Imaging of Prostate Cancer: MRI and PET

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MRI: Guiding Biopsy and Therapy

- 57 year old male, PSA 6.4
TRUS/MRI Fusion Guided Prostate Biopsy

Workflow:

- Pre-procedure:
  - MRI acquisition
  - Segmentation and Target identification

- Intra-procedure:
  - Move to procedure room
  - 3D ultrasound acquisition
  - MRI – 3D ultrasound registration
  - Targeted biopsy with realtime US/MRI fusion

References:

Singh AK, et al. BJU International 2008
TRUS/MRI Fusion Guided Prostate Biopsy

• 500 patients/3 years
• 8 patients/week

From Jochen Kruecker, Philips Research, USA
Journal of Urology

Molecular Imaging Program
Focused Laser Ablation

Test dose
3.75 W for 34 sec

Laser Doses
12 W for 32, 25, and 63 sec

Damage 18 mm by 17 mm

Temperature safety limits were set to protect the urethra, shutting down the laser power automatically.
Focused Laser Ablation

Laser Doses
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Damage 18 mm by 17 mm

Temperature safety limits were set to protect the urethra, shutting down the laser power automatically.
Is the lesion treated?

- Potential Role of PET in assessing tumor
  - C11 Acetate
  - F18 FACBC
  - F18 DCFBC
11C-Acetate PET/CT Imaging of Prostate Cancer

- A phase 2 trial of 40 patients
- 11C-Acetate PET-CT vs. MP-MRI vs. histopathology
- Equivalent to MRI for lesions >0.9cm but inferior for lesions <0.9cm
- High uptake in BPH nodules
58, M,
PSA=8.2
Gleason
3+4 tumor
18F-FACBC PET-CT Imaging of Prostate Cancer

• A synthetic L-leucine analogue
• Increased amino acid transport within tumors
• A Phase II trial of 30 patients
• 18F-FACBC PET-CT vs. MP-MRI vs. histopathology
• Open to accrual (21/30 patients)
• In collaboration with GE Healthcare
$^{18}$F-FACBC PET-CT Imaging of Prostate Cancer

57, M, PSA=5.41
Gleason 3+3 tumor
5-7min post-injection PET-CT
F-ACBC in localized disease

56 yo
PSA = 31 ng
Gleason = 3+4
SUV = 6.5

57 yo
PSA = 3.15 ng
BPH nodule
SUV = 6.8
F18-ACBC Summary

• **Results:** GE-148 (\(^{18}\)F) PET sensitivity and specificity were 0.6, 0.36 vs. enMRI 0.71, 0.21

• False positive lesions on GE-148 (\(^{18}\)F) PET were benign prostate hyperplasia (BPH) and prostatic intraepithelial neoplasia (PIN)

• The average SUV\(\text{max}\) for tumors, BPH and PIN were 6.6 (5-9.33), 8.1 (6.8-9.3), 4.8
$^{18}$F-antiPSMA PET-CT

- $^{18}$F-antiPSMA developed by Marty Pomper
- Collaboration between JHU and NCI

Published in: Sangeeta Ray Banerjee; Mrudula Pullambhatla; Youngjoo Byun; Sridhar Nimmagadda; Gilbert Green; James J. Fox; Andrew Horti; Ronnie C. Mease; Martin G. Pomper; J. Med. Chem. 2010, 53, 5333-5341.
**PSMA: Structure and Function**

- 110 kDa, type II, highly glycosylated transmembrane protein
- Member of a family of zinc-dependent exopeptidases with glutamate carboxypeptidase activity
  - NAALADase, FOLHI
- Found in prostate, brain, kidney proximal tubules, intestinal brush border membranes
- Expression is increased in prostate cancer and tumor neovasculature
- Function of PSMA in the prostate cancer is unclear; believed to play a role in tumor invasiveness
Initial Clinical Images with MIP1072 (PT 0201) at 4 hr pi
Other PET agents

• C11, F18 Choline (used in Europe, mainly for metastatic disease)
• C11 Methionine (amino acid uptake)
• F18 DHT (Dihydrotestosterone, androgen sensitivity)
Summary

• MRI is the mainstay of prostate cancer diagnosis.
• Limitations to MRI include: nonspecificity, post therapy Δ, recurrence, metastases
• Role for PET in management:
  – A number of viable candidate PET probes exist
  – Challenges:
    • Specificity: Cancer vs. BPH, PIN, inflammation
    • Sensitivity: Resolution of PET is poor compared to MRI leading to volume averaging
Acknowledgements

• NCI
  – Baris Turkbey
  – Yolanda McKinney
  – Marcelino Bernardo
  – Karen Kurdziel
  – Celene Chua
  – Peter Pinto
  – Brad Wood
  – Marston Linehan
  – Peter Herscovitch

• Collaborators
  – Jochen Krueger (Philips)
  – Barbara Withers (GE)
  – Marty Pomper (JHU)
  – John Babich (Mol Insight)
  – Steve Larson (MSKCC)