the heart tissue. The damaged tissue may become non-viable or scarred, and may no longer be able to contract and contribute to the pumping action of the heart. However, some of the damaged tissue may still be viable, meaning that it has the potential to recover and contribute to heart function following restoration of normal blood flow. FDG-PET can be used to distinguish between viable and non-viable heart tissue by visualizing the metabolic activity in the heart tissue. FDG-PET can also be used to guide the selection of patients for revascularization procedures to restore blood flow such as coronary artery bypass grafting (CABG) or percutaneous coronary intervention (PCI). Revascularization procedures aim to restore blood flow to the damaged heart tissue, but their success depends on the extent of viable tissue in the affected area.

LIMITATIONS TO THE USE OF PET

Despite the growing popularity of cardiac FDG PET scans, there are still some challenges associated with the procedure. One of the primary challenges is the high cost of the scan, which can limit its accessibility to patients.

Additionally, the use of radioactive tracers raises concerns about radiation exposure, although the amount of radiation used in cardiac FDG PET scans is generally considered to be safe. Nonetheless, physicians must carefully weigh the benefits of the scan against the potential risks and communicate these risks to patients.

Finally, the biggest challenge remains the limited availability of the scan in some areas of the country.

"Early diagnosis and intervention can play an important role in improving outcomes while also decreasing the morbidity and financial burdens of CVD. Medical imaging has been playing an increasingly important role in the diagnosis and management of heart disease."

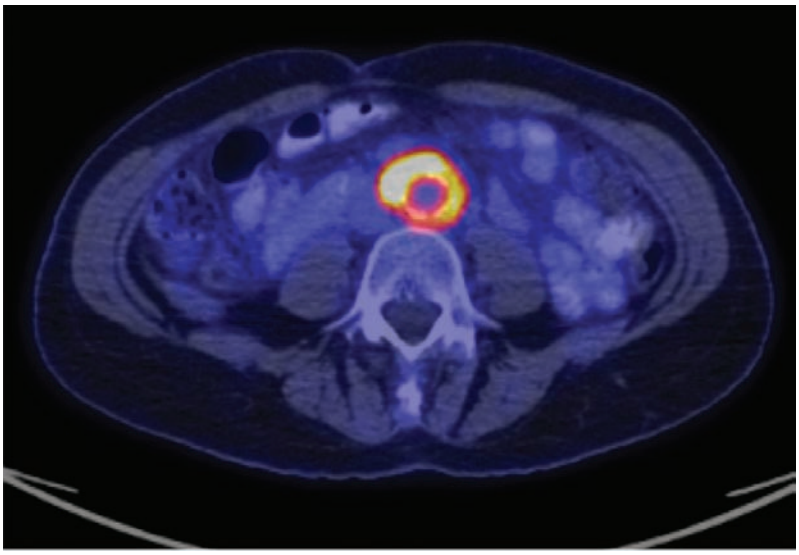


Figure 3. FDG PET is an accurate and straightforward test for the assessment of vasculitis. In this patient with large vessel vasculitis, intense uptake is noted involving the abdominal aorta.

MRI. This integration allows for more comprehensive and precise diagnostic information, and can enhance the accuracy of cardiac PET imaging in detecting and characterizing various cardiac conditions.

Additionally, ongoing research is exploring new applications for cardiac PET, including the use of PET for the assessment of myocardial viability, the prediction of cardiac events, and the evaluation of new therapies for cardiac disease.

Overall, the future of cardiac PET in Canada looks bright, with ongoing advancements in technology, research, and healthcare policy that are expected to further enhance the role and accessibility of cardiac PET in the diagnosis, treatment, and management of various cardiac conditions. ■

"The use of cardiac PET is being driven by the growing recognition of its clinical value, as well as ongoing advancements in PET technology and radiopharmaceutical development."

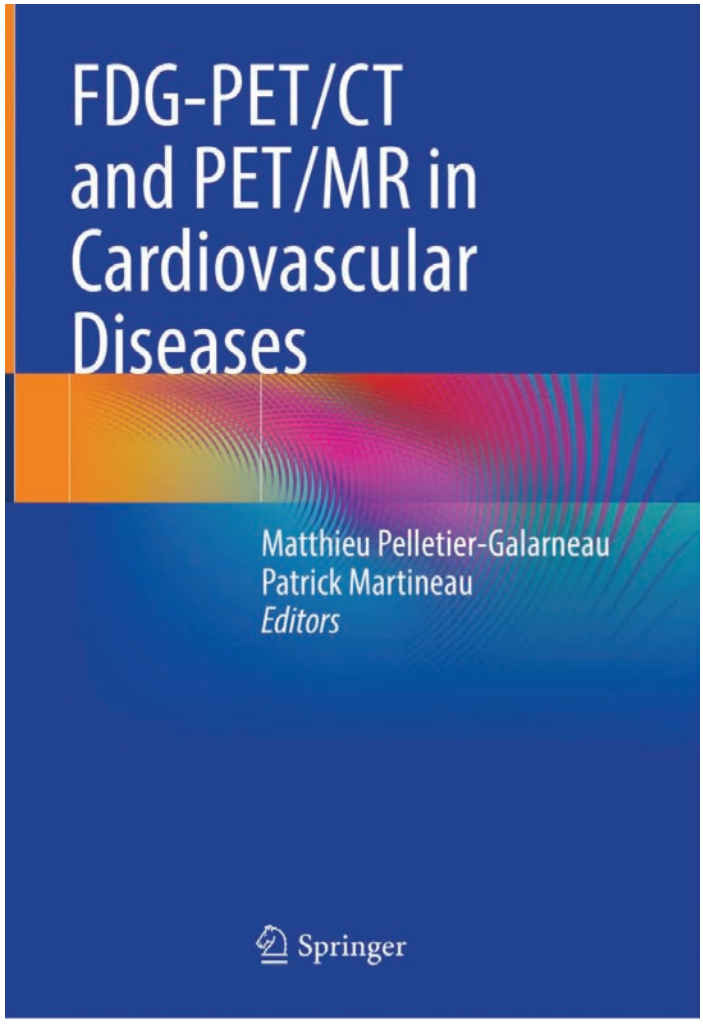
While major healthcare centers in urban areas are more likely to offer the procedure, patients in rural and remote areas may face significant barriers to accessing cardiac FDG PET scans.

THE FUTURE OF PET IN CANADA

The future of cardiac PET in Canada looks promising, with ongoing advancements in technology, research, and healthcare policy that are expected to enhance its roles and accessibility.

The use of cardiac PET is being driven by the growing recognition of its clinical value, as well as ongoing advancements in PET technology and radiopharmaceutical development. For example, new PET tracers are being developed that can provide more accurate and precise information on cardiac function and metabolism, as well as the presence and extent of cardiac disease.

Another important development is the integration of cardiac PET with other imaging modalities, such as CT and



Drs Pelletier-Galarneau and Martineau are co-editors of FDG-PET/CT and PET/MR in Cardiovascular Disease, a clinically oriented textbook, providing an up-to-date, and in-depth review of the various applications of FDG-PET/CT and PET/MR in cardiovascular diseases with emphasis on the current available evidence. This reference textbook targets a broad audience including cardiologists, nuclear medicine physicians, radiologists, residents, post-graduate fellows, and technologists. This 400 pages textbook contains 24 chapters, covering a broad range of cardiovascular diseases, and an atlas of representative cases and normal variants.

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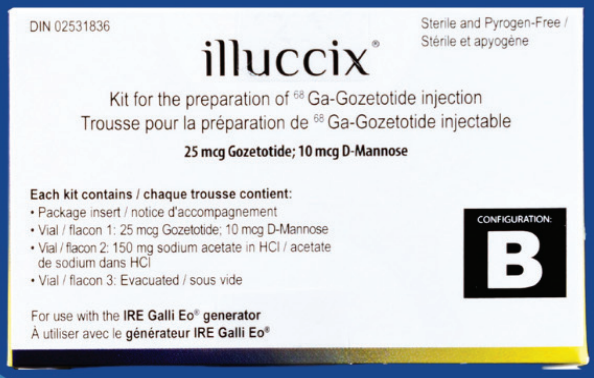

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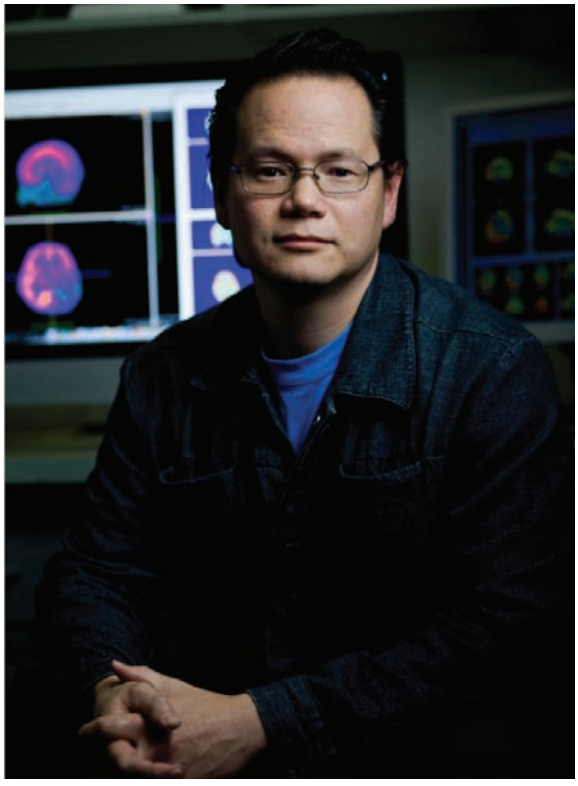
INTERVIEW WITH DR KEVIN LONDON



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- Clinical Senior Lecturer, Faculty of Medicine and Health, School of Health Sciences, The University of Sydney, Sydney, Australia.
- Nuclear Medicine Physician and Sonologist, Alfred Nuclear Medicine and Ultrasound, Newtown, Sydney, Australia.

My background:
I completed my primary medical degree at The University of Auckland, New Zealand, before undergoing clinical credentialing in general paediatrics and then nuclear medicine in Sydney Australia. My academic output includes co-authoring peer reviewed papers in paediatrics and paediatric nuclear medicine, five book chapters and completing a PhD in cerebral FDG imaging in children through the University of Sydney. I am the current President of the Australia and New Zealand Society of Nuclear Medicine and Medical Co-Head and Senior Staff Specialist at the Department of Nuclear Medicine, The Children's Hospital at Westmead, Sydney.

You are the president of the Australian and New Zealand Society of Nuclear Medicine (ANZSNM), Could you succinctly describe the role of the ANZSNM in the field of Nuclear Medicine?

The Australian and New Zealand Society of Nuclear Medicine (ANZSNM) is the only multidisciplinary organisation representing all professions working in the nuclear medicine field - medical specialists, technologists, physicists, radiochemists and radiopharmaceutical scientists, nurses, and students in Australia and New Zealand. Our mission is to promote research and education to enhance public health through the use of diagnostic and therapeutic nuclear medicine. A key function is advocating for nuclear medicine practice at all levels of government.

What have been the 3 most important changes that you have seen in the field of Nuclear Medicine over the last five years?

The increased accessibility of PET CT (although there is still much work to do in the more remote geographic regions), new tracer development (primarily in PET), and the rise of theranostics.

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

In Australia and New Zealand PET will continue to become increasingly accessible and novel tracers for different clinical conditions will emerge. We will, however, be challenged by workforce shortages (primarily technologists) and inadequate government funding.

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

The training of residents in Australia and New Zealand is well established with the same training pathway available to physicians and radiologists, consistently leading to highly trained nuclear medicine specialists. The ANZSNM is invested in promoting training pathways for technologists where we foresee challenges and potential changes to existing training programs to meet the demands of an increased workforce requirement in the coming years.

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

Accessibility. In Australia and New Zealand there are still populations that have difficulty accessing appropriate nuclear medicine services due to a multitude of reasons including socioeconomic disadvantage, cultural barriers, and geographic isolation. My wish is for every patient that would benefit from a nuclear medicine diagnostic or therapeutic intervention to have reliable and timely access to these services.

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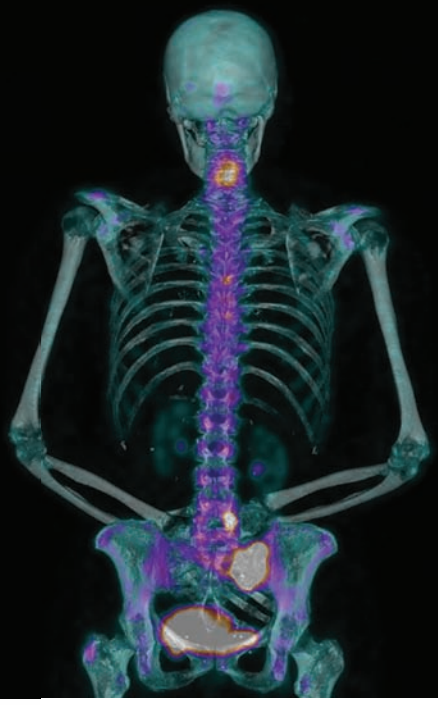

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Head of Nuclear Medicine
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Neuroendocrine Tumours: Finding Zebras with Nuclear Medicine

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

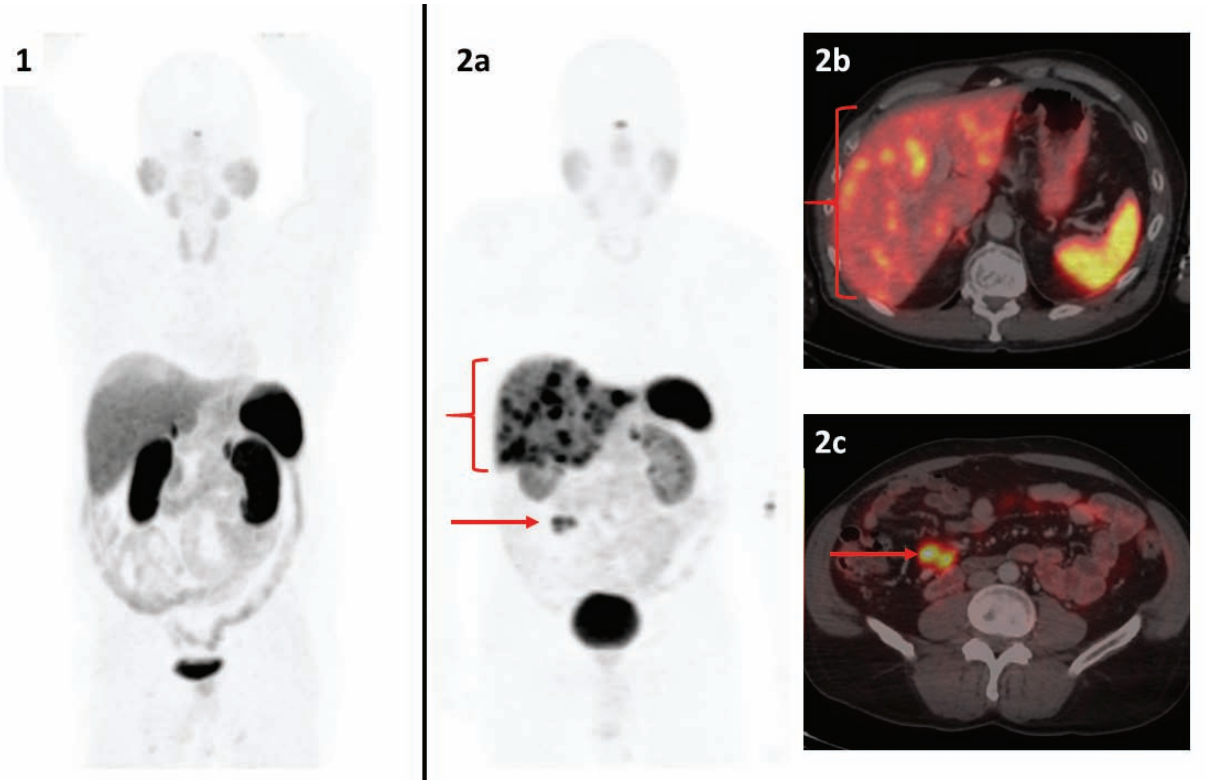
^{68}Ga-DOTATATE PET scanning is often the most accurate test for monitoring a NET patient's response to treatment, such as somatostatin analogs, chemotherapy, biologically-targeted therapies, or radioisotope therapies.

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.

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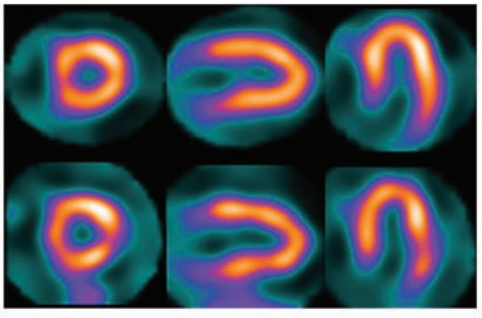
- Myoview vous permet de commencer à acquérir des informations diagnostiques tôt, 15 minutes après l'injection*[1]

*Selon la monographie de produit de Myoview, l'imagerie SPECT peut commencer 15 minutes après l'administration de l'agent.



Préparation efficace de la trousse[1]

- Myoview n'a pas besoin d'être bouilli et refroidi, ce qui peut faire gagner du temps avant son administration au patient

Durée de conservation post-reconstituée plus longue

- La durée de conservation de Myoview après reconstitution est de 12 heures[1]

La biodistribution de Myoview peut contribuer à raccourcir les études et les temps d'attente et peut aussi réduire le nombre d'examens répétés[2]

Au cours d'une étude prospective par Ravizzini :

- Il a été démontré que les études au repos et le temps d'étude total sont significativement plus courts avec Myoview[2]
- Les patients recevant Myoview ont subi moins d'examens répétés en raison d'une activité hors du cœur[2]

MYOVIEW™

[Trousse de préparation de la tétrofosmine marquée au technétium 99m (99mTc) pour injection]

Références : 1. Myoview [product monograph], February 12, 2018 (revised August 21, 2019), Control No. 211075.
2. Ravizzini GC, Hanson MW, Shaw LK, et al. Efficiency comparison between 99m Tc-tetrofosmin and 99m Tc-sestamibi myocardial perfusion studies. *Nucl Med Comm.* 2002;23:203-208.

IPM, Imagerie de perfusion myocardique; **TEMP,** tomographie par émission monophotonique.

INDICATIONS ET UTILISATION CLINIQUE DU PRODUIT : Myoview™ [Trousse de préparation de la tétrofosmine marquée au technétium 99m (99mTc) pour injection] est indiqué pour réaliser une scintigraphie myocardique après des administrations séparées sous stress (exercice et (ou) stress pharmacologique) et au repos chez les patients souffrant de coronaropathie connue ou soupçonnée. Il est utile dans la localisation des régions d'ischémie myocardique réversible en présence ou non de tissus myocardiques infarcis. L'épreuve de stress pharmacologique provoquée par du dipyridamole peut constituer une alternative à l'exercice chez les patients qui ne peuvent faire d'exercice adéquatement.

Renseignements importants sur l'innocuité de Myoview

CONTRE-INDICATIONS: Aucune connue. **MISES EN GARDE :** Lorsqu'on réalise des épreuves chez des patients présentant une coronaropathie connue ou soupçonnée, il est nécessaire d'assurer une surveillance cardiaque continue et de disposer des installations nécessaires pour administrer un traitement cardiaque d'urgence. L'usage de Myoview n'est pas recommandé chez les patients présentant une hypersensibilité connue à la tétrofosmine. Des réactions graves d'hypersensibilité et des réactions anaphylactoïdes ont été signalées pour Myoview. Le contenu d'un flacon de Myoview est destiné à être utilisé uniquement dans la préparation de tétrofosmine marquée au technétium 99m en injection et NON à être administré directement au patient. L'induction pharmacologique de stress cardiovasculaire peut être associée à de graves réactions indésirables telles que l'infarctus du myocarde, l'arythmie, l'hypotension, la bronchoconstriction et des accidents cérébrovasculaires. La prudence est de mise lorsque le stress pharmacologique provoqué par du dipyridamole est l'alternative retenue à l'exercice; cette substance doit être utilisée au moment indiqué et conformément à la monographie du produit et aux instructions relatives au dipyridamole (Persantine®). **MISES EN GARDE – Générales :** Des réactions allergiques et une anaphylaxie peuvent survenir avec Myoview. L'injection de tétrofosmine marquée au technétium 99m, comme c'est le cas de tout médicament radioactif, doit être manipulée avec précaution et des mesures de sécurité appropriées doivent être utilisées pour réduire au minimum l'exposition aux rayonnements pour le personnel clinique. Le contenu de cette trousse n'est pas radioactif. Cependant, après l'ajout du pertechnétate de sodium Tc-99m, un blindage adéquat de la préparation finale doit être maintenu pour réduire au minimum l'exposition aux rayonnements pour les travailleurs et les patients. Des précautions doivent également être prises pour réduire au minimum l'exposition des patients aux rayonnements, conformément à une prise en charge appropriée des patients. Afin de réduire au minimum la dose de rayonnements dans la vessie, les patients doivent être encouragés à vider leur vessie lorsque l'examen est terminé et aussi souvent que possible par la suite. Une hydratation adéquate doit être encouragée pour permettre des mictions fréquentes. Les réactions de marquage du Tc-99m dépendent du maintien de l'étain (ion stanneux) à l'état réduit. Par conséquent, les oxydants contenant du pertechnétate de sodium Tc-99m ne doivent pas être utilisés. Les produits radiopharmaceutiques devraient être utilisés uniquement par les praticiens dûment qualifiés dans l'utilisation de substances radioactives prescrites chez ou sur les humains. Les composants du flacon de réactif sont stériles et apyrogènes. Il est essentiel que l'utilisateur suive attentivement les instructions et applique une technique aseptique stricte. **Interactions médcamenteuses :** Les interactions médicamenteuses n'ont pas été notées et n'ont pas été étudiées dans les études cliniques au cours desquelles Myoview a été administré à des patients recevant un traitement concomitant. Des médicaments tels que les bêtabloquants, les inhibiteurs des canaux calciques et les nitrates peuvent influencer le fonctionnement du myocarde et la circulation sanguine. Les effets de ces médicaments sur les résultats d'imagerie ne sont pas connus. **Carcinogenèse, mutagenèse, altération de la fertilité :** Aucune étude n'a été menée pour évaluer le potentiel cancérogène ou les effets sur la fertilité. Le sulfosalicylate de tétrofosmine n'était pas mutagène *in vitro* dans le test d'Ames, le lymphome de souris ou les tests de lymphocytes humains, ni clastogène *in vivo* dans le test des micronoyaux chez la souris. **Utilisation chez les femmes enceintes :** Étant donné qu'aucune étude adéquate sur la reproduction n'a été réalisée chez l'animal pour déterminer si ce médicament affecte la fertilité des mâles ou des femelles, s'il a un potentiel tératogène ou s'il a des effets indésirables sur le fœtus, cette préparation radiopharmaceutique ne doit pas être administrée aux femmes enceintes, sauf si l'on considère que le les avantages l'emportent sur les dangers potentiels. **Femmes qui allaitent :** Le pertechnétate de technétium Tc-99m peut être excrété dans le lait maternel. Lorsqu'une évaluation du rapport avantage/risque suggère l'utilisation de ce produit chez les mères qui allaitent, le lait maternel doit être remplacé par du lait maternisé. **Utilisation pédiatrique :** Il n'existe pas d'études adéquates pour soutenir l'utilisation de ce produit radiopharmaceutique chez les enfants. **RÉACTIONS INDÉSIRABLES :** Les événements suivants ont été observés chez moins de 1 % des patients à l'étude : Angine de poitrine, hypertension, torsades de pointes, rougeurs, vomissements, douleur/gêne abdominale, allergie cutanée, hypotension, dyspnée, goût de métal, sensation de brûlure dans la bouche, sentir une odeur et vision anormale. Il y avait une faible fréquence (moins de 4 %) d'une augmentation transitoire et cliniquement non significative du nombre de leucocytes après l'administration de l'agent. **Pharmacovigilance :** Les réactions indésirables comprenaient une hypersensibilité, un choc anaphylactique ou anaphylactoïde, une réaction anaphylactique ou anaphylactoïde, une altération du goût, des étourdissements, une tachycardie, des douleurs thoraciques, une hypotension, une dyspnée, un bronchospasme, un serrement de la gorge, une toux, des nausées, des vomissements, des douleurs abdominales, de l'urticaire, des démangeaisons, des éruptions cutanées et un œdème de Quincke.

Avant l'administration de Myoview, veuillez lire la monographie complète du produit, disponible en appelant au 1 800 654-0118 (option 2, puis option 3).

Pour signaler des RÉACTIONS INDÉSIRABLES SOUPÇONNÉES, contactez GE HealthCare au 1 800 654-0118 (option 2, puis option 1), ou écrivez à l'adresse courriel canadainfo@ge.com pour demander un formulaire de signalement des réactions indésirables, ou encore envoyez une demande de formulaire par télécopieur au 905 847-5849. Les réactions indésirables peuvent également être signalées à Santé Canada comme suit :

- En ligne sur le site Web www.santecanada.gc.ca/medeffet
- Par téléphone au 1 866 234-2345 (sans frais)
- En remplissant un formulaire de déclaration du programme Canada Vigilance et en l'envoyant
  - par télécopieur au 1 866 678-6789 (sans frais);
  - par la poste au programme Canada Vigilance, Santé Canada, localisateur postal 0701E Ottawa, ON K1A 0K9
- Les étiquettes avec frais de port et le formulaire de déclaration de Canada Vigilance sont disponibles au www.santecanada.gc.ca/medeffet

MYOVIEW™

[Trousse de préparation de la tétrofosmine marquée au technétium 99m (99mTc) pour injection]

GE HealthCare

Avril 2023 JB00837CA

WORLD FEDERATION OF NUCLEAR MEDICINE AND BIOLOGY

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The Executive Board is the highest executive level of the Federation. It shall create a vision for the future of the Federation and develop strategies to fulfil them as well as to develop strategies regarding the cooperation with partner societies for the future of the medical specialty and the benefit of its Members and national Member societies.

It shall execute and supervise the execution of operational goals along the strategic lines as developed together with the different Integral Parts of the Federation. The Executive Board represents the Federation legally and is responsible for its financial management according to the Statutes and legal regulations.

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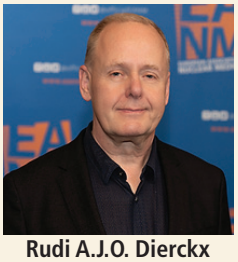

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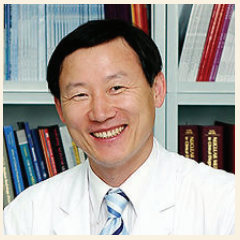

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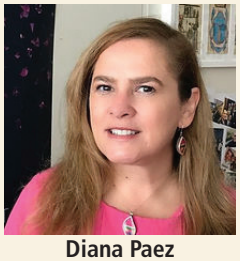

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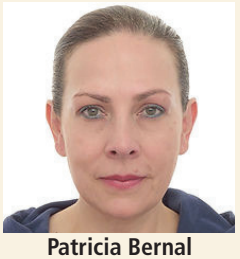

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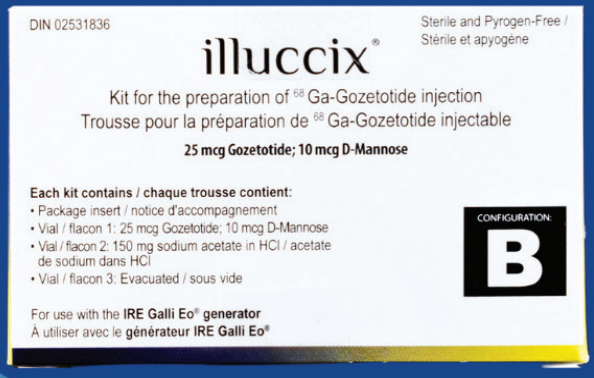

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2023 ANNUAL SCIENTIFIC CONFERENCE

CONFÉRENCE SCIENTIFIQUE ANNUELLE 2023

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Ottawa, ON

More information to come. Stay tuned

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AMSMNQ	10-12 mai 2024	Québec
SNMMI	24-27 june 2023	Chicago
CANM	19-21st october	Ottawa
EANM	9-13 september	Vienna
ALASBIM	2023	Argentina
WFNMB	2026	Cartagena

SAVE THE DATE :
CANM - October 19-21st
OTTAWA

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 · World Federation of Nuclear Medicine and Biology · ARCENM · ASNC · ARSNM Arab Society of Nuclear Medicine · AFNMB · IAEA International Atomic Energy Agency · alasbimn · South African Society of Nuclear Medicine · SFMN

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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.

Dr. Keu Khun Visith
Dr. Karine Provost
Responsable de la page Facebook de l'AMSMNQ

Cher lecteur,

Avec le support constant de la vice-présidente du comité, Dr Ophélie Bélissant et des autres membres du comité, nous organisons plus d'une vingtaine d'heures de formation médicale continue annuellement. L'activité principale est le colloque tenu au mois de mai en rotation dans les différentes régions du Québec. Nous organisons une dizaine de clubs de lecture par année en formule WEB pour permettre aux membres de discuter cordialement d'articles d'intérêts. Finalement, des webinaires thématiques sont ajoutés ponctuellement pour combler des besoins plus précis. Une série de webinaires sur la thérapie aux radioligands du PSMA est d'ailleurs prévue l'automne prochain. Plusieurs activités sont présentées sous forme de programmes interactifs d'auto-évaluation ou de simulation.

Les activités se déroulent habituellement en français mais les présentateurs anglophones intéressés à participer sont bienvenus! Pour plus d'information, visitez régulièrement le site WEB de l'AMSMNQ ou abonnez-vous à sa page Facebook.

Dr Sylvain Prévost
Président du comité de DPC de l'AMSMNQ
Spécialiste en médecine nucléaire, CHUS
Professeur d'enseignement clinique, Université de Sherbrooke

Dr Ophélie Bélissant
Vice-présidente du comité de DPC de l'AMSMNQ

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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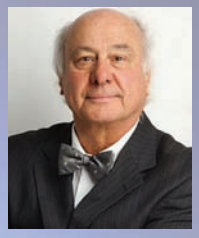

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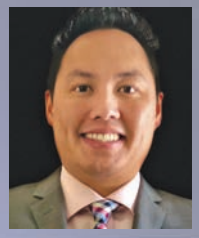
Président sortant (invité)



Dr. Keu Khun Visith
Conseillier

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Le début de l'année 2023 a vu l'arrivée de nombreuses nouvelles organisations dans la communauté de la médecine nucléaire à travers le monde et de façon marquée en Amérique du Nord. L'une de ces entreprises est Lemer Pax America, pourriez-vous nous en parler?

Avec plaisir! Lemer Pax America a établi ses bureaux à Montréal au Canada en début d'année. Cette entreprise est née d'une entente de partenariat entre CCNucléaire, un fournisseur de services spécialisés dans l'industrie nucléaire civil de Montréal, ainsi que Lemer Pax, société œuvrant dans le milieu de la radioprotection et de la médecine nucléaire depuis plus de 50 ans, basée en France, dans la région de Nantes.

Comme extension de Lemer Pax en Amérique, notre mission première est la protection de la vie. Nous offrons diverses solutions pour la médecine nucléaire, la radioprotection, la radiologie interventionnelle, la recherche et l'industrie nucléaire. D'une simple brique de plomb jusqu'à des appareils plus complexes comme des enceintes blindées pour la préparation de radiopharmaceutiques, accessoires pour radiopharmacies, activimètres, et d'injecteurs automatisés tant pour le diagnostic que pour la thérapie.

Certains de ces appareils sont bien évidemment hautement règlementés et nous travaillons activement à obtenir ces homologations au Canada et aux États-Unis.

Avec la véritable révolution en cours dans le monde de la médecine nucléaire, pour le plus grand bénéfice des patients, quelle contribution croyez-vous pouvoir apporter en tant que membre de l'industrie?

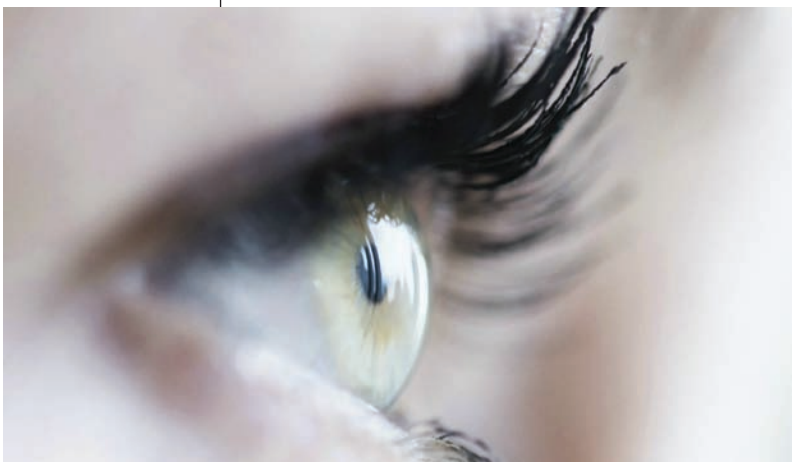
Je crois, tout d'abord, qu'il nous faut constater tout le potentiel de bienfaits que cela représente pour les patients. Cela doit être au cœur de chaque décision et orientation que nous prenons. Des nouveaux examens qui nous permettent de diagnostiquer plus précocement certaines maladies graves comme le cancer ou les maladies cardio-vasculaires, jusqu'aux nouvelles thérapies disponibles ou en développement, nous nous devons de développer des solutions novatrices qui adressent des problématiques précises. Il est primordial que les partenaires de l'industrie travaillent de concert avec les professionnels de la santé, incluant les médecins spécialistes, afin de fournir de meilleurs outils et en plus grand nombre. Tout la chaîne du continuum patient en dépend. Nous créons des produits qui permettent d'automatiser des tâches répétitives, obtenir des gains en termes d'ergonomie, d'augmenter la rapidité et la précision, d'assurer des communications fluides et fiables entre les systèmes informatiques, tout cela dans le respect des normes, de la règlementation et de façon sécuritaire.

Un milieu en plein essor peut parfois créer une compétition féroce entre les différents joueurs du marché, comment composez-vous avec cette réalité?

Bien qu'en tant qu'entreprise, il est vrai que le milieu de la santé et de la médecine nucléaire puisse être un terrain compétitif, nous avons de moins en moins cette impression. La raison est simple, il y a tellement à faire pour supporter la demande que la plupart des acteurs jouent plusieurs rôles. Une entreprise peut être à la fois fournisseur, client, partenaire, conseiller, support, etc. Dans le contexte économique mondial, il est bénéfique pour les membres dédiés à une industrie de s'épauler, de s'allier plutôt que de se nuire. Nous collaborons avec de nombreux clients comme les compagnies radiopharmaceutiques, les radiopharmacies, les fabricants d'appareils d'imagerie, les fournisseurs d'isotopes médicaux et bien sûr d'abord et avant toutes les cliniques d'imagerie, de thérapies et bien sûr les centres hospitaliers.

Comment entrevoyez-vous les prochaines années du point de vue des patients qui auront recours à la médecine nucléaire?

Au sein de notre organisation, nous croyons que l'avenir est extrêmement prometteur pour la santé des patients. Le nucléaire si craint par certains, n'a jamais été plus pertinent que maintenant dans le contexte mondial. Source d'énergie, le nucléaire par la bande, nous approvisionne en isotopes médicaux si utile pour détecter et traiter la maladie. Collectivement, l'impact de notre communauté contribue littéralement à sauver des vies ou à tout le



moins à prolonger une qualité de vie si précieuse. Les thérapies radiopharmaceutiques ciblées en médecine nucléaire possèdent en tous points les qualités recherchées dans le traitement des cancers, elles sont ciblées sur les cellules cancéreuses, évitent totalement les cellules saines (ce qui n'est pas toujours le cas avec la radiothérapie conventionnelle), ont peu ou pas d'effets secondaires, requièrent rarement l'hospitalisation et sont disponibles à un coût relativement raisonnable si l'on tient compte de la facture totale pour l'ensemble du traitement.

Cela n'est donc pas une surprise de voir tout l'engouement autour des nouvelles thérapies, les patients de nos jours sont informés et veulent être impliqués à fond au niveau de leur santé.

Bref, que de bonnes nouvelles du côté de tous les intervenants de la médecine nucléaire.

LEMER PAX AMERICA

The beginning of 2023 saw the arrival of many new organizations in the nuclear medicine community around the world and especially in North America. One of those companies is Lemer Pax America, can you tell us a bit more?

Of course! Lemer Pax America established its office in Montreal, Canada earlier this year. This company was born from an ownership agreement between CCNuclear, a service provider specializing in the civil nuclear industry from Montreal, and Lemer Pax, a company dedicated to radiation protection and nuclear medicine, founded more than 50 years ago based in Nantes, France.

As an extension of Lemer Pax in America, our primary mission is protecting life. We offer various solutions for nuclear medicine, radiation protection,

"Lemer Pax America established its office in Montreal, Canada earlier this year. This company was born from an ownership agreement between CCNuclear, a service provider specializing in the civil nuclear industry from Montreal, and Lemer Pax, a company dedicated to radiation protection and nuclear medicine, founded more than 50 years ago based in Nantes, France."

LEMER PAX AMERICA PROTECTING LIFE

interventional radiology, research, and the nuclear industry. From a simple lead brick to more complex devices such as shielded isolators and hot cells for the preparation of radiopharmaceuticals, accessories for radiopharmacies, dose calibrators, and automated injectors for both diagnostic and therapeutic radionuclides.

"Within our organization, we believe that the future is extremely bright from a patient health standpoint. Nuclear power, so feared by some, has never been more relevant than now with the current global context. As an energy source, the nuclear industry collaterally supplies us with medical isotopes that are so useful for detecting and treating disease. "

Some of these devices are obviously highly regulated and we are actively working to obtain the necessary approvals in Canada and the United States.

With the revolution underway in the world of nuclear medicine, for the greater benefit of patients, what contribution do you think you can make as a member of the industry?

Firstly, I believe that we need to recognize the potential of the benefits for patients. This must be at the core of every decision and direction we take. From new procedures that allow us to diagnose serious conditions such as cancer or cardiovascular diseases earlier, to newly available therapies or those in the development phase, we must design innovative solutions to address specific problems. It is essential that industry partners work together with healthcare professionals, including nuclear medicine physicians, to provide better tools and in a higher capacity. The entire chain of the patient continuum depends on it. We manufacture products that help automate repetitive tasks, provide better ergonomics, increase speed and accuracy, ensure smooth and reliable communications between computer systems, all in compliance with the highest standards, regulations, and safety.

A booming environment can sometimes create fierce competition between different players in the market, how do you deal with this reality?

While it is true that healthcare and nuclear medicine can be competitive fields, we experience this less and less nowadays. The reason is simple, there is so much to do to support the demand that most actors play multiple roles. A company can be a supplier, a customer, a partner, an advisor, a support system, etc. In the global economic context, it is beneficial for members dedicated to an industry to support each other, to ally rather than compete. We work with many clients such as radiopharmacies, radiopharmaceutical companies, imaging equipment manufacturers, medical isotope suppliers and of course first and foremost, imaging clinics, therapy clinics and hospitals.

How do you see the next few years from the point of view of patients who will be using nuclear medicine?

Within our organization, we believe that the future is extremely bright from a patient health standpoint. Nuclear power, so feared by some, has never been more relevant than now with the current global context. As an energy source, the nuclear industry collaterally supplies us with medical isotopes that are so useful for detecting and treating disease. Collectively, the impact of our community literally helps to save lives or at least extend the precious quality of life. Targeted radiopharmaceutical therapies in nuclear medicine have all the qualities sought after for the treatment of cancers. Specifically, they are targeted at cancer cells, completely avoid healthy cells (which is not always the case with conventional radiotherapy), have few or no side effects, rarely require hospitalization and are available at a relatively reasonable cost if we consider the total bill for an entire treatment.

It is therefore not a surprise to see all the enthusiasm around new therapies, patients nowadays are informed and want to be fully involved in their health and treatment pathways.

In short, only good news for all of those involved in nuclear medicine.

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INTERVIEW WITH STUART MORE

Stuart More
President of the South African Society of Nuclear Medicine (SASNM)

You are the president of the South African Society of Nuclear Medicine.(SASNM) Could you succinctly tell us your background?

I am currently based in Cape Town as the Acting of Nuclear Medicine at the University of Cape Town. I completed by undergraduate medical degree at the University of the Witwatersrand with my nuclear medicine training taking place at the University of Cape Town. I'm currently a PhD student at the University of Pretoria under supervision of Prof Michael Sathekge

Could you describe the role of the SASNM in the field of Nuclear Medicine?

I feel that SASNM has a wider role to play not only in South Africa in promoting the role and engagement of nuclear medicine and molecular imaging in different spheres of healthcare, but also as a bastion for NM in Africa.

Much of our work needs to align with patient advocacy particularly for the diagnostic imaging as well as radionuclide therapies we offer and make sure as best as we can that patients are able to access this.

What have been the three most important changes that you have seen in the field of Nuclear Medicine over the last five years?

This is definitely the burgeoning and growing role of molecular imaging in PET/CT diagnostics and the ability of what we are able to target. It is amazing over the last decade, as an example, of how PSMA PET/CT imaging has become part of the standard of care of staging of primary prostate cancer.

The second big change is obviously the role of patient-centred care particularly within the theranostic realm and the sheer potential of what we as a field can impact in personalized medicine.

The third and growing change I have witnessed is the very fast growth of artificial intelligence and machine learning within molecular imaging with PET/CT as well as theranostic applications and where it will fit in tailoring personalized care for patients in the future and assist physicians in key decision-making for favourable outcomes.

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

Over the next five years, there is going to be a growth in targets for varied oncological and non-oncological applications.

Different radioisotopes will be applied to current standard of care such as alpha-based therapy (e.g. Ac225/Pb212) and Terbium 161 as an example.

I do think that our role in women's oncology and theranostic work needs to grow as well as the next frontier. Aligning our field with different stakeholders in this realm would be key to make sure we keep at the frontier of science.

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

This is an interesting one for me. I still consider myself relatively young in the field and on the onset of my resident training the focus was predominantly on diagnostic imaging and its applications. With the advent of the interacting more with patients in therapy administration, training curriculums need to integrate this as part of the standard teaching programme of residents and technologists so that they are equipped with the necessary skill set and knowledge to execute this important aspect of our work. It is obviously varied in many parts of the world but we are fortunate to have access and exposure to the key radioligand therapies locally and be able to interact and assist with administration of this key. medication for patients on the clinical level as well as part of clinical trial work which we are involved in as well.

As president of the SASNM, what is your greatest wish for the specialty of Nuclear Medicine?

My greatest wish for Nuclear Medicine is to be able to harness the power of diagnostic and therapeutic applications to a wider reach of population who can access the tool and assist in clinical care.

In all honesty , it would be aiming to achieve as best as possible the greatest good that NM can do for the greatest number possible. ■

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

Minimalement invasif
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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.

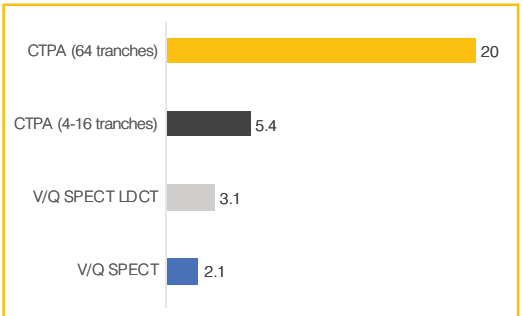

Tableau 1: Exposition à la radiation [8] (mSv)
(adapté des recommandations du CANM, 2018)

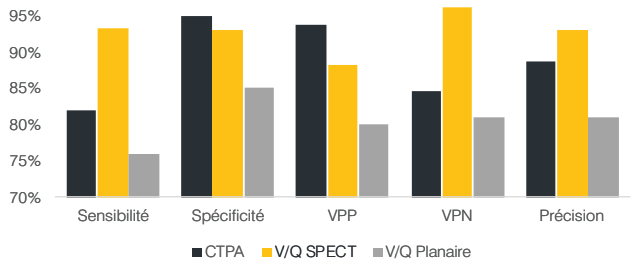

Tableau 2: Performances diagnostiques des différentes modalités à détecter l'EP (adapté de Hess et al, 2016)

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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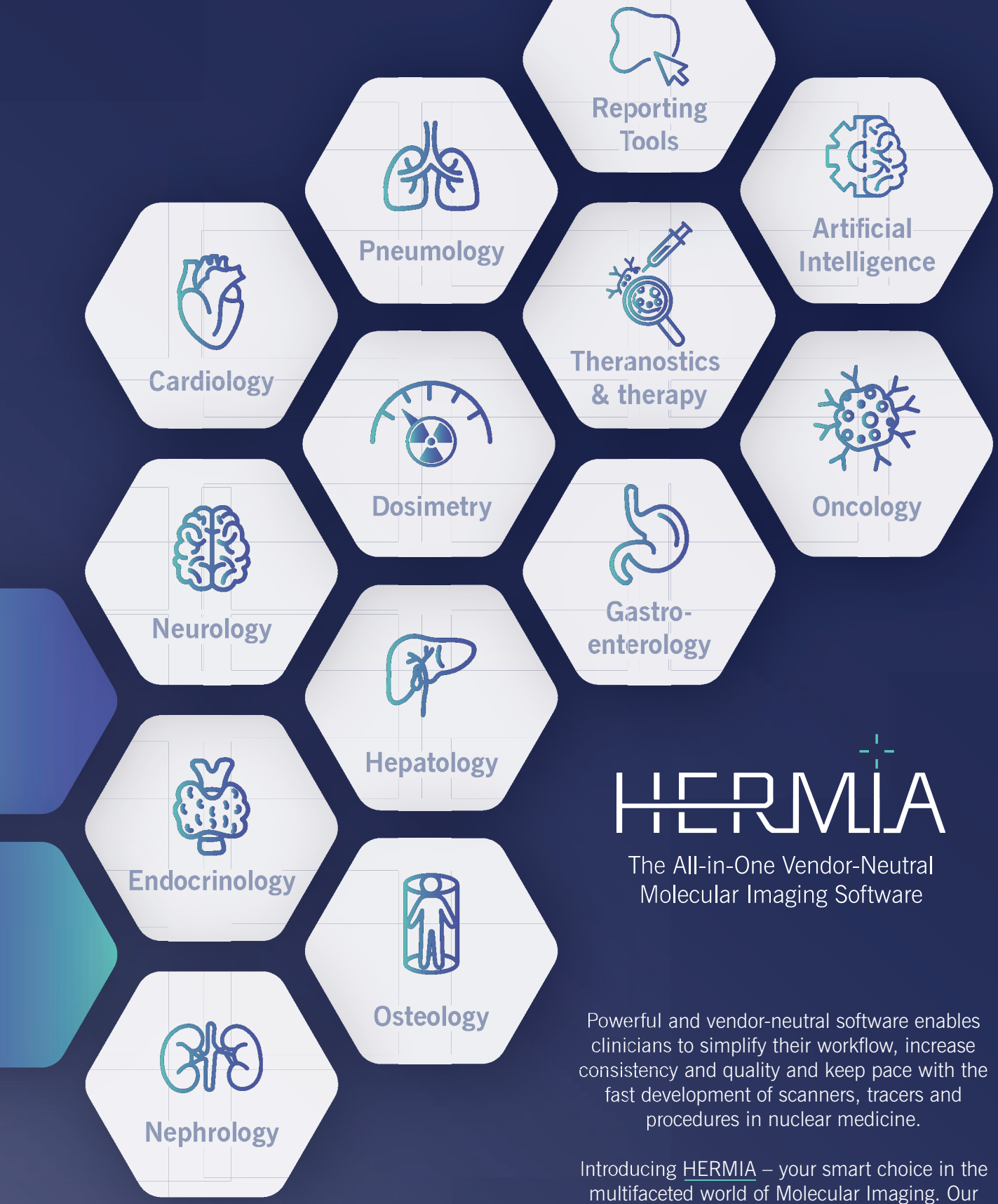

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