A Novel High Resolution, High Sensitivity SPECT Detector for Molecular Imaging Of Cardiovascular Diseases

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Cardiovascular disease is the leading cause of disability and mortality for both men and women in the western countries. Various stem cells hold promise for the treatment of human cardiovascular disease; results of clinical trials are somewhat disappointing emphasizing the need for prudential investigation as a means of better understanding basic mechanism. Regardless of stem cell origin, future clinical trials will require that the location and number of such cells be tracked in vivo, over long periods of time. Small animals are used widely in biomedical research. Mice in particular are favorite animal subjects. We have developed a compact, open, Dual Head pinhole SPECT system for high resolution molecular imaging with radionuclides of mice, for the study of stem cells capability to recover myocardial infarction. The gamma detector is largely made of standard, on the shelf, components (pinhole tungsten collimators, pixelated scintillators, matrix of multi-anode PMTs and individual channel readout). Measurements have been performed on phantoms and live mice devoted initially to test and calibrate the system and to optimize protocols. The implemented system and the first results will be presented, demonstrating the effectiveness of our dedicated SPECT detector for small animal imaging.

SMALL ANIMAL IMAGING IN MICIOCARDIAL INFARCTION THERAPY

Acute myocardial infarction (AMI or MI), more commonly known as a heart attack, occurs when the blood supply to a part of the heart is interrupted. The resulting ischemia or oxygen shortage causes damage and potential death of heart tissue.

Post-infarction survival has improved in recent years but NONE of the therapies is able to reverse the destructive cascade that occurs after acute myocardial infarction and lead to heart failure. Right now the results of clinical trials are somewhat disappointing:

- PRECLINICAL INVESTIGATION NEEDED to better understand basic mechanisms:
  - Best cell to deliver
  - Route of delivery
  - Fate of stem cells
  - Action mechanism

Small Animal SPECT Imaging (mice) allows:

- Direct monitoring of the dynamics of the infused cells;
- In vivo monitoring of disease/therapy efficacy;
- Translational studies

PRECLINICAL INVESTIGATION NEEDED:

- Overall Resolution ~ 0.8 mm
- Sensitivity ~ 10 cps/µCi (allowing dynamic studies and Tomographic acquisition ± 1 hour)
- Field of View ~ 25 × 25 mm² (mouse thoracic area dimension)

CONCLUSION

The characterization of the upper head of the above described SPECT system has demonstrated spatial resolution capability better than 0.8 mm. Analysis of lower head data as well as the combined reconstruction from the two sets of projections are in progress. Activity is also ongoing to probe the reproducibility of pinhole SPECT measurements of global and regional ventricular function in infarcted as well as in wild type mice.

OUTLOOK

- IMPROVE RESOLUTION:
  - Gated Image
  - Heart Rate and Volume Change affect Image Quality.
  - Sub-millimetre Intrinsic resolution could be achieved with:
    - Rugged Scintillator Material CsI(Na), CsI(Tl), pixel of ~ 0.8 mm are available
    - LaBr₃(Ce) Continuous, resolution of 0.5-0.8 mm are obtainable depending on design

- IMPROVE EFFICIENCY:
  - Multi Pinhole Collimation
  - A factor 2-4 (depends on design)
  - Increase Number of Detector Heads
  - A factor 4-8 (depends on mechanical constraint)
  - Combine Reconstruction from Different Sets of Projections
  - A factor 4-8 (depends on Number of Detector Heads)

- MOVE TO MULTIMODAL APPROACH:
  - Open System Could Be Used in Conjunction with:
    - Optical Detector (high sensitivity)
    - MRI (anatomical high resolution Information)
  - to get morphological as well functional features.
  - Magnetic field requires new photodetector technology (SiPM).