Prostate Cancer: Radiological Diagnosis, Staging, and Detection of Metastasis

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Outline

I. Index patient

II. Overview of prostate cancer

III. Prostate anatomy

IV. Role of imaging in the diagnosis/staging of prostate cancer

V. Detecting osseous metastases
Part I:
Index Patient
Patient “TM”:
Presentation and history

• TM – a 69 year-old male

• On routine lab work at his PCP’s office:
  • Prostate specific antigen (PSA): 5.5 ng/mL
  • Increased from 5 years prior, when his PSA was 3.0 ng/mL
  • Calculated PSA velocity: 0.5 ng/mL per year

• PMH/PSH:
  • s/p Repair of tibial plateau fracture
  • s/p TURP for alleviation of prostatitis – no cancer found at that time.
On the basis of TM’s moderately elevated PSA and PSA velocity, a decision was made to perform a transrectal ultrasound (TRUS)-guided prostate biopsy.
10 core biopsies were taken from throughout the prostate gland.
Patient TM: Biopsy findings

- Left mid-gland adenocarcinoma, Gleason score 6/10, involving 5-10% of core biopsy
- Right base adenocarcinoma, Gleason score 6/10, involving 30% of core biopsy
- High-grade prostatic intraepithelial neoplasia (PIN) throughout left base.
In order to further characterize the size and extent of TM’s prostate cancer, an endorectal MRI was performed.
Patient TM: Endorectal MRI

PROSTATE GLAND

RECTUM (dilated with balloon)

T2 Axial Contrast-Enhanced MRI
Patient TM: MRI finding #1

Focus of prostate cancer in right peripheral zone.
No extracapsular extension.
Patient TM: MRI finding #2

Left lobe mid-gland peripheral zone prostate cancer, 11mm. No extracapsular extension.
Patient TM: Staging and treatment

• Given that TM’s cancer was bilateral, yet confined to the prostate gland, his cancer was STAGE II.

• Some of his treatment options included*:
  • Expectant management (aka “watchful waiting”)
  • Radical prostatectomy
  • Brachytherapy +/- adjuvant hormonal therapy

• TM opted for 4 months of hormonal therapy, followed by brachytherapy.

• 5 months following brachytherapy, a repeat PSA was 0.1 ng/mL.

Part II:
Prostate Cancer Overview
• Prostate cancer is the second-most common cancer in American men.

• It is the second-most common cause of cancer-related deaths in men.

• It is estimated that 1 in 6 men will develop prostate cancer in their lifetime.

• However, only 1 in 34 men will die from prostate cancer.
Classification of prostate cancer

TNM Staging

- **Tumor size, Nodal involvement, distant Metastasis**
- **Cancer can be local, locally advanced, or metastatic**
- Further classified by “C” stage and “P” stage:
  - **C = clinical, determined by DRE and ultrasound exam**
  - **P = pathological, determined on exam of tissue biopsy**

Gleason Grade

- Analyzes glandular differentiation and structural architecture of biopsy as an approximation of tumor aggressiveness
- Scored from 2-10, with 10 being the most aggressive
SCREENING

- DRE (detects tumors in posterior and lateral prostate gland)
- PSA – general guidelines:
  - Absolute value > 10 → BIOPSY
  - Absolute value 4-10 → Patient/physician discretion
  - PSA velocity > 2 ng/mL per year → BIOPSY
- Molecular detection in urine*

DIAGNOSIS

- Biopsy: US- or MR-guided

Part III: Prostate Anatomy Review
Male reproductive tract
Prostate and seminal vesicles

U.S. National Cancer Institute
http://training.seer.cancer.gov
Prostate anatomy on digital rectal examination (DRE)

ANTERIOR GLAND (not palpable)

POSTERIOR GLAND (readily palpable)

LATERAL GLAND (usually palpable)
Prostate anatomy on endorectal MRI

Transverse/axial  Coronal  Sagittal

Images courtesy of Nicolas Bloch, MD
Prostate anatomy on endorectal MRI: Labeled

**PERIPHERAL ZONE**
**CENTRAL GLAND** (transition + central zones)
**SEMINAL VESICLES**

**BASE**
**MID-PROSTATE**
**APEX**
Part IV: Role of imaging in the diagnosis and staging of prostate cancer
Radiologic tests most commonly used for diagnosing/staging prostate cancer

- Transrectal ultrasound
- Endorectal MRI
- Bone scan

We will now discuss each of these imaging modalities individually.

Arnold Krongrad, MD
http://stanford.wellsphere.com/
But first… Why is radiological staging of prostate cancer so important?
Significance of appropriate radiological staging

• Different stages of prostate cancer are managed with different treatment modalities.

• Accurate staging ensures that a patient will receive the most appropriate therapy for his prostate cancer.

• In addition, it reduces morbidity associated with potentially unnecessary procedures.
Transrectal Ultrasound (TRUS)

- Uses:
  - Biopsy
  - Cancer screening (not recommended due to poor sensitivity)
    - Study: nearly 40% of prostate cancers would be missed if biopsied on the basis of abnormal TRUS alone.*
  - Prostate gland measurement, calculation of PSA density
  - Therapy (brachytherapy seed implantation, cryotherapy)

PROS
- Simple, outpatient procedure
- Reasonably well-tolerated
- Inexpensive

CONS
- Low sensitivity, low PPV
- Large inter-observer variability
- Transrectal approach intolerable for some

TRUS as an aid to biopsy

This is TM’s ultrasound. Only 3 images were captured, as the primary purpose of the ultrasound was to localize the prostate for biopsy. There was little need to capture multiple views.
Approach to prostate biopsy

- Traditional sextant approach: biopsies are taken from the base, mid-prostate, and apex bilaterally
- Extended biopsy: 10 or more biopsies are taken
Companion patient #1: TRUS as a diagnostic tool

60 yo male with PSA of 12.6. Biopsy later confirmed prostatic adenocarcinoma of the left base.

Greater than 20 images were taken from a multitude of views to aid in diagnosis.
Differential diagnosis of a hypoechoic nodule on TRUS

DDx:

1. Benign hyperplasia
2. Prostate adenocarcinoma

A 2005 study* looked at 472 men suspected of having prostate cancer, all of whom were found to have a hypoechoic nodule on TRUS-guided biopsy:

- 65.68% had benign findings on histopathology
- 34.32% had prostate adenocarcinoma

Endorectal MRI

• Uses:
  • Prostate cancer detection
  • Local and distant staging
    • Accuracy in staging prostate cancer ranges from 54-93%*
  • Guide biopsy

**PROS**
- Superior detection of tumors in transition zone and anterior prostate
- Excellent resolution allows fairly accurate assessment of tumor size, invasion
- Multiple scanning paradigms allow for a variety of images

**CONS**
- Large inter-observer variability noted*
- Time-consuming, uncomfortable
- Expensive
- Must wait as long as 6-8 weeks post-biopsy, as hemorrhage may hamper tumor detection*

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Endorectal MRI: Rectal coils

Image courtesy of Nicolas Bloch, MD
Companion Patient #2

58 year-old male with PSA of 7.2, elevated PSA velocity, and microhematuria.

Large central cancer with extracapsular invasion (stage T3b). This appears as an area of lower signal intensity.

T2 Axial Contrast-Enhanced MRI
Companion Patient #2

58 year-old male with PSA of 7.2, elevated PSA velocity, and microhematuria.

T2 Axial Contrast-Enhanced MRI

BPH
Dynamic Contrast Enhanced MRI (DCEMRI) analyzes contrast wash-in and wash-out rates. Tumor-induced changes in vascular permeability allow us to detect cancerous lesions.*


Companion patient #3: Patient had an elevated serum PSA and negative TRUS-guided biopsy. Cancer later confirmed on MR-guided biopsy.
Part V: Detecting osseous metastases
Bone is the most common site of prostate cancer metastasis

- 5% of patients have bone mets at presentation

Radionuclide bone scan is a sensitive method of detecting osseous metastases, particularly those that are osteoblastic.

PSA guidelines:

- PSA 10-50 ng/mL → 10% incidence of positive bone scan
- PSA >50 ng/mL → 50% incidence

Many radiologists recommend reserving bone scanning for symptomatic patients or patients with a PSA >10 ng/mL.

*Hricak et al (2007)
Radionuclide Bone Scan: More information

Basics:

• Technitium-99-MDP (methylene diphosphonate) is injected into the patient.

• This radiotracer is preferentially taken up in areas of active bone formation.

• Thus, osteoblastic metastases (typical of prostate cancer) appear “hot” on bone scan.

Confirmation:

Men who have a positive or equivocal bone scan are often further worked up with plain radiographs or an MRI.
Application of the bone scan to TM: our index patient

- Over a 1-year period following treatment, TM’s PSA rose from 0.1 to 14.3 ng/mL. He was asymptomatic.

- A bone scan was performed and was equivocal.

- When his PSA remained elevated, a repeat scan was performed 5 months later.

- This repeat scan showed a new sclerotic focus, consistent with metastatic disease.
Patient TM: Bone scans

12 months post-brachytx

17 months post-brachytx

“Increased uptake at L1… consistent with metastatic disease.”
Patient TM: further workup and treatment course

• An MRI was then performed, which confirmed this lesion as an osteoblastic metastasis.

• TM began a second course of hormonal therapy.

• His most recent scan showed no lesions (except for a minor compression fracture), compatible with successfully treated metastasis.

• TM will continue to be monitored regularly for recurrence throughout his treatment.
Summary

• Prostate cancer presents in many different forms and levels of severity, and there are numerous therapeutic options available.

• Appropriate use of imaging techniques allows for the timely diagnosis and staging of prostate cancer, as well as the formulation of the most appropriate treatment plan for each patient.

• We have reviewed several imaging modalities and their utility in prostate cancer, including:
  • TRUS: biopsy and diagnosis
  • Endorectal MRI and DCEMRI: biopsy, diagnosis, and staging
  • Radionuclide bone scan: detection of osseous metastases
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References


• Kantoff P, Taplin ME (2008). Overview of the clinical presentation, diagnosis, and staging of prostate cancer. *UpToDate™*
