Establishing and Expanding Nuclear Medicine Programs

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Key existing Applications of $^{99m}$Technetium

Myocardial perfusion imaging for coronary artery disease (CAD)

- Decreased use in the US during the last 5 years due to changes in the reimbursement system
- Still dominates the overall demand for technetium-99m due to the high prevalence of CAD and relatively large amounts of $^{99m}$Tc needed/scan
- Well established evidence supporting its use for
  - Diagnosing CAD
  - Guiding (invasive) therapies
  - Assessing prognosis

Key existing applications of $^{99m}$Technetium

Bone scans

• Whole body imaging of bone metabolism
  – Detection of bone metastases
  – Several (smaller) indications in benign bone diseases, such as inflammation

• Part of international guidelines for common malignancies, including breast and prostate cancer (e.g. prostate cancer working group criteria).

• Use has decreased because of the success of FDG PET/CT for detection of bone and soft tissue metastases

• Still commonly used in international clinical trials of new pharmaceuticals
Key existing applications of $^{99m}$Technetium

Other applications, less commonly used but important

- Sentinel node imaging before surgery of breast cancer, melanoma, ...
- Thyroid scans
- Lung scans
- Renal scans
- Individually less commonly used than bone scans/myocardial perfusion imaging
- However, few (really) competing modalities due to simplicity and cost-effectiveness of the $^{99m}$Tc
Future development of existing applications

Solid state (CZT) detectors and dedicated camera systems
- Substantially increased sensitivity and spatial resolution of $^{99m}$Tc images
- Faster data acquisition, reduced radiation exposure
- Clinical use has started for myocardial perfusion imaging

Improved software for data analysis
- Operator independent reporting
- Quantitative instead of qualitative reporting

Multimodal imaging (SPECT/CT)
- “One stop-shop”
Bone Scan Index (BSI)

- Time consuming and complex to calculate manually
- Can now be calculated operator independently by imaging processing software
- Objective definition of disease progression in prostate cancer

Automated measurement of BSI

Anand et al. J Nucl Med (2016) 57:41-45, Figure 3
SPECT/CT with $^{99m}$Tc-DPD as “one stop shop” to evaluate bone pain

“Something is wrong with the bones of the right foot”

“Acute arthritis of the talonavicular joint”
New developments

- Development of new $^{99m}$Tc labeled pharmaceuticals has been very slow in the last 20 years
- Focus of research was on PET imaging agents because of the higher sensitivity and easier quantification of PET signals
- Unique advantages of $^{99m}$Tc compared to PET radiopharmaceuticals
  - Intraoperative detection/imaging is significantly easier due to lower gamma energy
  - $^{99m}$Tc can be used for dual-isotope imaging allowing for multiparametric imaging
  - Longer physical half-life compared to $^{18}$F allows for higher image contrast, radiation exposure is lower than for long-lived PET isotopes
- New camera systems (solid state detectors) and sophisticated reconstruction algorithms are decreasing the difference in sensitivity/quantification of gamma camera imaging as compared to PET
Imaging of lymphatic drainage with $^{99m}$Tc-Tilmanocept

Agrawal et al. MD Anderson Ann Surg Oncol (2015) 22:3708–3715, Fig 1
Intraoperative free-hand SPECT and ultrasound fusion

Wendler et al. Technical University Munich, Eur J Nucl Med Mol Imaging (2010) 37:1452, Figure 1
Bluemel et al. University of Wuerzburg, Eur J Nucl Med Mol Imaging (2016) 43:2304, Figure 2
New Imaging agents labeled with $^{99m}$Tc

Prostate specific membrane antigen (PSMA) for staging of prostate cancer


Figure 2
Dual isotope SPECT/CT for detection of endocarditis

Caobelli et al. Eur Heart J 38:436-443, Figure 2,3
Conclusions

- The medical use of technetium-99m has decreased during the last 10 years due to changes in the reimbursement system and the success of competing imaging modalities (PET/CT, MRI, CT angiography).
- However, there are several indications for which there are no cost-effective alternatives.
- New camera systems and new technetium-99m labeled radiopharmaceuticals have the potential to increase the future demand for this radioisotope or at least keep the demand stable.