New England Chapter E-Journal of Nuclear Medicine Technology

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In-person Continuing Education Meetings are back!

34th Annual Northeast Meeting

Sponsored by The Greater New York and New England Chapters of the SNMMI

Hyatt Regency Greenwich
Greenwich, CT
November 5-6, 2021

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New England Chapter of the Society of Nuclear Medicine and Molecular Imaging Technologist Section's

52nd Annual NECTS Spring Symposium

March 5 – 6, 2021 | Portsmouth, NH

Join us for the 52nd Annual Spring Symposium! A great opportunity to meet with vendors, obtain CEUs and catch-up with colleagues.

Program & Registration information coming soon!

Please Visit Our Website for More Information

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President's Report by Leo Nalivaika, MBA, CNMT, FSNMMI-TS

Hello to the members of the New England Chapter. I hope that all of you are well and are surviving this pandemic. It was a pleasure to see many of you at the virtual meeting last April as well as some of you that may have attended the national meeting virtually.

As we start another year of the chapter we are still in limbo in regards to this pandemic. It seems like the candle one can not extinguish. Our planning for future meetings has taken on looking at a variety of scenarios. The next spring meeting is scheduled to be held in Portsmouth New Hampshire in the spring of 2022. At this time we hope that it will be a real event, but we must also plan for the possibility that the pandemic climate may change for the worse. We also must deal with travel restrictions that may or have been placed by employers. The national meeting is scheduled to be held in Vancouver in June, but again this is dependent on the Canadian government restrictions as well as the conditions that will exist.

I am blessed to have a terrific group of executive committee members and I hope that some of you Maybe and or considering running for office. Matt McMahon our past president is in charge of elections. It would be great to have you get involved.

There will be a live meeting by the physician's group and you may have received the email, and it is also addressed here in the newsletter. I hope to see many of our members in attendance, but as I have mentioned I am still waiting to see if there are any travel restrictions in place from my employer.

This past year has been an indescribable disaster. It was the worst-case scenario and many of our members stepped up in unsurmountable roles. There were sick patients with Covid, and even if they did not have the virus one carefully treated them as if they had. You went into your facilities and performed as a true professional would. I am very proud and in awe of all of our facility-based technologists and I thank you for being there for the patients.

If there are any questions comments and or suggestions please feel free to reach out to me.

Leo

President-elect Report by April Mann, MBA, CNMT, NCT, RTN, MASNC, FSNMMI-TS

I hope this newsletter finds everyone well and safe! To say the least this past year has been a challenge for all of us as we try to balance normalcy and doing the right and safe thing for our families and patients. To support the Chapter and conduct necessary business, we on the Executive Committee will do our best to make decisions in the best interest of our members. With that said, as we think about how to proceed in the upcoming year, your feedback and concerns are very important, and we would love to hear from you. Please feel free to reach out to us, your voice matters!

If you are in need of CE Credit or looking for an opportunity to reconnect and network with colleagues, please join us at the upcoming 34th Annual Northeast Regional Scientific Program to be held November 5-6, 2021 at the Hyatt Regency Greenwich, Greenwich CT. The program committee has put Covid policies in place to keep faculty and attendees safe. To learn more and register for the meeting please visit: https://greaternycsnmmi.org/upcoming-events/#northeast-regional-meeting
We look forward to seeing everyone there!

As always, thanks so much for your continued support!

Upcoming Meetings

34th Annual Northeast Meeting - The Greater New York and New England Chapters of the SNMMI
November 5-6, 2021 | Hyatt Regency, Greenwich, CT

2022 SNMMI Mid-Winter & ACNM Annual Meeting
January 27-29, 2022 | Orlando, Florida, USA

52nd Annual NECTS Spring Symposium
March 5 – 6, 2021 | Portsmouth, NH

SNMMI 2022 Annual Meeting
June 11 – June 14, 2022 | Vancouver Convention Centre, British Columbia, Canada

SNMMI Technologist Section's Quarterly Webinars:

Excellence in Nuclear Medicine Pediatric Imaging
Joseph (Joby) MacLean, **Wednesday, November 10, 2021** (Time: TBD)

Considerations for Myocardial Blood Flow
April Mann, **Wednesday, December 8, 2021** – 12:00 pm EST

Past President's Report by Matthew C McMahon MS, CNMT, RT(CT)

Hello New England Chapter members. We've made it through another year, and I have gladly turned the reins of leadership back over to Leo. It was an honor to serve as your President during very unprecedented times, and I hope that everyone continues to remain healthy and safe. The Chapter will be in tremendous hands for the next year, and I look forward to the hopes that collectively we can all come together to get this virus under control so that we might finally have a Spring Meeting in person. Get vaccinated and wear a mask!

As is the case every year, we will again have a few open positions on the ballot for this coming Spring election. The following offices will have openings

- President-Elect - 3-year term. 1st year President-Elect, 2nd year- President, 3rd year- Immediate Past- President - Responsibilities during year of President-Elect include coordinating of the annual Spring Symposium with help from the program committee. If the current president cannot execute the duties of that office, the president elect assumes the office of the president

- Treasurer – 2-year term. The treasurer's responsibilities include but are not limited to: Chapter bank account management, Chapter expense management, and management of the Chapter's tax filings.

For full listing of duties and responsibilities please utilize the following link

NECTS Chapter By-Laws

I hope that everyone will consider giving back and serving your colleagues. The opportunity to serve as your President has been an honor and a privilege. Should you have any questions on the above positions or the elections themselves please don't hesitate to reach out.

Matt McMahon, Immediate Past President
matthewconormcmahon@gmail.com

Treasurer Report by Tom Morneau, R.T.(N) CNMT

Hello Everyone.

This Treasurers Report will be a short one. Due to our inability to have our annual Spring Meeting last March, there has not been much activity with the chapters finances this past year. Our financial position is sound. We are all optimistic going forward we will get to have a Spring Meeting in 2022. Looking forward to seeing everyone again.

Tom Morneau
Treasurer NECTS-TS

Important Changes announced by ARRT for Continuing Education Credits beginning January 1, 2022

Kathy Thomas, MHA, CNMT, PET, FSNMMI-TS

Professional organizations, including the SNMMI, recognized by the ARRT to award continuing education (CE) credit must meet strict criteria for those CE credits to be accepted. ARRT calls these approved organizations 'RCEEMs'. RCEEM: 'a recognized **continuing education evaluation** mechanism ((RCEEM) is a radiology-based or medical imaging-based organization that ARRT has approved to evaluate the content, quality, and integrity of proposed continuing education (CE) activities.

Recently, the ARRT made two critical changes associated with how RCEEMs assess or calculate educational offerings. First, the minimum number of questions required to test the competency and understanding of the participant has been reduced to 8 questions per hour of live/recorded content. Effective immediately, the number of questions associated with live/recorded webinars will be reduced from 10 per hour to 8, with a score of 6 correct (or 75%) required to pass.

Second, a complex formula has been developed to calculate educational credits awarded for written materials (e.g., journal articles) based on the estimated time for an average person to read the material.

New CE formula for written materials:

- $Total\ CE\ Credits\ Awarded$**=(#** $of\ words$ **÷140)+(**$Video\ time$**)+(#** of **?**s **×1.85) / 50**

While the number of questions required for webinars will be reduced from 10 to 8, in order to maintain 1.0 CE credits for written journal articles that meet the minimum 3600-word count, 10 questions (8 correct, or 80%) will continue to be required for journal articles.

The bottom line: Moving forward, CE Journal Articles will need to be at least 3600 words and have 10 questions to offer 1.0 credits. The Continuing Education Office will work closely with the Publication Committee to provide accurate information for each written publication as this new formula is implemented beginning January 1, 2022.

The TS Continuing Education Committee continues to look for new ideas to develop educational offerings specific to the needs of nuclear medicine technologists. If you have suggestions or want to participate in creating an educational offering, please contact me at ksthomas0412@msn.com.

If you have questions regarding CE credits, online activities, or available educational offerings, please contact the SNMMI Education Department team at Education@snmmi.org or 703 708-9000, x 1. Caroline Krystek and Jane Kamm will be happy to help you with any questions.

2020 Student Abstracts

The following pages are student abstracts.
Congratulations to all of our students and thank you to the program directors and volunteers!

Is Lutetium-177 PSMA-617 the new Xofigo?

Hanan Abdallah
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Nuclear Medicine Technology Program

Objectives: Worldwide, prostate cancer (PC) is the second most common cancer and is the 5th leading cause of death. The American Cancer Society (ACS) states that in 2021 there will be about 248,530 PC cases and 34,130 deaths in American men. The first line of treatment for PC is a combination of hormonal therapy, radiotherapy, and surgery if the PC is localized [5]. However, some PC cells will develop resistance to the hormonal therapy, and this is referred to as castration resistant prostate cancer (CRPC). If CRPC has metastasized, it is referred to as metastasized castrate resistant prostate cancer (mCRPC). Second- and third-line therapies are then opted for mCRPC patients and they include chemotherapy, immunotherapy, and Radium-223 (Xofigo) if metastasized to the bone only [5]. Despite treatments, some patients with mCRPC will developed resistance to treatments which results in over-expressed levels of prostate-specific membrane antigen (PSMA). Subsequently, researchers tipped the scale and exploited this antigen to develop a radioligand for therapeutic proposes. In Radioligand Therapy (RLT) the PSMA peptides are labeled with Lutiteium-177 creating Lu-177 PSMA-617. RLT reduces serum PSMA levels by 50% or more in some patients [4,2] as opposed to Xofigo that only targets osteoblastic activity thus reducing alkaline phosphate levels [1].

Methods: Multiple journal papers were reviewed, mostly retrospective studies that compared the efficacy of Lu-177 PSMA-617 to PC traditional treatments and analyzed the hemototoxicity of the RLT after Ra-223 treatment.

Results: The German nuclear medicine society gathered information from 12 therapy centers adding up to 145 patients that have undergone 248 cycles of RLT. The aim was to produce a large cohort study focusing on the efficacy and biochemical response of RLT. Altogether, 99 out of 145 patients demonstrated a biochemical response to RLT. Patients that have undergone Xofigo prior to the RLT were also in the inclusion criteria. A 50% decline in PSA levels were demonstrated in 45% of the patients and 60% presented a general decline in PSA levels. The

A literature review comparing different computer aided methods in diagnosing Parkinson's Disease on DaTscan

Julia Kuhn
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Lifespan School of Medical Imaging-Nuclear Medicine Technology

Parkinson's Disease (PD) is a progressive neurodegenerative disorder with no known cause or cure. This disease causes neurons in the brain to weaken or die; ultimately, lowering dopamine levels that the brain needs to regulate movement. Physicians use a combination of several tests to diagnosis a person with PD. There are some diagnostic tests that can help aid in the official diagnosis of PD such as, SPECT DaTscan. This literature review compares different AI methods that further help the readability of DaTscans. One of these is a Local-interpretable Model-Agnostic Explainer (LIME). This application allows visual tracings around the ROIs (putamen and caudate region) as well as increased dopamine activity in the areas around the ROIs to determine the diagnosis of the patient. This can be seen through the super-pixels that the LIME model applies. The other computer-aided method is a Support Vector Machine (SVM) classifier. This method produces quantitative measures based on striatal intensity, shape, symmetry, and extent.

Methods: The LIME method utilized data and case studies from Parkinson's Progression Markers Initiative (PPMI) which, is funded by The Michael J. Fox Foundation for Parkinson's Research. The dataset was divided into two classes: PD (N = 430) and non-PD (N = 212). The raw SPECT DaTscan images went through preprocessing before they were added to the data (attenuation correction & cropping). Cropping was applied to bring uniformity to size because of different size brains. The SVM method had a probable PD group of 31 and a healthy, non-PD, control group of 12. These images all went through preprocessing for more accurate results. The raw SPECT data went through intensity normalization, segmentation, and ellipsoid fitting.

Results: After applying augmentations to all the subsets in the LIME model, the review was based on 64 test images (PD = 42, non-PD = 22). Ultimately, after applying the parameters of an optimal threshold, PR (precision recall) and a ROC (Receiver Operating Characteristic) curve, this study resulted with an accuracy of 95.2%, specificity of 90.9%, sensitivity of 97.5%, and precision of 95.2%. To break that down further, there were 40 true positives, 18 true negatives, 4 false positives, and 1 false negative. The SMV tested on a total of 43 SPECT images. Ultimately, they resulted in an accuracy of 97%, specificity 100%, sensitivity 96%. The ellipsoid fitting went through a non-linear optimization algorithm and was then added with the rest of the parameters into the SVM classifier to obtain these results.

Conclusion: Both studies were done in attempt to have a more efficient method of diagnosing PD on SPECT DaTscan images. Both have room for improvement however, they both proved to be successful in efficiently diagnosing PD vs non-PD. Both studies used similar pre-processing techniques to reach their conclusions. The LIME model used a larger dataset compared to the SVM method which, can ultimately affect the result of accuracy. The LIME model also used all stages of PD for their control group while, the SVM method only used PD patients that were already in the later stages of the disease. I personally favored the LIME model over the SVM

model; however, both models proved to be dependable and provides essential framework for future computer-based diagnoses for Parkinson's Disease.
Submitted by:
Julia Kuhn

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study stated that a decline in any amount in the first RLT cycle is associated with prolonged survival, pain relief and improved quality of life [4,2]. In another study, 10 patients underwent only 1 cycle of RLT, 70% of them demonstrated a decline in PSA level with more than 50% decline in PSA levels in rest [3]. Furthermore, another cohort of 24 patients received 2 cycles of RLT; 15 of them experienced a >50% decline in PSA levels [3]. Lu-177 PSMA RLT have shown promising results of antitumor activity with favorable toxicity profiles [1]. Follow-up included blood tests every 8 weeks to evaluate for hemototoxicity and PSA response before commencing to the next cycle [1,2,3,4]. Finally, another study that focused on patients that have undergone Xofigo prior to RLT stated that there was no increased hematotoxicity in patients that received RLT after exposure to Ra-223 or chemotherapies, further emphasizing that toxicity depends on the extent of bone and bone marrow metastases [1] .

Conclusions: Despite having RLT as their last option, mCRPC patient's response to RLT was superior to the hormonal therapy, chemotherapy, and other immunotherapy a mCRPC patient would usually receive. The process of internalization of the RL into the cell after binding to the PSMA has revolutionized RLT for mCRPC perhaps in the future becoming the new Xofigo as it not only improves overall survival and quality of life but also alleviates bone pain.

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The EXPLORER total-body PET scanner.

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Positron Emission Tomography (PET) imaging reveals information pertaining to the metabolic mechanisms of various physiological processes of the human body. While this noninvasive imaging technique has many advantages, drawbacks include long imaging time, low signal-to-noise ratio (SNR), and concerns about radiation exposure (*2*). Such limitations have inspired researchers at UC Davis to develop the EXPLORER, the first total-body PET scanner. Its design allows scans to be completed with a 40-fold reduction in patient dose or scan time, while producing high quality diagnostic images with improved sensitivity and SNR over traditional PET scans.

Methods: A review of current literature was performed to investigate the potential advantages of the EXPLORER total-body PET scanner versus current PET imaging technology.

Results: The distinction between whole-body versus total-body PET is what sets the EXPLORER apart from traditional PET imaging. Modern PET scanners are capable of performing whole-body imaging in which several bed positions are scanned until the desired anatomical coverage is met for the indicated study. PET scanners detect less than 1% of the available emission signal because only about 1/8 of the average adult body is covered within the scanner's axial field of view (FOV). The EXPLORER makes total-body PET possible because it has more detectors, extending the FOV of typical PET scanners from 20-30 cm to about 2 meters, providing full body coverage with a single scan (*4*). This allows physiologic information to be collected from all body tissues simultaneously and improves the likelihood that emitted annihilation photons will hit the detectors, thereby improving the image's SNR and spatial resolution. The EXPLORER's 40-fold increase in sensitivity allows scans can be completed in less time or with less radiation (*3*). A total-body PET scan with a typical 10-20 mCi dose of F-18 FDG can be completed in under one minute; shortened scan time reduces the chance of patient motion and introduces the possibility for PET scans to be completed in a single breath. Studies have shown that a dose of 0.7 mCi or less of F-18 FDG is adequate to acquire diagnostic quality images (*1*). This would benefit patients with chronic conditions requiring repeat scans and populations such as children and pregnant women for whom the radiation dose of a PET scan would no longer be a limiting factor. The EXPLORER's high sensitivity also warrants extended delayed imaging in which scans can be performed up to 5 half-lives later than previously possible (*1*). Extended delayed imaging improves image contrast due to enhanced tissue clearance, meaning the EXPLORER can detect smaller lesions and lower grade diseases than previously permissible with traditional PET.

Conclusion: The EXPLORER can potentially transform diagnostic imaging as we know it today. Improvements in geometric coverage and sensitivity translate to faster scan times and enhanced disease detection over current technology. Reduced radiation exposure would allow for an expanded use of PET imaging in pediatrics and patients with chronic disease for whom recurrent scans are essential in monitoring disease progression.

Submitted by:
Anna Perillo

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An investigation on the role of F-18 FDG PET/CT imaging on brown adipose tissue for potential weight loss benefits

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Obesity is a very prevalent problem affecting nearly 42.4% of the United States. There are an abundance of detrimental effects caused by obesity, including heart disease, strokes, cancer and large medical cost burdens[1]. Obesity is characterized by an increase in adipose tissue mass. Brown adipose tissue plays an important role in non-shivering thermogenesis through the metabolism of glucose and fatty acids[2.] With the activation of brown adipose tissue, there is energy spending at the result of increased glucose uptake. Studies have been conducted to explore the prevalence of brown adipose tissue in humans that could potentially assist in future studies exploring weight loss benefits in obese adults.

Methods:
A study was conducted at a large academic medical center in Boston using previous PET scans and patient demographic data acquired from August 2003- May 2006. This included 3,640 F-18 Fluorodeoxyglucose PET/CT scans from 1,972 patients. The numerous diagnostic studies were evaluated for the presence of brown adipose tissue deposits. The adipose tissue deposits needed to be at least 4mm in diameter with FDG uptake values of at least 2.0g/mL to be recorded in the study[4.] F-18 FDG was used in this study because of its ability to concentrate in cells that undergo glucose metabolism. Once F-18 FDG is transported into these cells, it is phosphorylated and consequently trapped, making it ideal for imaging[3].

Results: A considerable amount of brown adipose tissue was visualized with the assistance of F-18 FDG PET/CT imaging. Regions of uptake included the cervical supra-clavicular region, ventral neck, and sternocleidomastoid muscles. Women had a 7.5% positivity rate with 76 of 1,013 participants testing positive, while men had a 3.1% positivity rate with 30 of 959 participants testing positive for BAT uptake. This demonstrates a 2:1 female to male ratio of brown adipose tissue activation. Some of the factors correlated to BAT activation included outdoor temperature on the day of the scan (probability: 0.02%), participant age (probability: .001%), beta blocker use (probability: .001%) and body mass index of participants (probability: .007%).

Conclusion: Brown adipose tissue is functionally present in humans and its metabolic rate is affected by temperature, age, beta blockers and body mass index. The study suggests BMI and

age are inversely correlated to the amount of brown adipose tissue deposits. The metabolic nature of this tissue suggests the ability to increase metabolism in humans when activated. Previous studies have been conducted to evaluate the use of temperature facilitated activation of BAT as well as BMI on BAT prevalence. Further studies in conjunction with F-18 FDG imaging are being conducted to study the future of BAT activation on obesity management.

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Lutathera therapy as treatment for neuroendocrine tumors.

Cassandra Pierre

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Neuroendocrine tumors (NETs) are malignant tumors commonly arising from the body's endocrine glands. Typically found in the gastrointestinal tract and lungs, these tumors usually express somatostatin receptors. Previously there has been limited treatment for these tumors; however, in January 2018, the Food and Drug Authority (FDA) approved Lutetium Lu-177 Dotatate (Lutathera) as the first peptide receptor radionuclide therapy. Lu-177 Dotatate binds to the somatostatin receptors and is a beta emitter with a maximum beta range of 2mm in tissue. Lu-177 Dotatate has demonstrated effectiveness in response rates and progression free survival of patients with NETs. These results have provided promising outcomes for the use of Lutathera therapy as treatment for NETs.

Methods: Several journal articles were reviewed (1,2,3) pertaining Lutathera treatment. In addition to this, a case study was reviewed of a patient who received and completed Lutathera treatment. The patient was given 200mCi of Lutetium 177 Dotatate on four separate occasions with 6–8-week intervals in between. The patient was also given an amino acid infusion to protect the patients' kidneys. The infusion started before the administration of Lutathera and continued four hours after administration. After the completion of all the Lutathera treatments, the patient had two separate Gallium-68 Dotatate PET/CT scans to monitor the progression of his NETS.

Results: Prior to treatment**,** a Gallium 68 Dotatate scan was done to stage the patients NETs. The patient then received a total of 4 Lutathera treatments. Additional Gallium 68 Dotatate Pet/CT scans were done 1 month and 3 months after completion of the last Lutathera treatment. The first scan after treatment demonstrated minimal progression of malignant disease, however certain regions remained unchanged compared to the very first scan. The second scan demonstrated no significant change in comparison with the previous scan. There was no definite new Dotatate avid lesion suggestive of a new metastatic site. This falls in line with the effectiveness of Lutathera therapy as treatment.

Conclusion: Lutathera shows promising results in the management of NETs compared to previous treatments and is a safe and effective therapy option for patients with NETs. While not a cure, Lutathera slows the progression of disease, allowing patients to live longer and improve their quality of life.

Submitted by:
Cassandra Pierre

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Efficacy of Ga68 DOTATATE over In-111 pentetreotide for neuroendocrine tumor

Jigmey Sangye

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Objectives: In-111 pentetreotide, also commonly known as Octreotide, has been used to detect neuroendocrine tumors, metastasis from neuroendocrine, and some non-neuroendocrine tumors with somatostatin receptors. In-111 Octreotide is a radiolabel analog of somatostatin, and because these tumors have high amounts of somatostatin receptors, the tumor is detected more easily. Like Octreoscan, PET Ga-68 DOTATATE also binds to somatostatin receptors but provides better spatial resolution than planar and SPECT images, therefore, it increases the sensitivity and specificity of the exam, (Kumar, 2014).

Methods: Thirty-seven patients underwent octreoscan on the Siemens dual detector gamma camera. Twenty-eight days later, the same patient went through Ga68 DOTATATE on the Biograph 16 Siemens PET/CT scanner. The findings of the two scans were then compared with other modalities such as CT or MRI to accurately confirm the presence of lesions, with a consensus read afterward. “Lesions quantified were in organs, lymph nodes, and bones”, (Kumar, 2014)

Results: When the results from the two scans were compared, Ga-68 DOTATATE showed a significantly higher detection rate than octreotide scan for lesions in the organs and bones. Although, findings on the lymph nodes were pretty similar between the two scintigraphy.

Conclusion: Overall, Ga-68 DOTATATE is more superior than octreotide scan for staging neuroendocrine tumors with somatostatin receptors. In additional, PET provides better resolution, higher sensitivity, lower radiation and length of exam is significantly shorter. However, this does not mean that PET is always preferred over planner or

SPECT. For example, in neuroblastoma FDG PET is more reliable in detection of lesion in soft tissue than MIBG where as MIBG is more superior than FDG PET for bone lesion.

Summited by:
Jigmey Sangye

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Xofigo: A modern method of prolonging life in castration resistant prostate cancer patients.

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Xofigo is a type of cancer treatment that is indicated for those with castration resistant prostate cancer, symptomatic bone metastases, and no known visceral metastatic disease. Xofigo also known as Radium 223, is an alpha particle emitting radioactive therapeutic drug that imitates calcium. Being able to do so gives it the ability to form hydroxyapatite mineral complexes in bone metastases or areas of high bone turnover. Alpha particles offer unique attributes not found in beta or gamma emitters, including a high linear energy transfer.(3) The high linear energy transfer is reported to lead to a high frequency of double strand DNA breaks in surrounding cells, that can inhibit or prevent bone metastases.(3)The therapeutic dose is 1.35uCi/kg. It is administered at 4 week intervals, totaling six injections.

Methods:
Patients with hormone-refractory prostate cancer often have multiple bone metastases. The resulting bone pain is associated with reduced life quality, increased cost of therapy, and impairment of overall survival.(1) In, a randomized study using the α-emitter 223RaCl2 showed for the first time, a longer overall survival of 3.6 months in treated patients as a sign of an antitumor effect.(2) The time to first skeletal-related events was also significantly longer in the therapy group compared with placebo. Because of the short range of α-emitter, the bone marrow toxicity of radium therapy is low, and so this radionuclide could also be a candidate for combination with chemotherapy.

Results: Radium 223 significantly prolongs the overall survival of patients with castration resistant prostate cancer and bone metastases. Life expectancy was increased approximately 3.6 months when compared to those who received placebo, giving a median life expectancy of 14.9 months, and a 36-month survival of 46%, associated with a 30% reduction in death risk.(2)

Conclusion: Radium 223 is the first treatment directed to bone that has demonstrated significant improvement on overall survival. It also prolonged the time to the first skeletal event and the median time to PSA increased significantly.(2) It is important to emphasize that radium-223 is the only radiopharmaceutical to demonstrate a life-prolongation effect.

Submitted by:
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A literary review of F-18 Florbetapir scans for Cardiac Amyloidosis.

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Cardiac amyloidosis (CA) is a rare and under-diagnosed condition characterized by the deposition of well-structured protein fibrils, proteoglycans, and serum proteins as amyloid plaques inside the heart [7]. The process of diagnosing CA has been the subject of improvement in the recent decades and the role of Positron Emission Tomography (PET) imaging has developed significantly with the aid of a few ground-breaking research studies. Since the FDA's approval of F-18 Florbetapir (Amyvid) in April of 2012 for the localization of beta amyloid plaques, Amyvid PET imaging has become an important tool for early diagnosis and accurate noninvasive differentiation between wild type (ATTR) and light chain (AL) CA [4].

Methods: Numerous journal articles were reviewed pertaining to the development of the protocol for F-18 Florbetapir scans. Additional articles were reviewed on the quantification and methods of diagnosis of CA utilizing different modalities. Furthermore, the author was allowed to observe the current research protocol for performing Amyvid scans during student observations in a large academic medical center department in Boston.

Results: Several PET imaging protocols for CA have been utilized with different quantitative processes. The current research protocol for Amyvid imaging involved the intravenous injection of 10 mCi with an immediate 30-minute gated Cardiac PET acquisition, followed by a 30-minute skull base to pelvis acquisition, and completed by a 10-minute PET brain acquisition [1]. These multiple acquisitions allow for the dynamic analysis of the heart's retention of the Amyvid, as well as the survey for non-cardiac organ involvement of the Amyloidosis. Throughout all studies reviewed the time activity curves of patients with confirmed AL CA showed the highest retention of activity with ATTR CA having significantly less retention and control patients having significantly less retention than the ATTR CA patients [8].

Conclusion: After review of all the articles, it is evident that PET imaging of Cardiac Amyloidosis has established itself as an important tool in the differentiation and quantification of Amyloidosis throughout the body. Furthermore, PET imaging has made great progress in developing in the process of diagnosing and differentiating this under diagnosed condition while still maintaining an non-invasive and clinically accessible approach.

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Comparative study between Tc-99m and PET/CT agent of NaF for detecting bone metastases in the body

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Objective: With the introduction of PET/CT in nuclear medicine, the NaF (sodium fluoride) has become an increasing interest in detecting osseous metastases with known cancer. Earlier, the Tc-99m was related with decreased sensitivity and poor resolution with limited specificity. The high resolution and better sensitivity of F-18 NaF has made it an ideal agent in bone disease. Due to the higher first extraction rate (100%), the PET/CT agent has detection rate for lesion is much improved.

Method: Tc-99m and F-18 NaF bone scan was performed on proven cancer patients in 3 case studies. In first case study of 37 patients 9 had breast cancer, 8 lung, 6 prostrate, 2 gastric cancer, 1 nasopharynx, 1 cervix, 1 bladder, 1 colon, 1 renal cell carcinoma, 1 renal cell carcinoma and neuroendocrine tumor, 1 colon and prostrate, 1 lung and prostrate, 1 pancreas, 1 Hodgkin's Lymphoma, 1 non-Hodgkin Lymphoma, and 1 uterine leiomyosarcoma. In second case study 44 patient had various forms of cancer. In third case study of 77 patients 51 had prostate cancer, 7 breast cancer, 12 sarcoma, and 7 other cancers. The lesions were detected, and test images were compared.

Results: Tc-99m and F-18 NaF were used to perform whole bone scintigraphy. Both scans demonstrated equal lesions in patients but F-18 NaF showed multiple pathological foci in greater percentage of patients. This resulted in F18- NaF being a better choice at showing lytic and blastic lesions. Higher resolution and higher target/background ratio provided much clearer images of small lesions. Additionally, Tc-99m demonstrated no bone marrow involvement, whereas F-18 NaF resulted in 13% positive cases. Overall, F-18 NaF performed better at detecting bone metastases in the body than the Tc-99m. Tc-99m and F-18 NaF has similar biodistribution but F-18 has lower protein binding which makes it better and faster for single passage extraction. This also resulted in higher concentration of tracer in bone; roughly twice greater than Tc-99m. It has a yielded sensitivity of 96% and specificity of 91%, thus providing a much superior images of bone.

Conclusions: The F-18 NaF provide superior images with much higher target background contrast and improved anatomical information. It has greater biodistribution of the fluoride tracer. F-18 NaF uses higher-energy photons which allows for better tissue penetration than Tc-99m single-photon technique. Thus, the F-18 NaF is better choice for detecting bone metastases.

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A literature review of the advantages using antibody-based radiotracers in PET/SPECT imaging for chronic inflammatory diseases.

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Chronic inflammatory disease (CID) is a prolonged disease lasting from months to a lifetime, causing progressive physical damage. Early diagnosis is critical for a treatment to be tailored to the patient and symptoms managed. Many non-invasive imaging techniques exist aside from nuclear medicine; however, those modalities do not provide functional molecular information with high contrast and sensitivity into the nano- or pico- molar range (1). Monoclonal antibodies (mAbs) are synthesized to effectively evaluate chronic inflammatory diseases in addition to classifying patients into their appropriate treatment. Antibody-based tracers are perfect contenders for this highly specific diagnostic role because the diversity among its possible targets, including adhesion molecules, immune cell markers, and cytokines.

Methods: Multiple journal articles were reviewed for understanding the synthesis of monoclonal antibodies, and their nuclear imaging application on a variety of animal models pertaining to CID.

Results: To understand the pharmacokinetics of the antibody-based tracers, a general comprehension of the synthesis is necessary. Antibodies are conjugated with chelators using the reactive amine or sulfhydryl groups on the antibodies, followed by an incubation period with radiometal solutions (1). This intact mAb molecule can be manipulated into antibody fragments with lower molecular weights to achieve a faster plasma clearance with the potential enhancement in the biodistribution (1). An example of antibodies targeting immune cell markers is the development of ^{99m}Tc-labeled Nb targeting macrophage mannose receptors in macrophages and osteoclasts. A SPECT/CT was performed with ^{99m}Tc-labeled Nb on mice models with collagen-induced arthritis. Figure 1 depicts increased uptake in the arthritic paw of the symptomatic mouse model, indicated by the white arrows. The opposite non-arthritic paw also shows slight signal of the tracer suggesting the potential utility of ^{99m}Tc-labeled Nb in the early detection of rheumatoid arthritis before presentation of clinical symptoms (1). This study displays the advantages of antibody-based tracers in CID with more that can be found in references.

Conclusion: Along with the many antibody-based diagnostic options, there are nearly 35 antibody-based treatment options approved for use in various cancer types (2). This further supports the claim of antibody-based tracers having multiple uses beyond imaging. Furthering this research will provide a greater understanding of the various CID conditions, and grant physicians more tools for diagnosing and monitoring their patients (1).
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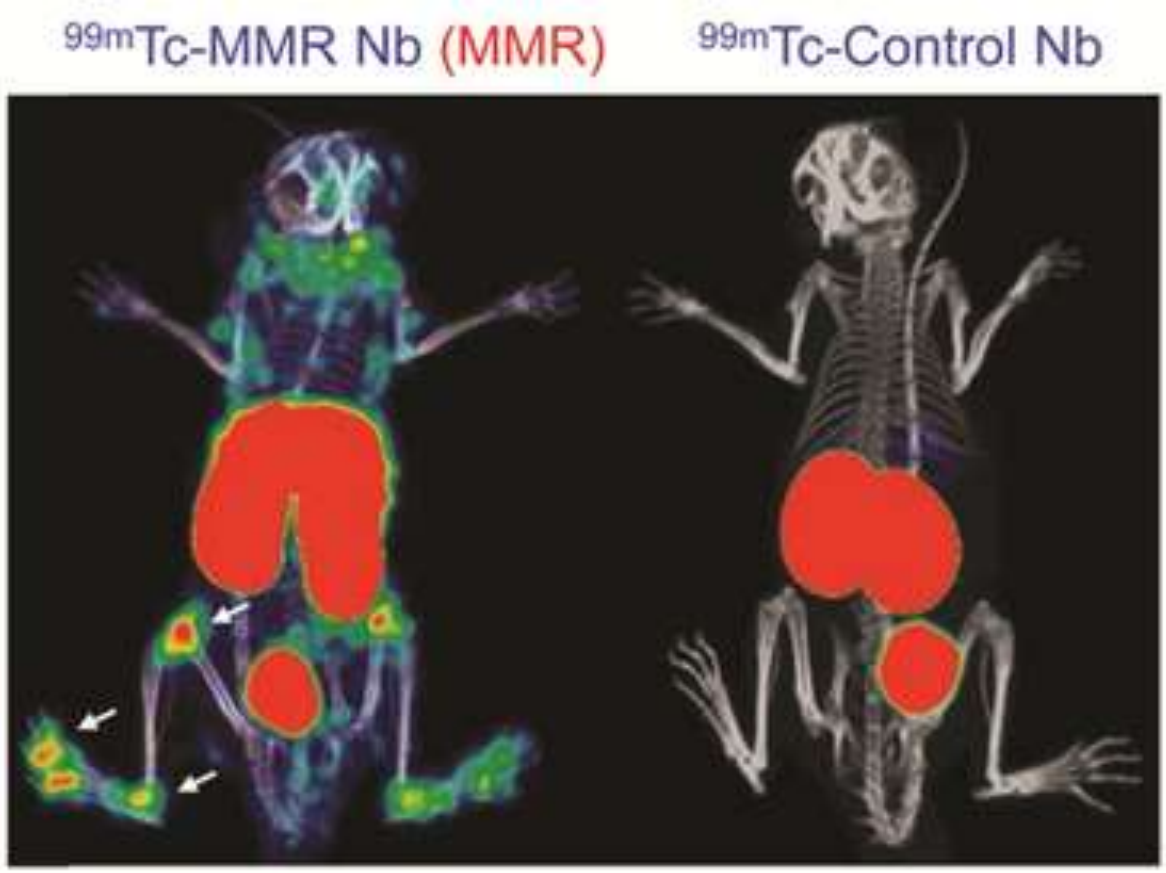
Figure 1



A case study evaluating 3 hour delay images to diagnose transthyretin cardiac amyloidosis with 99mTc-PYP.

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In Nuclear Medicine Technology (NMT), 99mTc-PYP is used to aid in the diagnosis of transthyretin cardiac amyloidosis (ATTR). Cardiac amyloidosis can occur because of the progressive build up of tissues which in turn can negatively affect the function of the heart. The American Society of Nuclear Cardiology (ASNC) states to include both 1 and 3 hour imaging protocols. Patients are said to be positive for ATTR with a myocardium to contralateral lung ratio (H/L) of 1.5 or greater and negative with a ratio of 1 or less (1). Studies were assessed to determine the need for 3 hour delayed images and how that could affect the diagnosis of cardiac amyloidosis.

Methods: Multiple studies have been reviewed for the use of 3 hour delayed imaging.

Results: In the first case study, 35 patients underwent 99mTc-PYP imaging. Of the 35 patients evaluated 10 patients had a 1 hour H/L ratio of 1.5 or higher, and 2 out of these 10 had a visual grade of 1 or less on the 3 hour image (1). This study determined 30% of the 10 patients with a 1 hour H/L ratio were false positives, showing no uptake on the 3 hour delay (1). The second case study showed 122 subjects who underwent both 1 and 3 hour planar/SPECT 99mTc-PYP imaging (3). About 66% of the subjects had a H/L ratio between 1 and 1.5 on the 1 hour images, and only 11% of these patients had grade 1 uptake in the 3 hour delay (3). This study concludes that the use of 1 hour imaging alone could lead to a misdiagnosis, and that 3 hour imaging is still necessary.

Conclusion: Both studies aid in determining that 3 hour imaging is necessary in diagnosing transthyretin cardiac amyloidosis. Inconsistency between the images could be caused by blood pooling which could elevate the 1 hour H/L ratio compared to the delayed image and lead to a misdiagnosis if the 3 hour delay isn't done (1).

Submitted by:
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A Study Comparing the Effectiveness of ^{99m}Tc Lymphoseek and Filtered ^{99m}Tc Sulfur Colloid Mapping Sentinel Lymph Nodes in Breast Cancer Patients.

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Finding the sentinel lymph nodes in pre-operative breast cancer patients has greatly lowered the number of lymph nodes removed during surgery. This is important because a patient who has less surgical intervention will experience less effects post-surgery. Currently there are two radiopharmaceuticals being used to perform the lymphoscintigraphy procedure: Lymphoseek and filtered sulfur colloid. Lymphoseek, also referred to as ^{99m}Tc tilmanocept, is a receptor-targeted radiopharmaceutical made specifically for sentinel lymph nodes. Filtered ^{99m}Tc sulfur colloid is the more traditional radiopharmaceutical used in mapping sentinel lymph nodes. This literature review compares the two tracers to see how well they target the sentinel lymph nodes and how many are removed during surgery.

Methods: A literature review was performed on two studies. Both studies took two groups of women with invasive breast cancer and compared how many nodes would need to be removed based on the radiopharmaceutical used. These women were all undergoing SLN biopsies at UCSD (University of California San Diego).

Results: In one study, 84 women were injected with Lymphoseek and 115 women were injected with Tc SC, both tracers were accompanied by VBD. Both groups of patients received the same dose of 0.5 mCi whether Lymphoseek or Tc SC was used. The identification rate for both tracers was 100%. However, patients injected with Lymphoseek needed fewer SNLs removed compared to Tc SC. 96% of Lymphoseek patients had 3 or less nodes removed. 20% of Tc SC patients needed more than 4 nodes removed. Tilamanocept was specifically created to be a receptor-targeted radiopharmaceutical, therefore it was designed to achieve superior SLN-targeting compared to Tc SC. The average number of nodes removed using Lymphoseek was 1.85 and the average number for Tc SC was 3.24. Similar results were identified in the second study. 11 patients were used in the data collection: 5 Lymphoseek and 6 Tc SC. The average SLNs removed in the Lymphoseek was 1.5 and 3.5 for Tc SC. This is important because removal of fewer lymph nodes and less surgical intervention reduces the chance of a patient's morbidity.

Conclusion: As a literature review, it was proven that fewer SNLs were removed when Lymphoseek and VBD were used in pre-operative breast cancer patients. Even though both tracers had a 100% identification rate for SLNs, the receptor-targeted tracer, tilmanocept, was the superior radiopharmaceutical.

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Amyloid-PET imaging compared to FDG-PET imaging for aiding in the diagnosis of Alzheimer's Disease

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Positron Emission Tomography (PET) imaging with Fluorodeoxyglucose (FDG) has been useful in assisting in the diagnosis of neurodegenerative diseases such as dementia, frontotemporal lobar degeneration, and Alzheimer's Disease. Amyloid-PET imaging is still being researched, however has proven to aid in identifying biomarkers that are specific to Alzheimer's Disease. FDG-PET looks at the hypometabolism of the brain and provides information on many brain pathologies, while Amyloid-PET looks at amyloid-B plaques which are a pathological hallmark of AD. If Amyloid-PET imaging is successful in identifying AD, it could change the course of treatment for many patients as the only way to diagnosis AD in a patient now is by performing an autopsy of the brain after death. Could Amyloid-PET imaging outperform FDG-PET imaging in diagnosing and differentiating AD and/or other neurodegenerative diseases?

Methods: Several journal articles were reviewed regarding Amyloid-PET and FDG-PET imaging in diagnosing Alzheimer's Disease. Journal articles that evaluated these radiopharmaceuticals did so by comparing their visual and quantitative diagnosis of AD.

Results: The journal articles compared multiple scans of patients with known AD and those without. These scans were interpreted by nuclear medicine physicians with a great deal of experience in reading FDG-PET brain scans and were taught how to read Amyloid-PET scans. The nuclear medicine physicians were unaware of the patients' clinical diagnosis when interpreting the images. In some cases, the AD was confirmed after the patient's death by performing an autopsy. When assessing these scans visually they were read using the same image display software and color scale. Both scans were assessed quantitatively by manually drawing a region of interest on both cerebral hemispheres to obtain an average uptake value. Amyloid-PET's quantitative analysis was significantly better, this was also shown through their Cohen's effect size which is a way of calculating the size of difference between two groups. Cohen's effect size for Amyloid-PET was 3.87 and 1.53 for FDG-PET.

Conclusion: The studies showed the diagnosis of AD was easier to read and more accurate visually and quantitatively for Amyloid-PET than FDG-PET images. Amyloid-PET shows great promise in aiding the diagnosis of Alzheimer's Disease

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Could Nuclear Medicine Cardiac Amyloid Imaging Be Beneficial For Patients Diagnosed with Carpal Tunnel Syndrome as A Precautionary Cause?

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Cardiac nuclear medicine imaging has developed in strides to produce the best images and protocols for cardiac patients with different cardiology ailments. There is a cardiac nuclear medicine scan that can be used as a precautionary step for patients who have known carpal tunnel syndrome that could also have cardiac amyloidosis. The Tc-99m PYP scan is used to show deposits of amyloid in the heart known as cardiac amyloidosis. Cardiac amyloidosis is a deadly disease that if untreated could result in death as early as 6 months (Sharma, 2020). Another way to detect cardiac amyloidosis is by a cardiac biopsy where a small sample of heart tissue is taken out and examined for amyloid deposits (Hopkins, 2021). With this being said, the correlation between carpal tunnel syndrome and cardiac amyloidosis is becoming more relevant. Would this scan be beneficial for patients with known carpal tunnel syndrome because of the correlation is has with the life-threatening cardiac amyloidosis disorder?

Methods: This is a literature review to study the risks of amyloidosis compared to carpal tunnel syndrome. The patients for this study were gathered from Danish healthcare systems who underwent surgery for carpal tunnel syndrome, information was taken from inpatient and outpatient healthcare facilities, resulting in 56,032 patients with carpal tunnel syndrome and 56,032 patients used as a control group (diagnosed amyloidosis). Patient information was gathered for 16 years, from January 1, 1996 to December 31, 2012. The parameters that were used for this research included patients who underwent carpal tunnel syndrome surgery, but patients with prior known amyloidosis who were undergoing carpal tunnel surgery were not included and the patients had to be alive for the whole duration of the study.

Results: The results to this research were that the patients who had diagnosed carpal tunnel syndrome had a higher chance of developing amyloidosis than those without diagnosed carpal tunnel syndrome. The incidence of amyloidosis is low, 0.10% of the patients who were diagnosed with carpal tunnel syndrome but this is still more significant than those without which was 0.006%. Of the patients who developed amyloidosis, it took approximately 3.1 years after carpal tunnel surgery to be diagnosed. Tc-99m PYP imaging is highly accurate for the diagnosis of cardiac amyloidosis, with a positive predictive value of 100% (Masri, 2020). Tc-99m PYP has a sensitivity of 97% and specificity of 100% for detecting cardiac amyloidosis which makes this an accurate test for diagnostic purposes (Bokhari, 2015).

Amyloidosis	Unadjusted Hazard Ratio 95%SD	P Value	Adjusted Hazard Ratio 95%SD	P value
Carpal Tunnel Syndrome	1.59 (1.49-1.69)	<0.0001	1.54 (1.45-1.64)	<0.0001
Control subjects	1.00		1.00	

TABLE 1: Unadjusted and Adjusted HRs for Amyloidosis Outcomes Associated With CTS

Conclusion: In conclusion, it would be beneficial for patients who underwent carpal tunnel syndrome to have a Tc-99m PYP study done on them as a precautionary cause for amyloidosis. Ideally the PYP study

should take place at or around 3 years post carpal tunnel syndrome surgery as this was the average timing it was being diagnosed for the patients in the research group. From the research, patients with carpal tunnel syndrome have a greater chance of developing cardiac amyloidosis than patients without carpal tunnel syndrome. Detecting amyloidosis is important with the frequency in finding it with the PYP scan because it is noninvasive and can be diagnosed quickly and accurately. Once diagnosed patients can be treated with medications to stabilized or silence the gene producing the amyloid deposits.

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Improving the patient experience during 177 Lu-DOTATATE therapy by changing the amino acid infusion required as part of the therapy: a retrospective review

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Nausea and vomiting are known side effects that can result from the administration of amino acid infusions used for renal protection in therapy with 177 Lu-Dotatate for neuroendocrine tumors. In this retrospective study we are quantifying how many patients experienced these side effects along with further evaluating if the change from Clinisol to a compounded Arginine/lysine solution lead to less nausea and vomiting in patients.

Methods: The information from this study was collected from the Lifespan Redcap database from a prior study that looked into the factors that lead patients to discontinue treatment with 177 Lu – Dotatate. The study had a total of 17 patients between the dates of 8/10/2018 and 8/4/2020. The therapy consists of four infusions over a period of time and the dates and symptoms for each infusion were reviewed. The data was organized in an excel spread sheet and was then used to differentiate and compare between those patients who experienced nausea and vomiting and those who did not.

Results: Clinisol is a bulk amino acid infusion with more than 17 amino acids. This solution was originally given to all the patients treated before May,2019. Clinisol was replaced by an Arginine/lysine infusion as this one contained the 2 essential amino acids needed for renal protection.
7 patients underwent therapy prior to May 2019. Which means they were treated with Clinisol . It was found that all 7 patients who underwent therapy prior to this change in amino acids experienced nausea and vomiting in each one of their infusions.
7 patients underwent therapy after May,2019. This group of patients were treated exclusively with the new solution of amino acids Arginine/lysine. Only 2 of these patients experienced nausea/vomiting; and 5 patients had neither nausea nor vomiting.
Interestingly, 3 patients fall in the middle. These 3 patients greatly highlight the difference in nausea and vomiting caused by the old and new amino acid infusion. In patient X: 3 out of 4 infusions were done with Clinisol, during the first 3 infusion the patient experienced consistent nausea and vomiting. The last infusion was with the new Arginine/lysine infusion and the patient experienced neither nausea nor vomiting. In patient Y: The patient received only the first infusion with Clinisol in which the patient experienced nausea and vomiting. For the last 3 infusions the patient received Arginine/lysine and the patient was symptom free. Patient Z: The patient received 2 out of the 4 infusions with Clinisol and experienced nausea and vomiting , for the last 2 infusion the patient received the Arginine/lysine infusion and experienced no nausea or vomiting

Conclusion: The patients who experienced more nausea and vomiting were those patients who received Clinisol for their amino acid infusion. After the hospital changed from Clinisol to the Arginine/Lysine infusion the nausea and vomiting in patients decreased to a minimum. As a result, the Arginine/Lysine amino acid infusion is better tolerated by patients by reducing nausea and vomiting and contributes to a better patient experience.

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Which imaging technique is more suitable to diagnose Cardiac Sarcoidosis: PET/CT or Cardiac Magnetic Resonance Imaging?

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Sarcoidosis is a seemingly mysterious autoimmune disease that causes inflammation and organ damage, and it can affect anyone. Cardiac Sarcoidosis (CS) can cause arrhythmias, and a depressed left ventricular ejection fraction (LVEF), which can lead to death if it is untreated. It is extremely important to diagnose early to best determine the prognosis for the patient. 18F-Fluorodeoxyglucose (FDG) positron emission tomography (PET) is becoming more widely utilized in the diagnosis and clinical management of sarcoidosis. Numerous studies highlighted the advantages of FDG-PET in the diagnosis of CS over cardiac magnetic resonance imaging (CMR). The purpose of this literature review is to analyze articles to demonstrate the superiority of PET/CT over CMR.

Method: This literature review analyzed three articles relating to the diagnostic accuracy of FDG-PET/CT over CMR. The studies were performed on patients who were instructed to be on low carbohydrate diet, high fat diet and NPO for 4 hours prior to the study, and underwent the myocardial perfusion images with 82Rubidium or 13N-ammonia, or 99mTc-sestamibi or tetrofosmin on a single-photon emission computed tomography camera (SPECT). After the perfusion study, F-18/FDG- PET/Computed Tomography was performed. Additionally, one article used data from prior studies to compare the diagnostic accuracy.

Result: In the study conducted by Dr. Divakaran (2019), FDG-PET/CT and CMR imaging were performed on 49 patients at Brigham and Women's Hospital and Massachusetts General Hospital to assess the extent of CS disease. The data showed that FDG-PET had a specificity of 100% and a sensitivity of 83.3% using a highly probable cutoff, while the CMR had a specificity of 90% using a highly probable cutoff (Divakaran et al., 2019). In the study conducted by Genovesi (2019) supported that the affinity and blood flow of F18-FDG PET are different in each stage of CS. The data showed that 18F-FDG PET yielded 89% of sensitivity and 78% of specificity for CS detection. In another study, data from multiple prior studies were collected to demonstrate that FDG-PET has a high sensitivity of 80-100%, while CMR has shown a sensitivity of 75% (Roth et al., 2020).

Conclusion: Diagnosing cardiac sarcoidosis is extremely imperative to start early treatment and decrease motility. A variety of different literatures indicate that FDG-PET has higher specificity or sensitivity compared with CMR. Owing to the FDG-PET ability to detect inflammatory cellular infiltrates, FDG-PET is more suitable to diagnose and to assess the extent of CS disease.

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