mi TNM staging of prostate carcinoma in PSMA imaging

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Prostate-specific membrane antigen (PSMA) targeting positron emission tomography (PET) has emerged as a reference imaging tool for staging and restaging patients with prostate cancer.

The updated PROMISE V2 framework integrates an improved miTNM staging system, enhanced assessment of local disease, and a modified PSMA-expression score for clinical routine.

AA

The Need for Standardized Reporting

Superior Accuracy

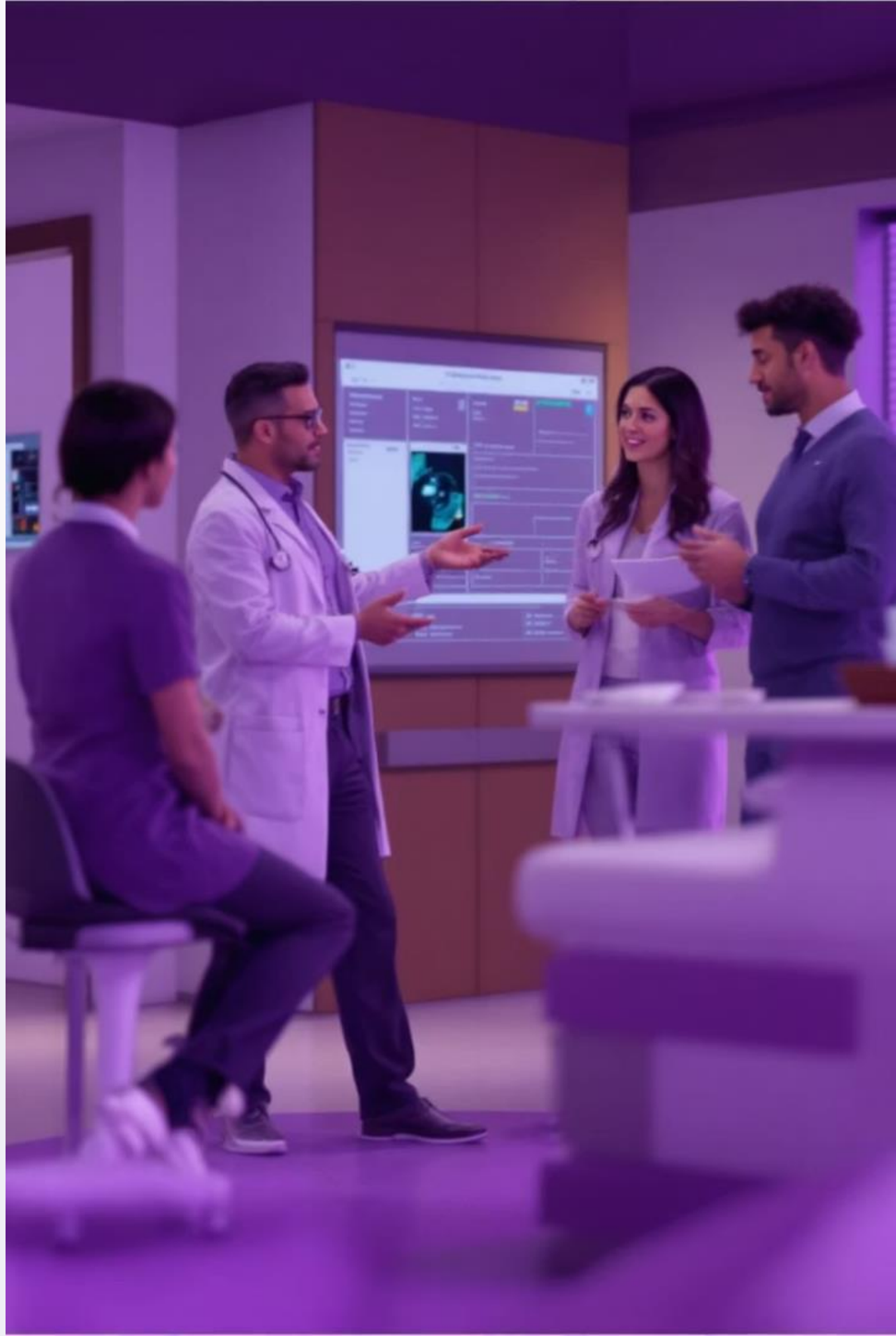
PSMA-ligand hybrid imaging demonstrates superior accuracy compared to conventional imaging across various indications and disease extents.

Growing Adoption

Level 2b evidence for superior detection rates at early biochemical recurrence has led to a grade A recommendation by the European Association of Urology.

Clinical Communication

Standardized reporting enhances communication between centers, facilitates research, and supports acceptance of this technology to benefit patients.



miTNM: Standardized Whole-Body Staging

Local Tumor (T)

Categories miT0 (no tumor), miT2 (organ-confined), miT3 (non-organ confined), miT4 (invasion of adjacent structures), and miTr (local recurrence after prostatectomy)

Intrapelvic Nodes (N)

Categories miN0 (no positive nodes), miN1 (single lymph node region), and miN2 (multiple lymph node regions)

Distant Metastases (M)

Categories miM0 (no distant metastasis) and miM1 (distant metastasis) with subcategories for distant lymph nodes (miM1a), bones (miM1b), and visceral sites (miM1c)

The miTNM system enables standardized reporting of PSMA-PET findings.

Key modifications in PROMISE V2 include alignment of pelvic lymph node definitions with the American Joint Committee on Cancer staging manual, with only lymph nodes in the true pelvis regarded as regional. Common iliac lymph node metastases are now reported in the miM1a category.

Local Tumor (T) Classification

miT0

No local tumor

miT2

Organ-confined tumor (unifocal or multifocal)

miT4

Tumor invading adjacent structures other than seminal vesicles

miT3

Non-organ-confined tumor (extracapsular extension or seminal vesicle invasion)

Categorization of local tumor is based on extent and organ confinement. To describe the anatomic distribution of intraprostatic tumor extension, information on prostate involvement is described on a sextant basis (left/right base, mid, and apex).

Pelvic Nodes (N) Classification in PROMISE1

miN0

No positive regional lymph nodes

miN1a

Single lymph node region harboring lymph node metastases

miN1b

Multiple (≥2) lymph node regions harboring lymph node metastases

Pelvic node metastases are categorized as single involved nodal regions (miN1a) or multiple involved nodal regions (miN1b). A standardized template for pelvic lymph node regions provides anatomic information to facilitate comparison with surgery, histopathology, or other imaging findings.

The specific location of lymph node metastases is critical for surgery and radiation therapy planning. For instance, the presacral and mesorectal regions, as well as the retroperitoneum, lie outside the typical surgical field.

Distant Metastases (M) Classification

miM1a

Extrapelvic lymph nodes

miM1b

Bone metastases

miM1c

Other sites/organs

In accordance with the clinicopathologic TNM system, distant metastases are separated into 3 categories.
Bone disease is further subcategorized as showing unifocal involvement, oligometastatic involvement (≤3 lesions), disseminated involvement, or diffuse marrow involvement.

The pattern of bone involvement can have important implications for prognosis and management. For instance, unifocal involvement may be targetable with curative intent by external-beam radiation therapy.

PSMA-Expression Score: Assessing Target Expression

Score 0: No Expression

Uptake equal to or lower than blood pool

PSMA status: Negative for radioligand therapy

Score 1: Low Expression

Uptake equal to or lower than liver and higher than blood pool

PSMA status: Negative for radioligand therapy

Score 2: Intermediate Expression

Uptake equal to or lower than parotid gland and higher than liver

PSMA status: Positive for radioligand therapy

Score 3: High Expression

Uptake higher than parotid gland

PSMA status: Positive for radioligand therapy

The PSMA-expression score uses a 4-point scale to assess target expression, applicable only to lesions with morphologic correlate >10mm diameter.

A score of ≥2 is generally required for eligibility for PSMA radioligand therapy.

For patients with advanced disease, reporting both highest and lowest scores illustrates the spectrum of disease positivity.

*For PSMA ligands with liver-dominant excretion (e.g., 18F-PSMA1007), spleen is recommended as reference organ instead of liver.

*Expression categories are defined in relation to mean uptake in the blood pool, liver, and parotid gland.

Interpretation Criteria and Certainty

Assess Uptake Pattern

Evaluate focal uptake and miPSMA score in context of location and morphology

Consider Clinical Context

Interpret findings based on PSA level, prior treatment, and clinical history

Assign Certainty Level

Report diagnostic certainty using a 5-point scale from "consistent with" to "no evidence of disease"

Provide Final Diagnosis

Conclude with positive, negative, or equivocal (only when other techniques may clarify)

Interpretation of miPSMA scores must be performed with consideration of the clinical context and other imaging findings.

Future Development and Applications

Whole-Body Tumor Volumetry

Introduction of tools for whole-body tumor volumetry based on a combination of molecular and morphologic techniques might overcome several limitations of solely morphology-based criteria.

Quantitative Biomarkers

PSMA-derived tumor volume, total lesion PSMA, or bone PET indices could serve as quantitative imaging biomarkers for predicting prognosis and response.

Clinical Validation

Prospective evaluation of miTNM needs to be performed and its impact on patient prognosis and management assessed as the system evolves with clinical experience and scientific data.

Further advances in software-assisted tumor delineation will help to automatically delineate total tumor volume and target expression, potentially improving patient outcomes.

Advanced Staging and Management of Prostate Cancer: Case Studies

A comprehensive analysis of 5 PSMA SPECT/CT through clinical case presentations.

AA by Atena Aghaee

Case Presentation: Primary Assessment

1

Patient Demographics

62-year-old male patient

Referred for prostate cancer staging

2

Laboratory Values

PSA markedly elevated at 32 ng/ml

Indicates likely advanced disease

3

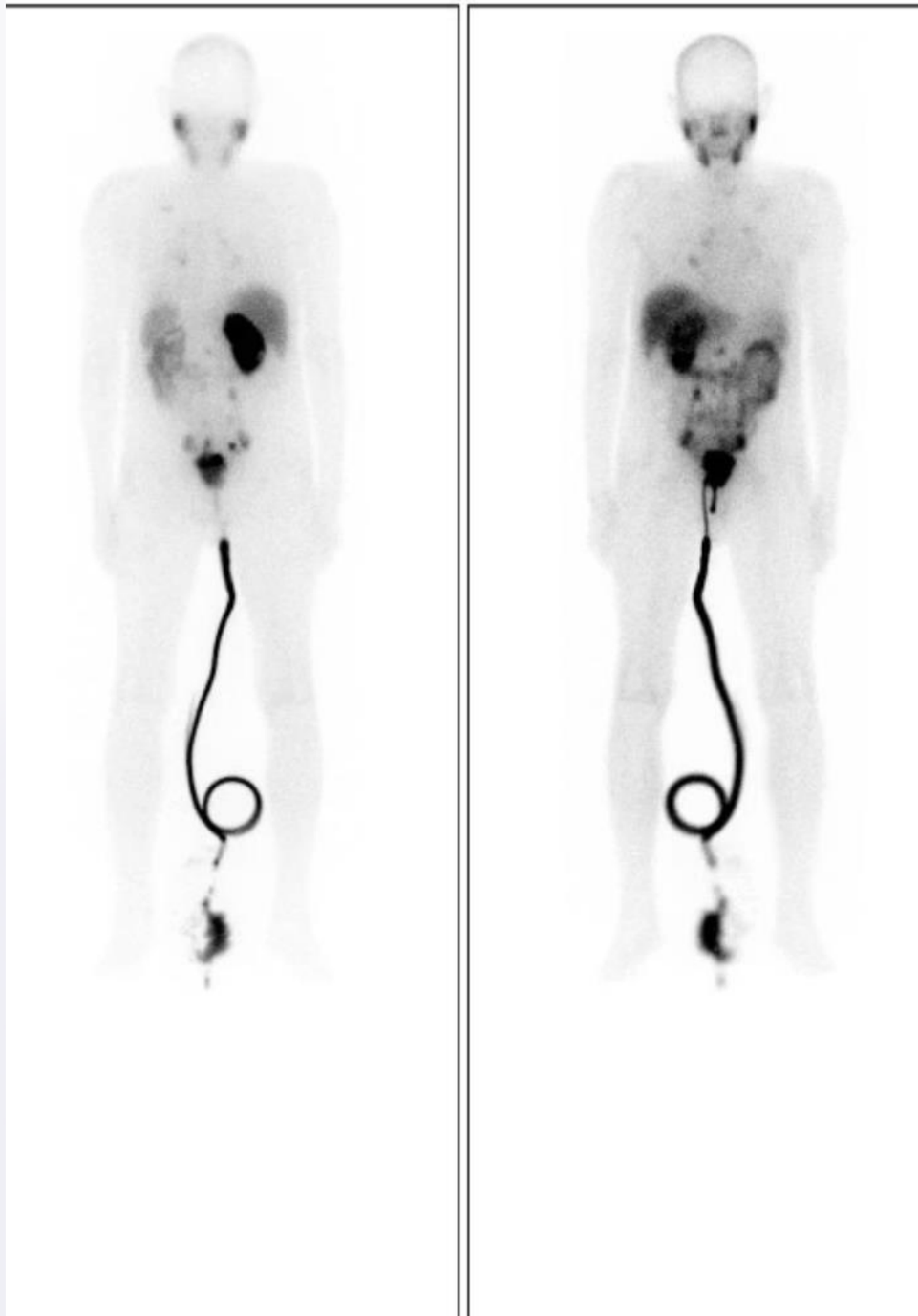
Histopathology

Gleason score 4+4=8

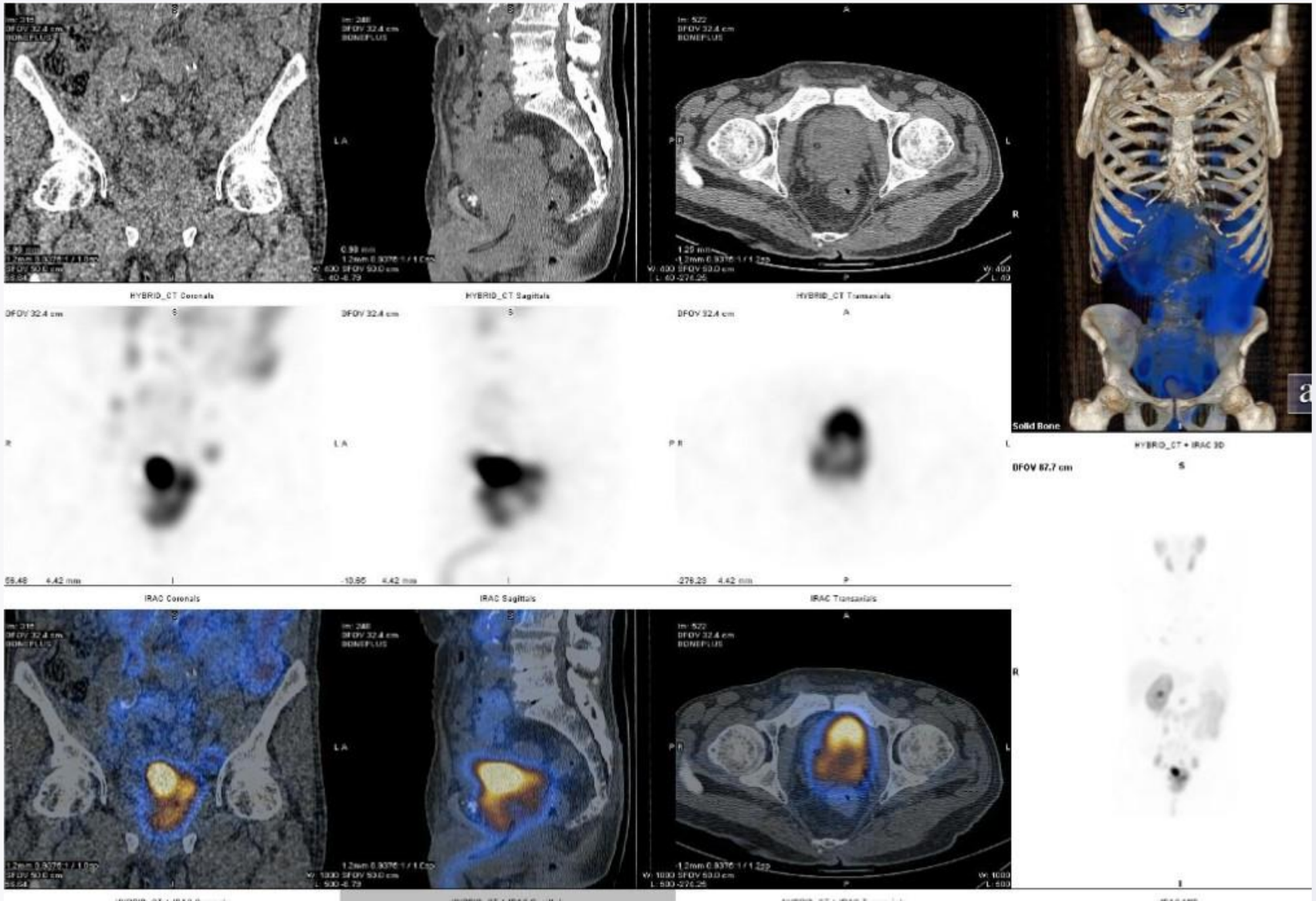
High-grade adenocarcinoma

4

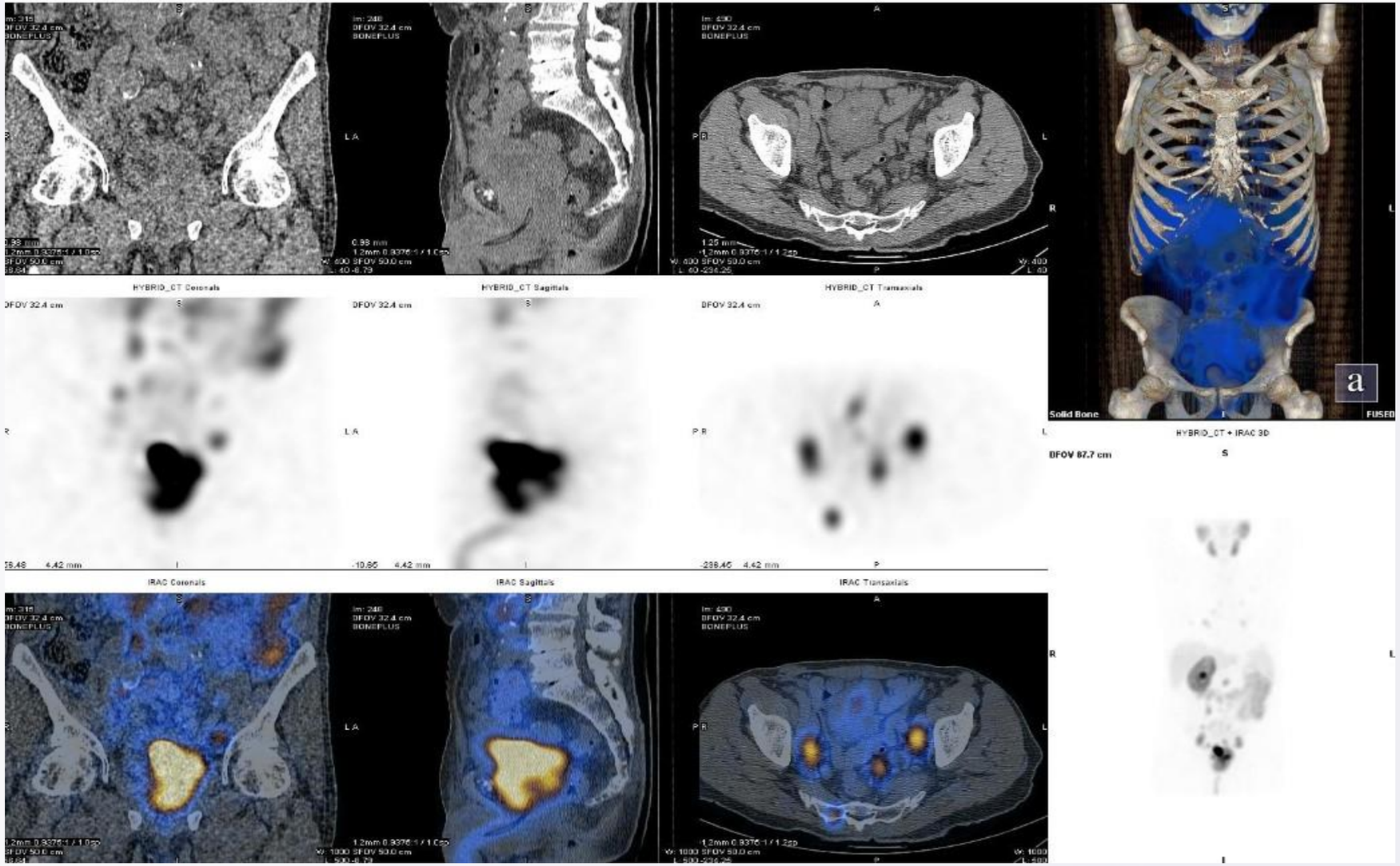
Staging Workup



Tumor invasion to posterior bladder wall=T4



N2-M1a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Visceral Metastasis (M1c)

Hepatic Involvement

Multiple hypodense lesions within liver parenchyma

Consistent with metastatic deposits

Pulmonary Metastasis

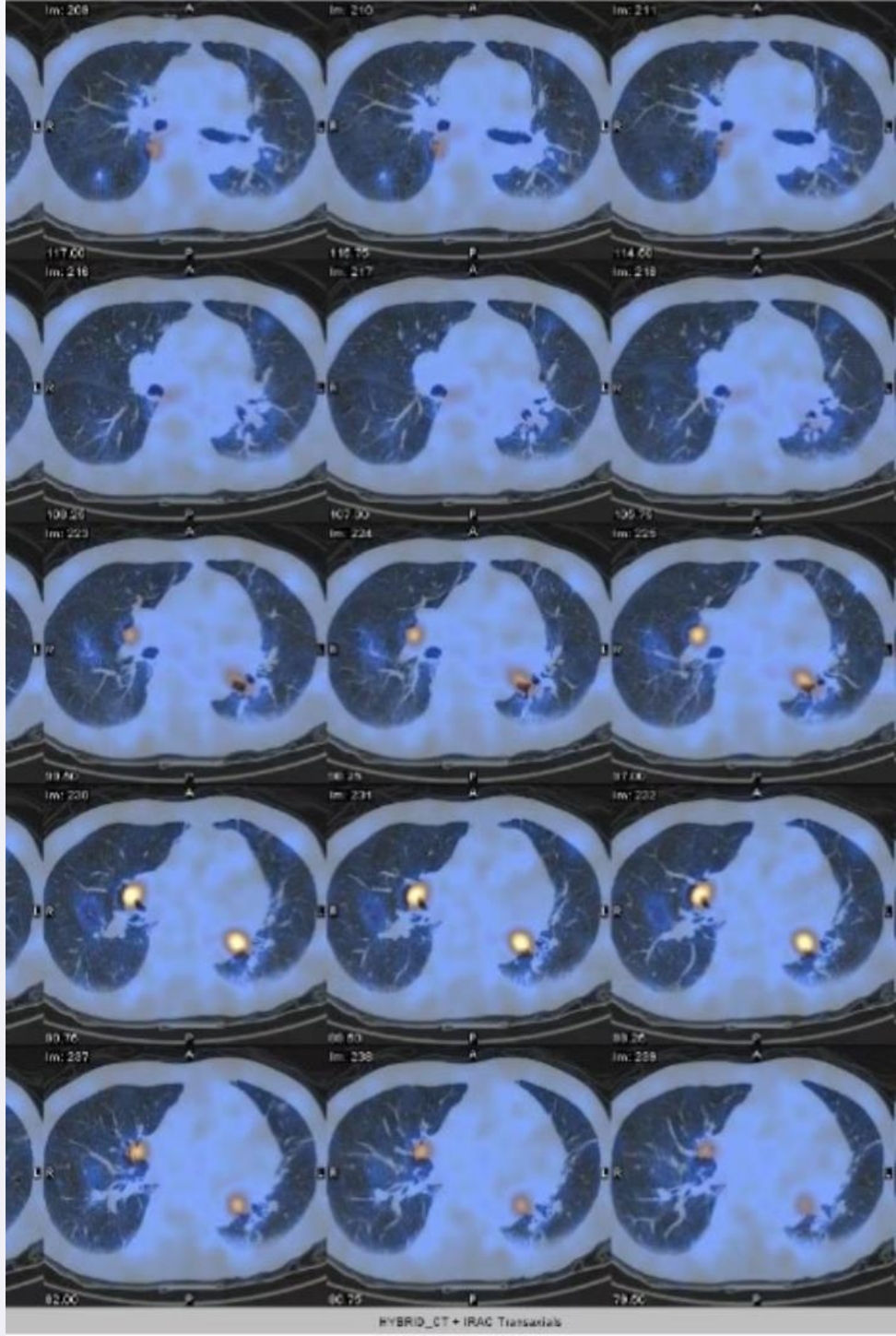
Less common than bone or liver

Poor prognostic significance

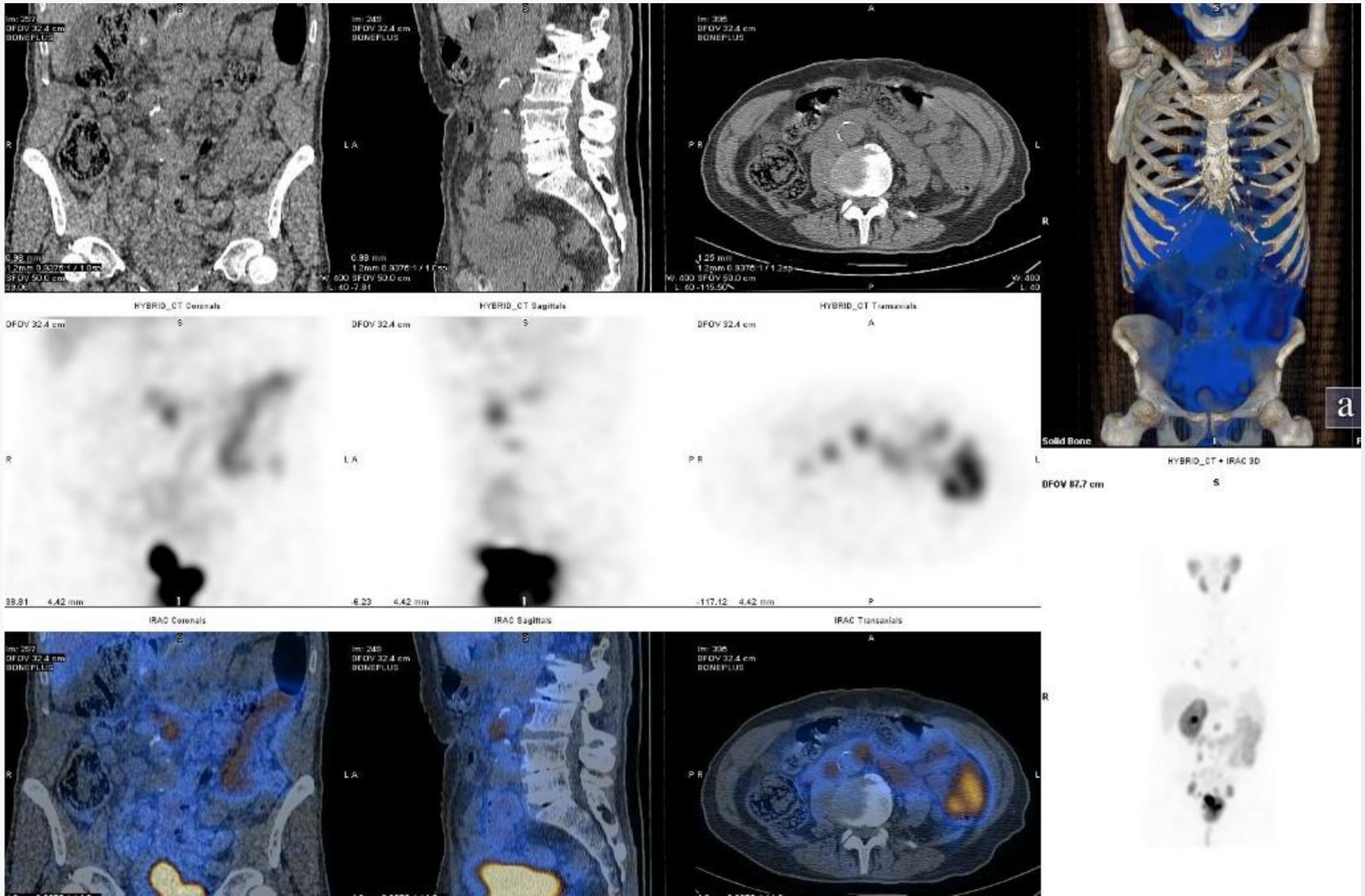
Treatment Approach

Systemic therapy indicated

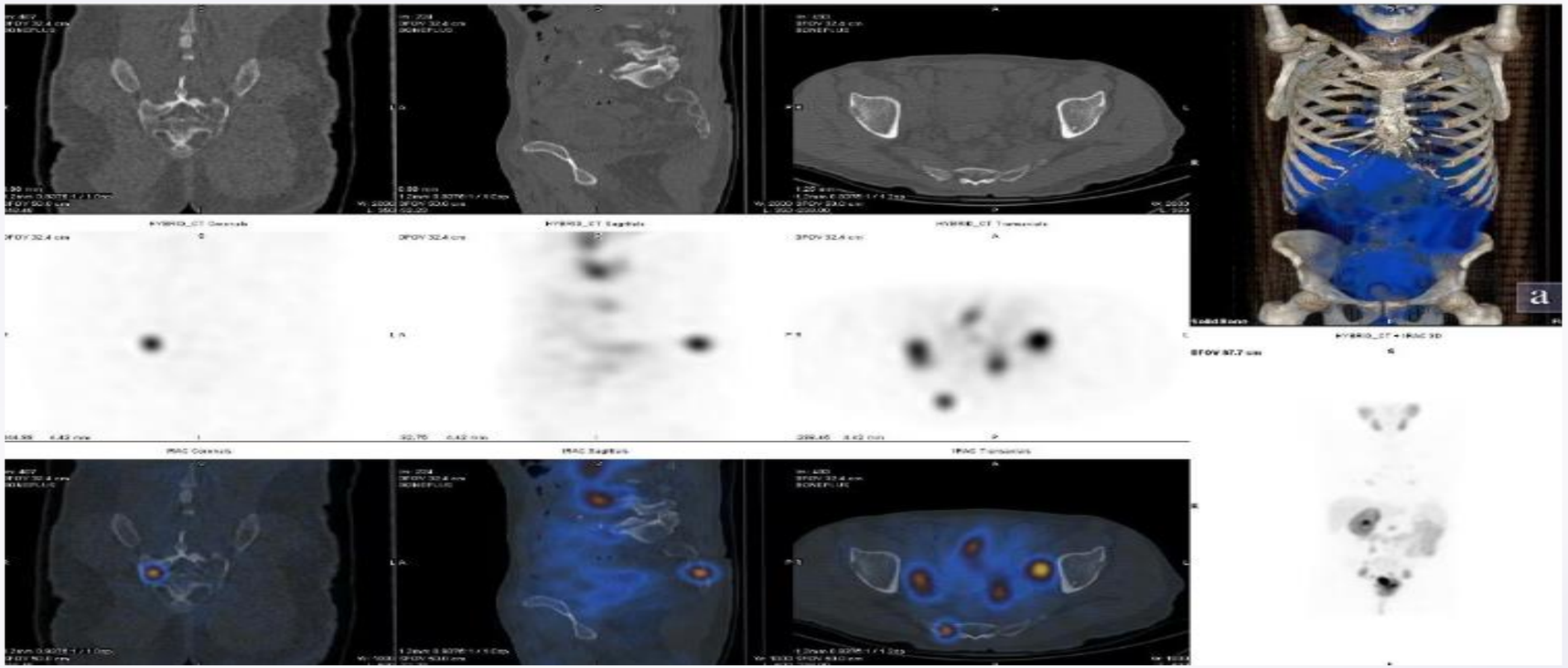
Consider targeted agents based on genetic profiling



Lymph node involvement at a level, upper than bifurcation= M1a



Solitary Bone Metastasis (M1b)



Radiological Features

Osteoblastic lesion with sclerotic appearance

Vertebral Predilection

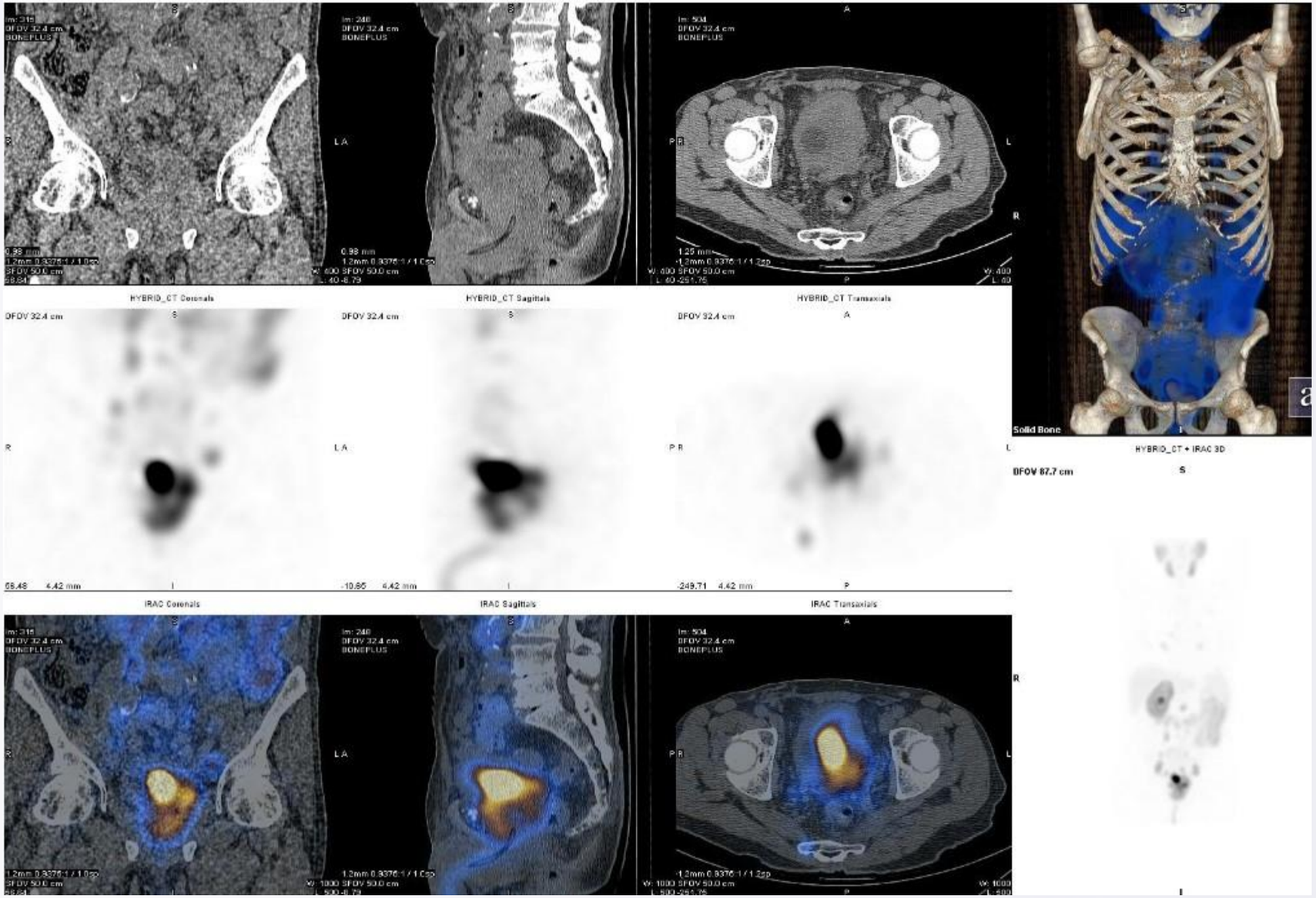
Axial skeleton most commonly affected

Therapeutic Implications

May qualify for metastasis-directed therapy

Prognostic Value

Better prognosis than multiple bone metastases



Seminal vesicles invasion

GHAEM HOSPITAL

Nuclear Medicine Department

[redacted] 1403/11/28

WHOLE BODY PSMA SCAN & SPECT/CT:

Four hours after IV injection of 20 mCi of Tc-99m-PSMA scanning was performed in routine views. SPECT/CT images were also performed from the thoracic and abdomino-pelvic regions for better localization and attenuation correction.

The whole body scan showed PSMA uptake multiple foci of increased tracer uptake in the thoracic and abdominopelvic regions.

The SPECT/CT images revealed multiple lymph nodes with increased tracer uptake in bilateral hilar, right lower paratracheal, bilateral peri-bronchial, aorto-caval, para-aortic, para-caval, bilateral common iliac, bilateral external iliac, bilateral obturator, left internal iliac regions.

In addition, the SPECT/CT images revealed a focus of increased tracer uptake in the right side of the sacrum as well as DJD and scoliosis in the thoraco-lumbar spine were noted.

Moreover, the SPECT/CT images showed increased tracer uptake in bilateral apex, mid and base portions of the prostate gland with extension to both seminal vesicles and invasion to the posterior bladder wall, rectal wall and left pubic bone.

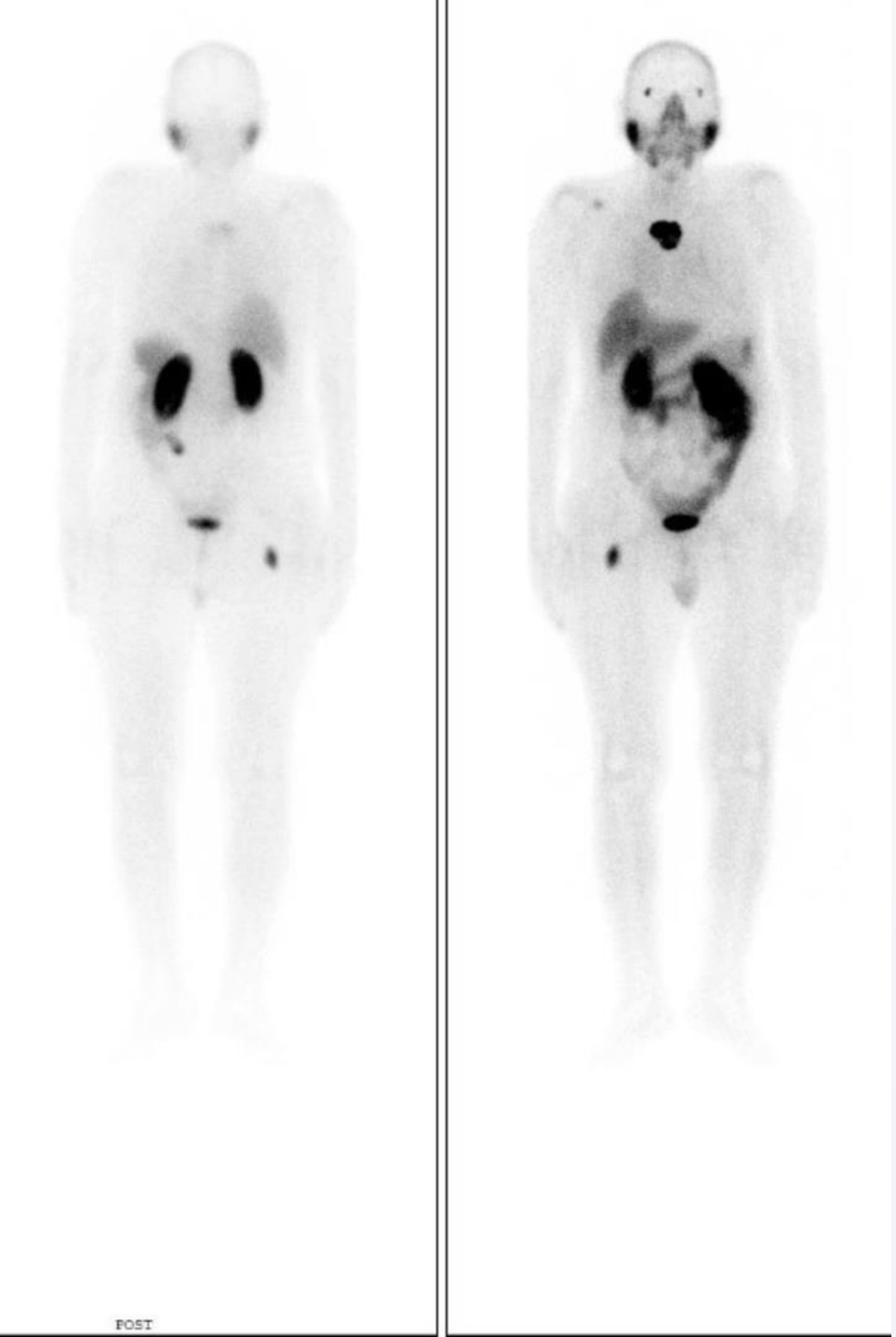
The lung window of the dedicated CT study revealed several pulmonary nodules throughout both lungs with increased tracer uptake in most of them on the SPECT images.

Furthermore, the dedicated CT images showed two cysts in the right kidney, decreased tracer uptake in the left kidney likely due to decreased parenchymal tissue, and reduced function of the left kidney.

INTERPRETATION:

1. ***One PSMA-avid skeletal metastasis in the right side of the sacrum.***
2. ***Multiple PSMA-avid metastatic lymph nodes in the bilateral hilar, right lower paratracheal, bilateral peri-bronchial, aorto-caval, para-aortic, para-caval, bilateral common iliac, bilateral external iliac, bilateral obturator, left internal iliac regions.***
3. ***Several PSMA-avid pulmonary metastatic nodules throughout both lungs.***
4. ***Focal increased PSMA uptake in bilateral apex, mid and base portions of the prostate gland with extension to both seminal vesicles and invasion to the posterior bladder wall, rectal wall and left pubic bone.***
5. ***Two cysts in the right kidney and decreased tracer uptake in the left kidney likely due to decreased parenchymal tissue and reduced function of the left kidney.***
6. ***DJD and scoliosis in the thoraco-lumbar spine.***

- ***Molecular imaging TNM: $T_4 N_2 M_{1a} M_{1b\ (oligo)} M_{1c\ (lung)}$***
- ***Primary Score: 5***
- ***PSMA expression score: 1-2***



Case 2: Biochemical Recurrence with Elevated PSA

Patient Profile

58-year-old male patient presenting with biochemical recurrence.

PSA significantly elevated at 18ng/ml, indicating active disease.

Clinical Significance

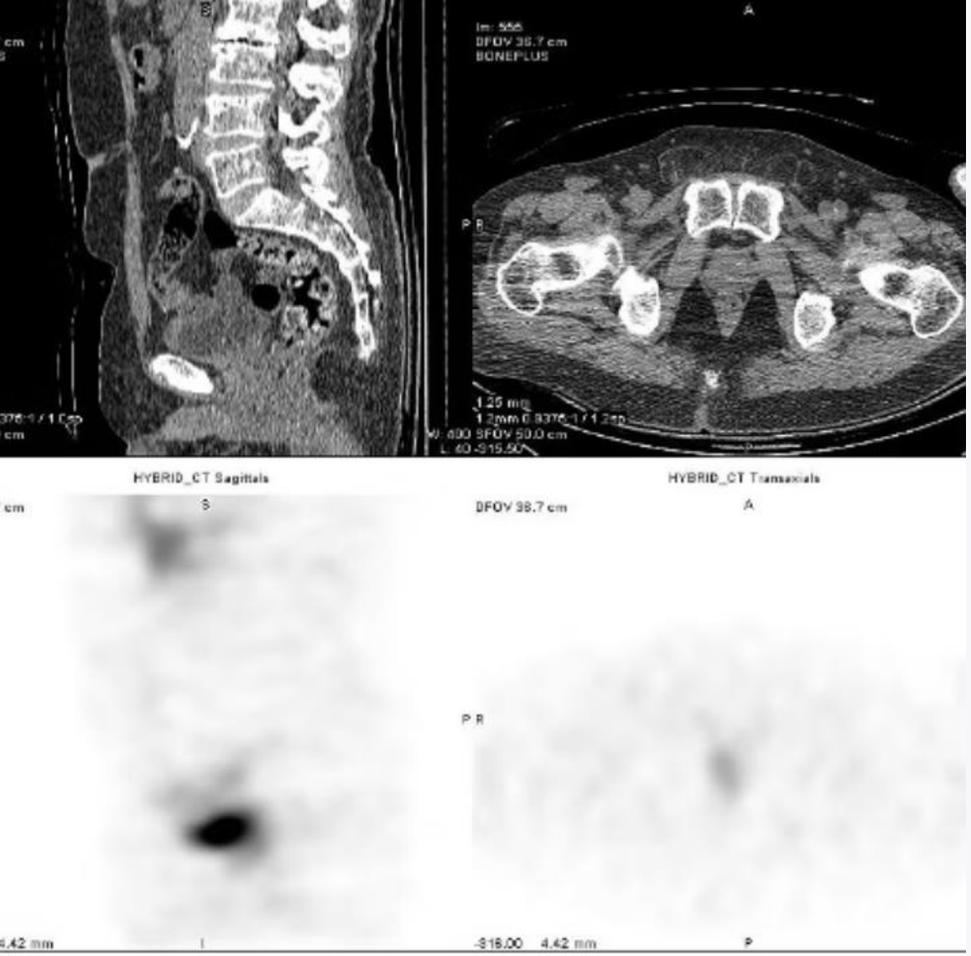
BCR indicates treatment failure after primary therapy.

PSA velocity and doubling time are critical prognostic factors.

Next Steps

Advanced imaging to locate recurrence site.

Histopathological confirmation when feasible.



T-Staging Assessment

T2c

Tumor involving both prostate lobes but confined within prostatic capsule.

T3a

Extracapsular extension beyond prostatic capsule.

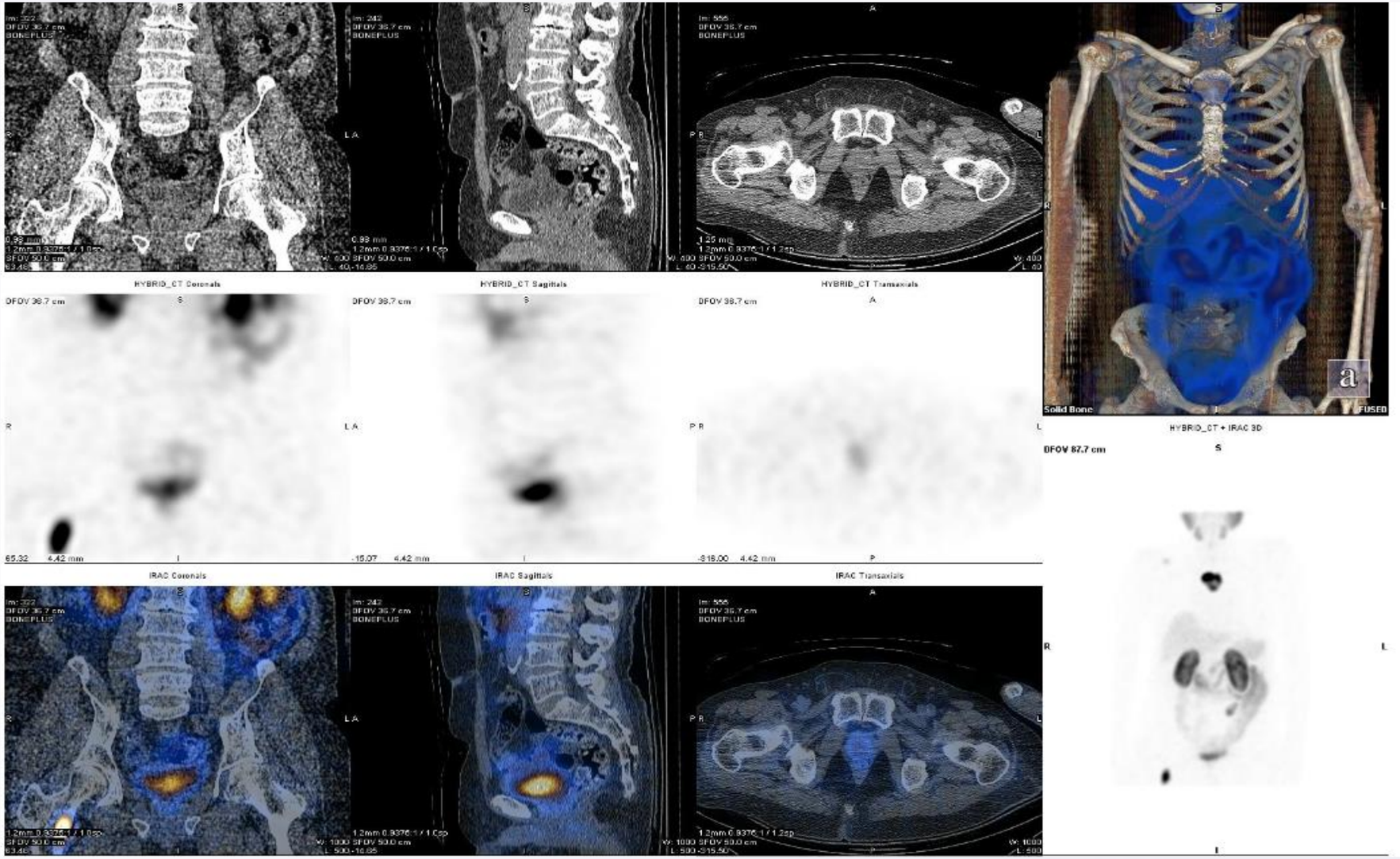
T3b

Invasion into seminal vesicles visible on imaging.

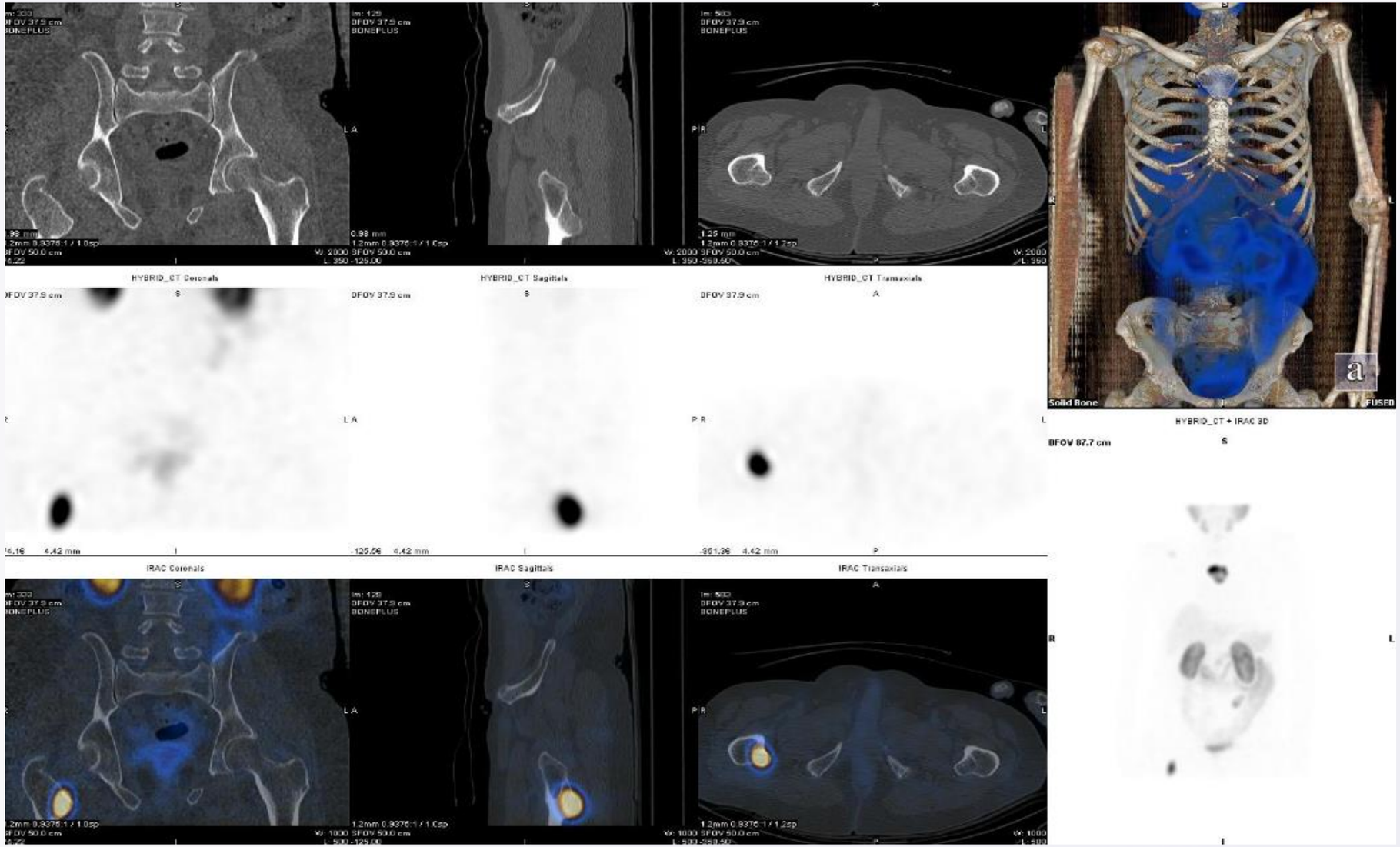
T4

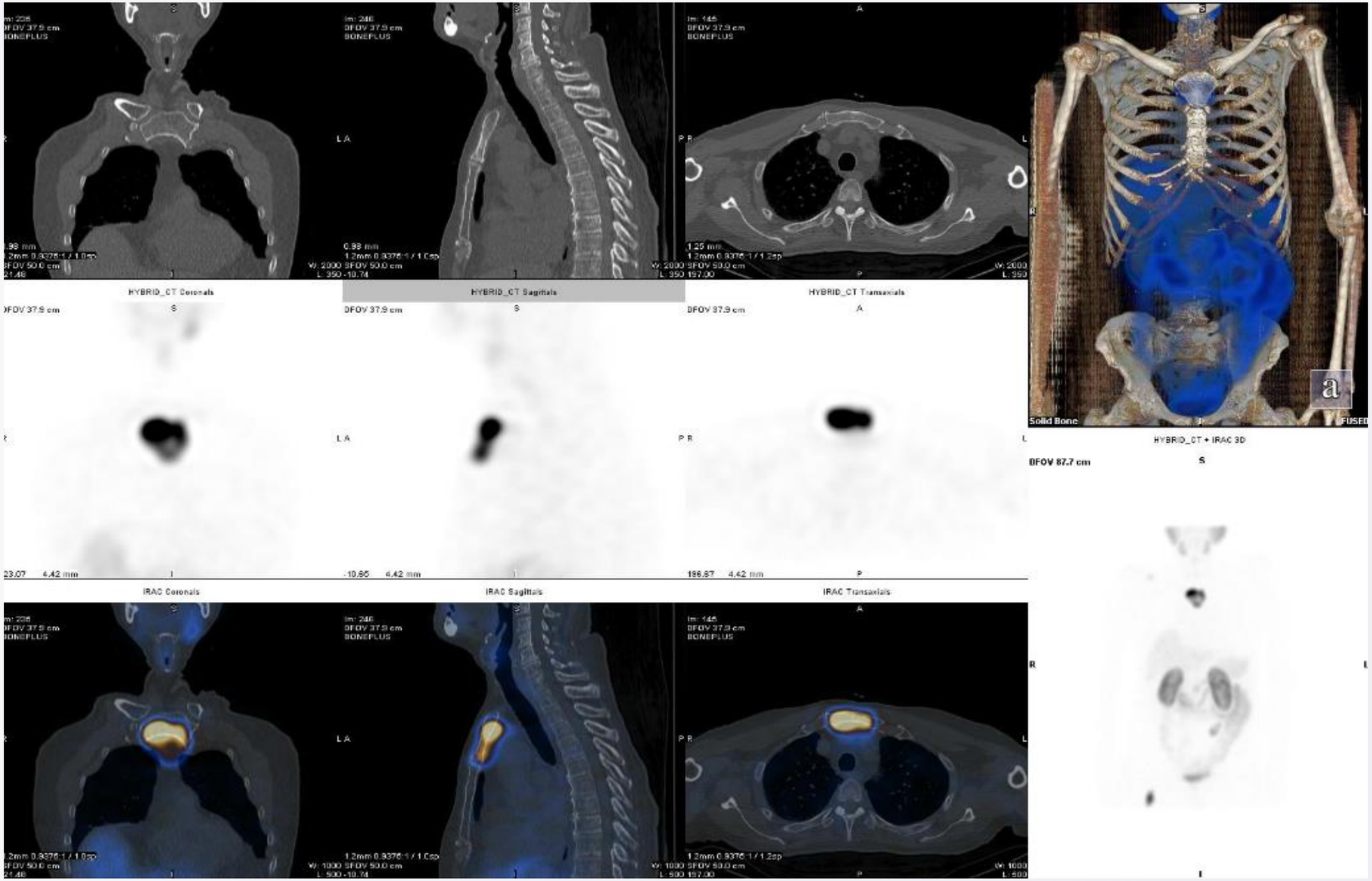
Direct invasion into adjacent structures like bladder or rectum.

What do you think about T staging?



And about M staging?

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GHAEM HOSPITAL
Nuclear Medicine Department

RE: Mr. Saberi, Jome Goldi 1404/01/31

WHOLE BODY PSMA SCAN & SPECT/CT:

Four hours after IV injection of 20 mCi of Tc-99m-PSMA scanning was performed in routine views. The SPECT/CT images were also performed from the thoracic and abdomino-pelvic regions, for better localization and attenuation correction.

The whole body scan revealed showed foci increased tracer uptake in thoracic, abdomino-pelvic and right femur regions.
The whole body scan also showed normal distribution of the radiotracer in the salivary and lacrimal glands, kidneys, bladder, as well as in the liver, spleen and GI tract.

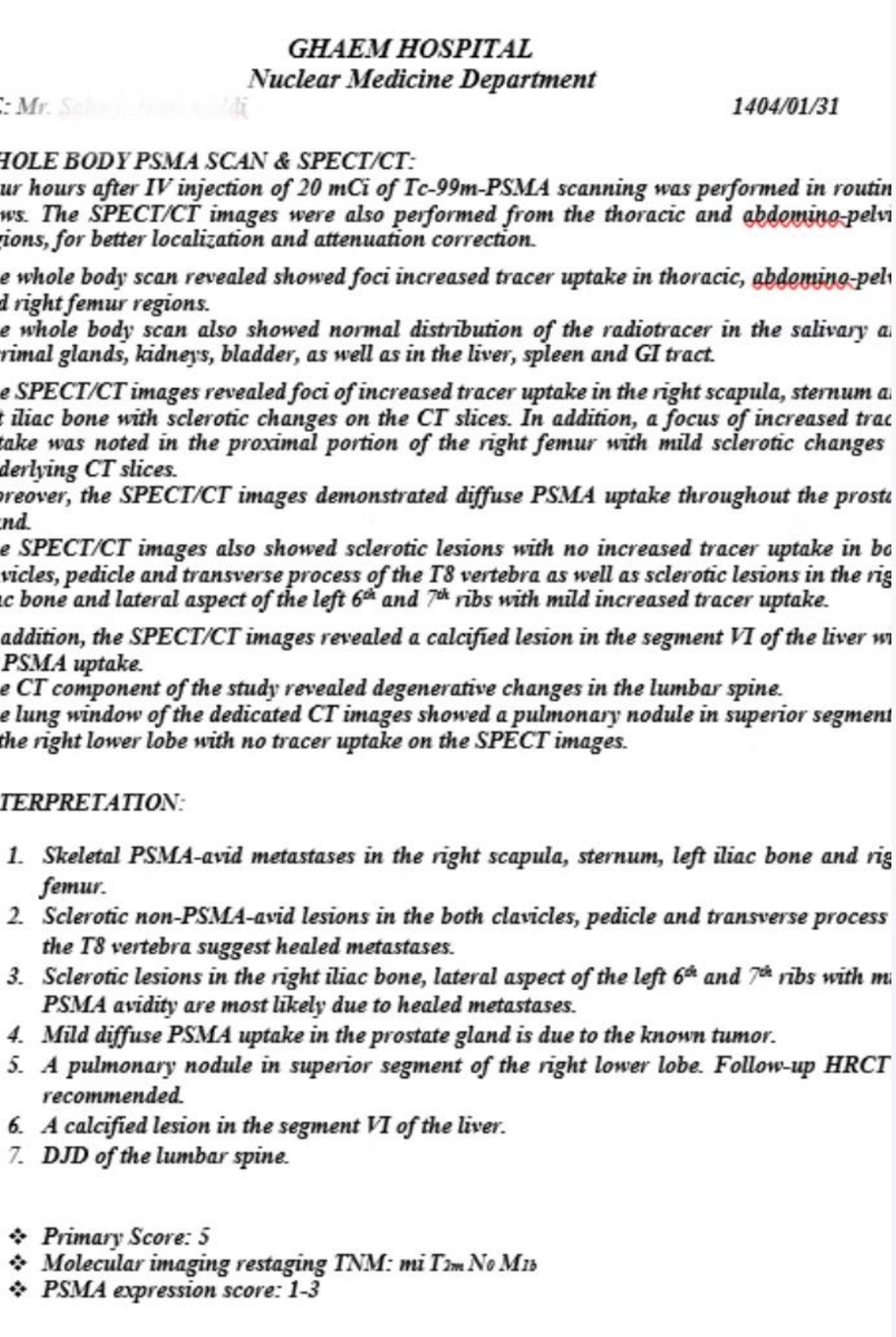
The SPECT/CT images revealed foci of increased tracer uptake in the right scapula, sternum and left iliac bone with sclerotic changes on the CT slices. In addition, a focus of increased tracer uptake was noted in the proximal portion of the right femur with mild sclerotic changes in underlying CT slices.
Moreover, the SPECT/CT images demonstrated diffuse PSMA uptake throughout the prostate gland.
The SPECT/CT images also showed sclerotic lesions with no increased tracer uptake in both clavicles, pedicle and transverse process of the T8 vertebra as well as sclerotic lesions in the right iliac bone and lateral aspect of the left 6th and 7th ribs with mild increased tracer uptake.

In addition, the SPECT/CT images revealed a calcified lesion in the segment VI of the liver with no PSMA uptake.
The CT component of the study revealed degenerative changes in the lumbar spine.
The lung window of the dedicated CT images showed a pulmonary nodule in superior segment of the right lower lobe with no tracer uptake on the SPECT images.

INTERPRETATION:

1. *Skeletal PSMA-avid metastases in the right scapula, sternum, left iliac bone and right femur.*
2. *Sclerotic non-PSMA-avid lesions in the both clavicles, pedicle and transverse process of the T8 vertebra suggest healed metastases.*
3. *Sclerotic lesions in the right iliac bone, lateral aspect of the left 6th and 7th ribs with mild PSMA avidity are most likely due to healed metastases.*
4. *Mild diffuse PSMA uptake in the prostate gland is due to the known tumor.*
5. *A pulmonary nodule in superior segment of the right lower lobe. Follow-up HRCT is recommended.*
6. *A calcified lesion in the segment VI of the liver.*
7. *DJD of the lumbar spine.*

- *Primary Score: 5*
- *Molecular imaging restaging TNM: mi T_{3m} N_0 M_{1b}*
- *PSMA expression score: 1-3*



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: Mr. [redacted] 1404/01/31

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2. Sclerotic non-PSMA-avid lesions in the both clavicles, pedicle and transverse process
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4. Mild diffuse PSMA uptake in the prostate gland is due to the known tumor.
5. A pulmonary nodule in superior segment of the right lower lobe. Follow-up HRCT
   recommended.
6. A calcified lesion in the segment VI of the liver.
7. DJD of the lumbar spine.

- Primary Score: 5
- Molecular imaging restaging TNM: mi T_{2m} N_0 M_{1b}
- PSMA expression score: 1-3

Treatment Approach for M1b Disease

Systemic ADT

Primary treatment modality to suppress testosterone production.

Novel Hormonal Agents

Abiraterone, enzalutamide, apalutamide improve survival outcomes.

Targeted Radiotherapy

Radium-223 for symptomatic bone metastases.

Chemotherapy

Docetaxel for high-volume disease or rapid progression.

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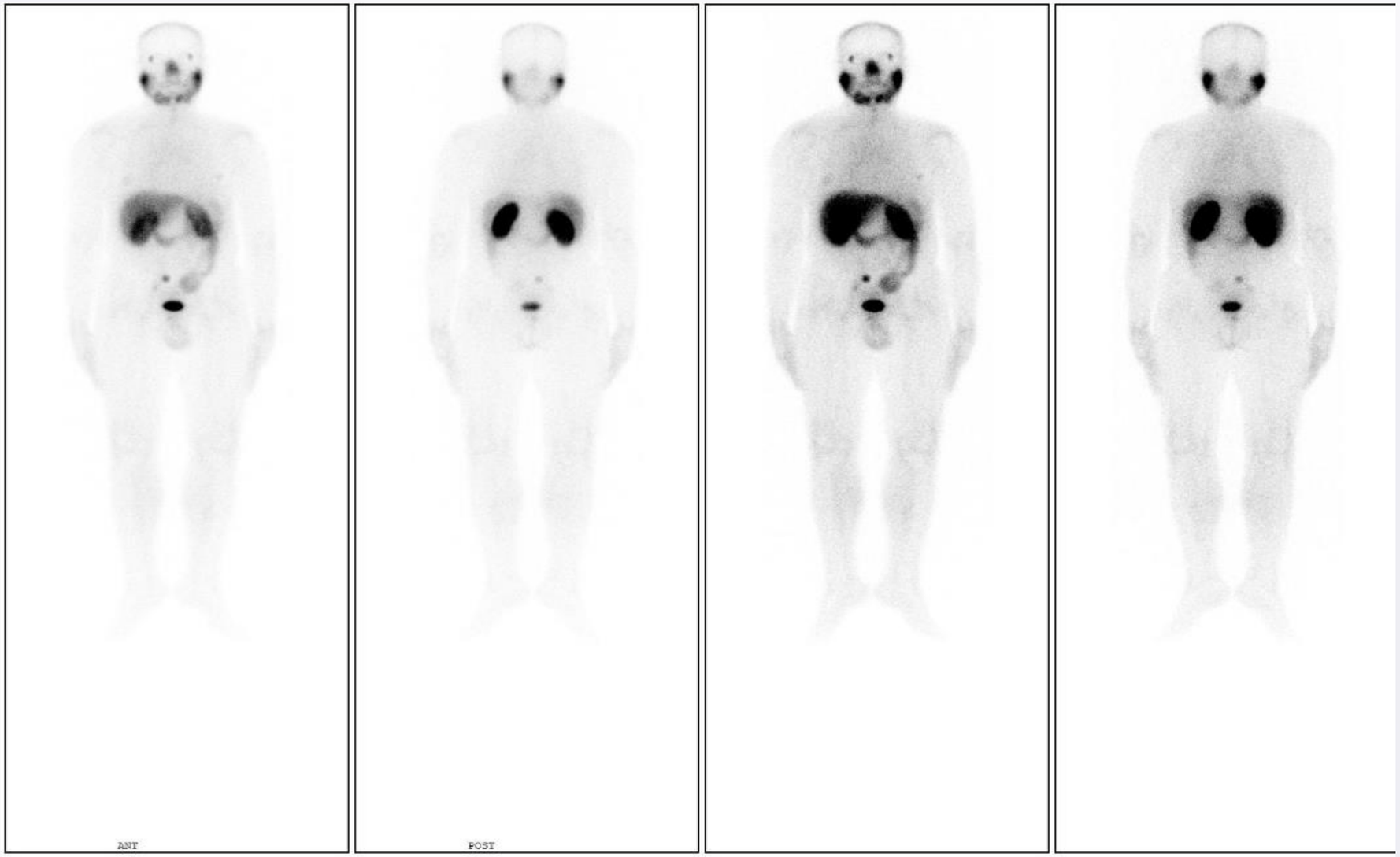
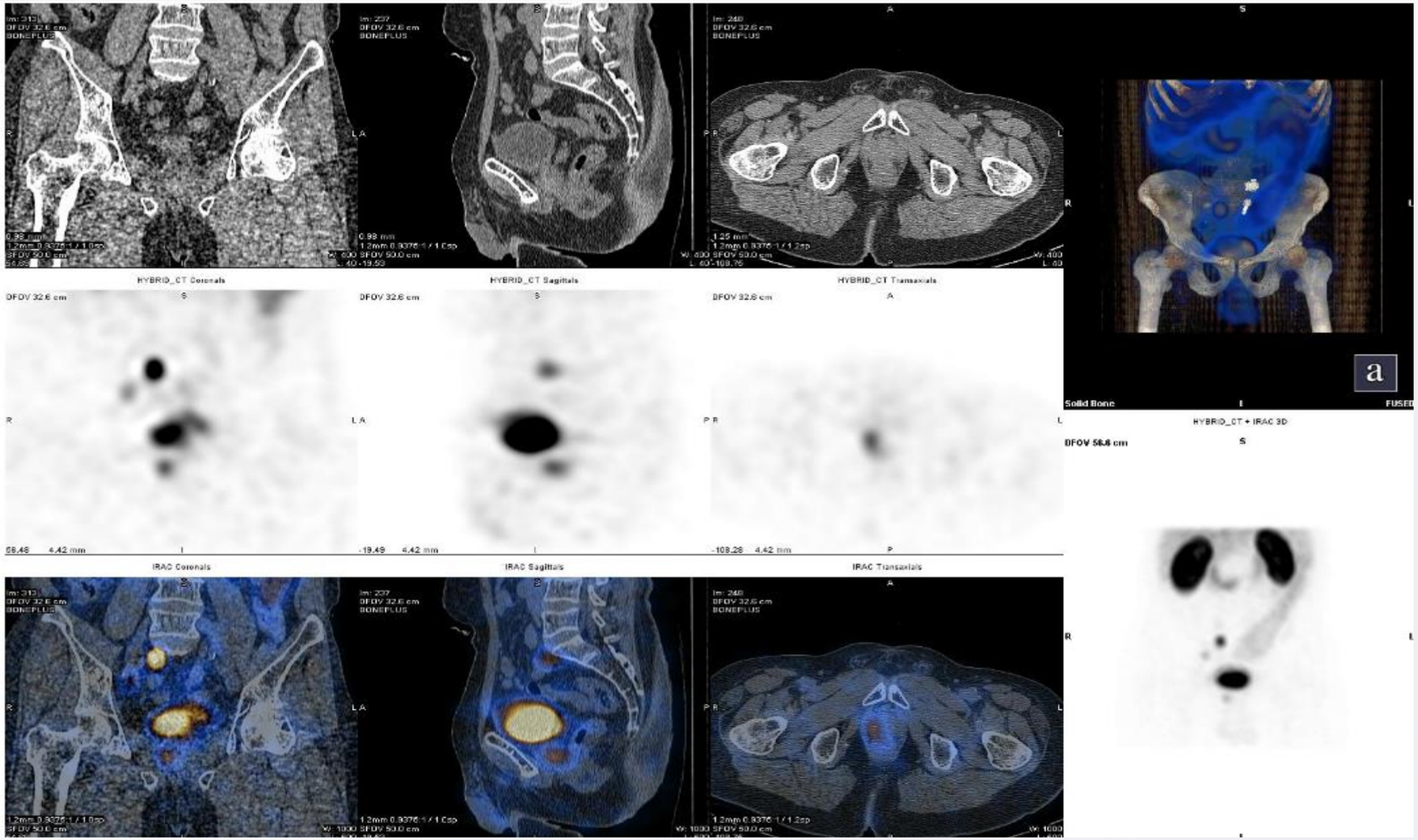
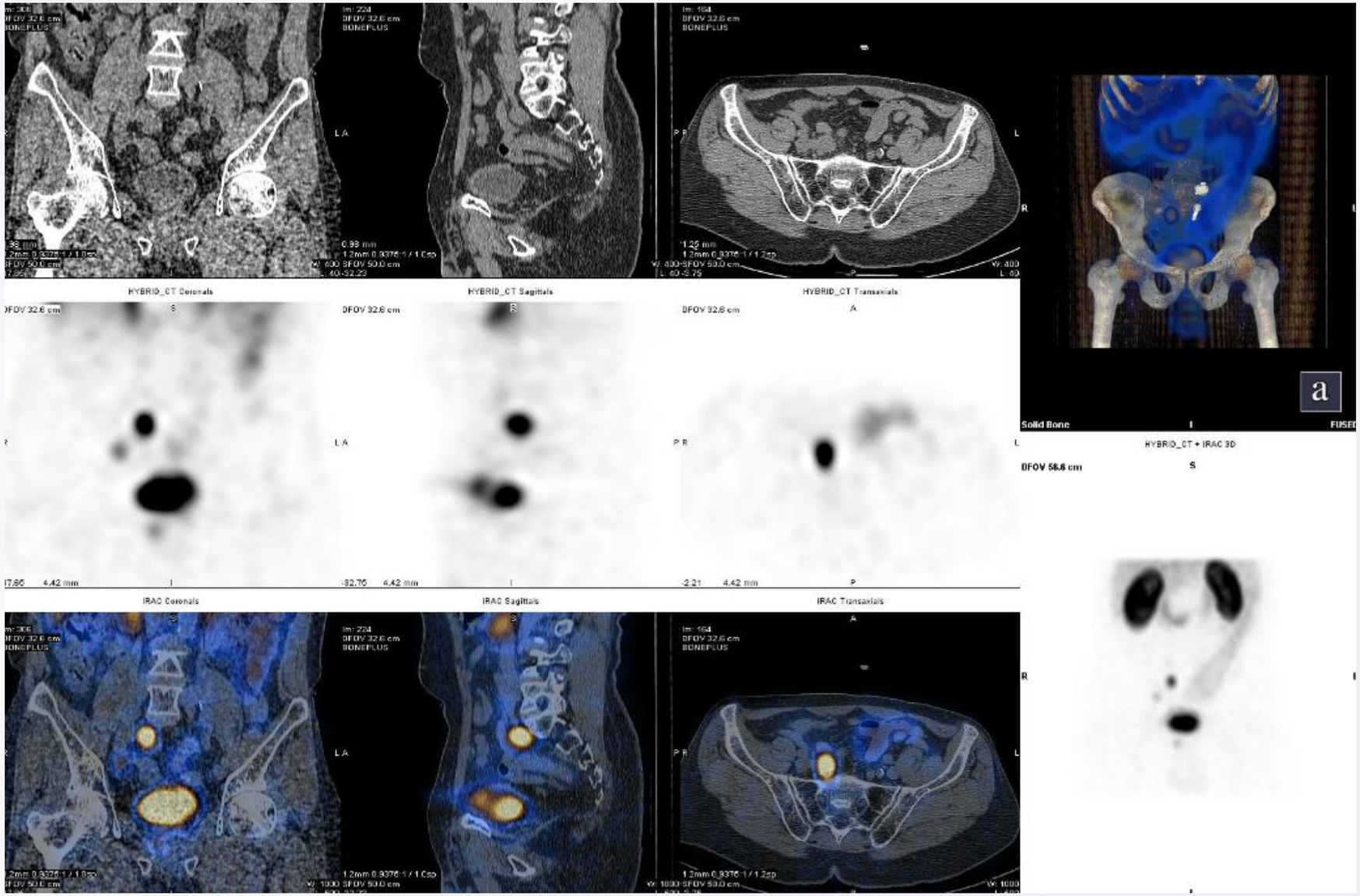
60 years old gentleman referred for staging P ca



What do you think about the T stage?

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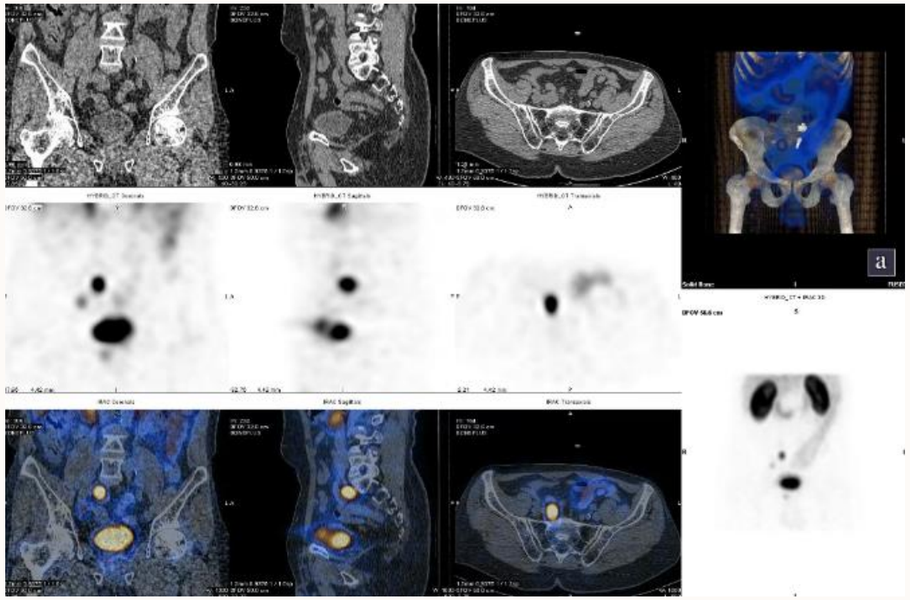
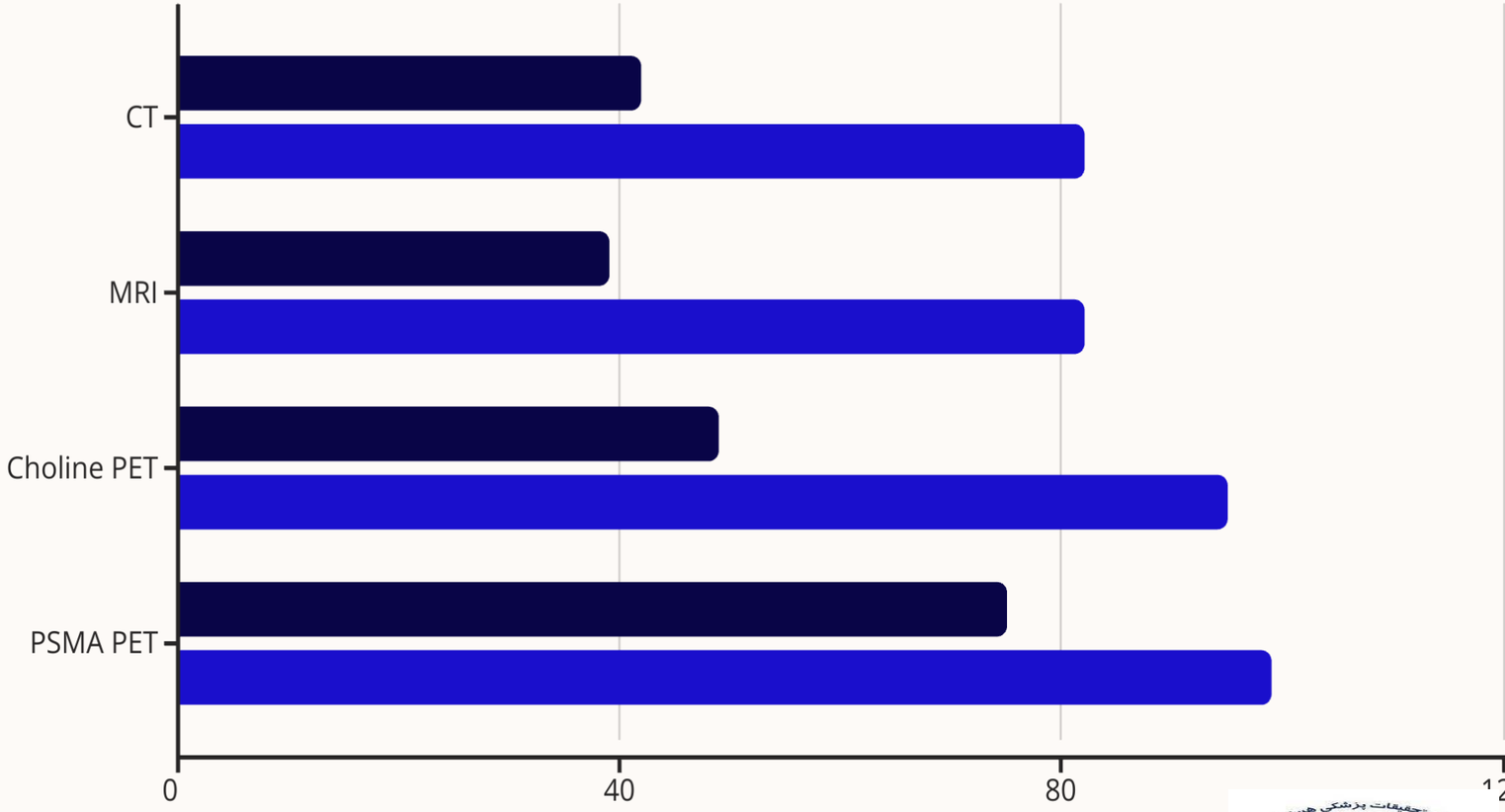
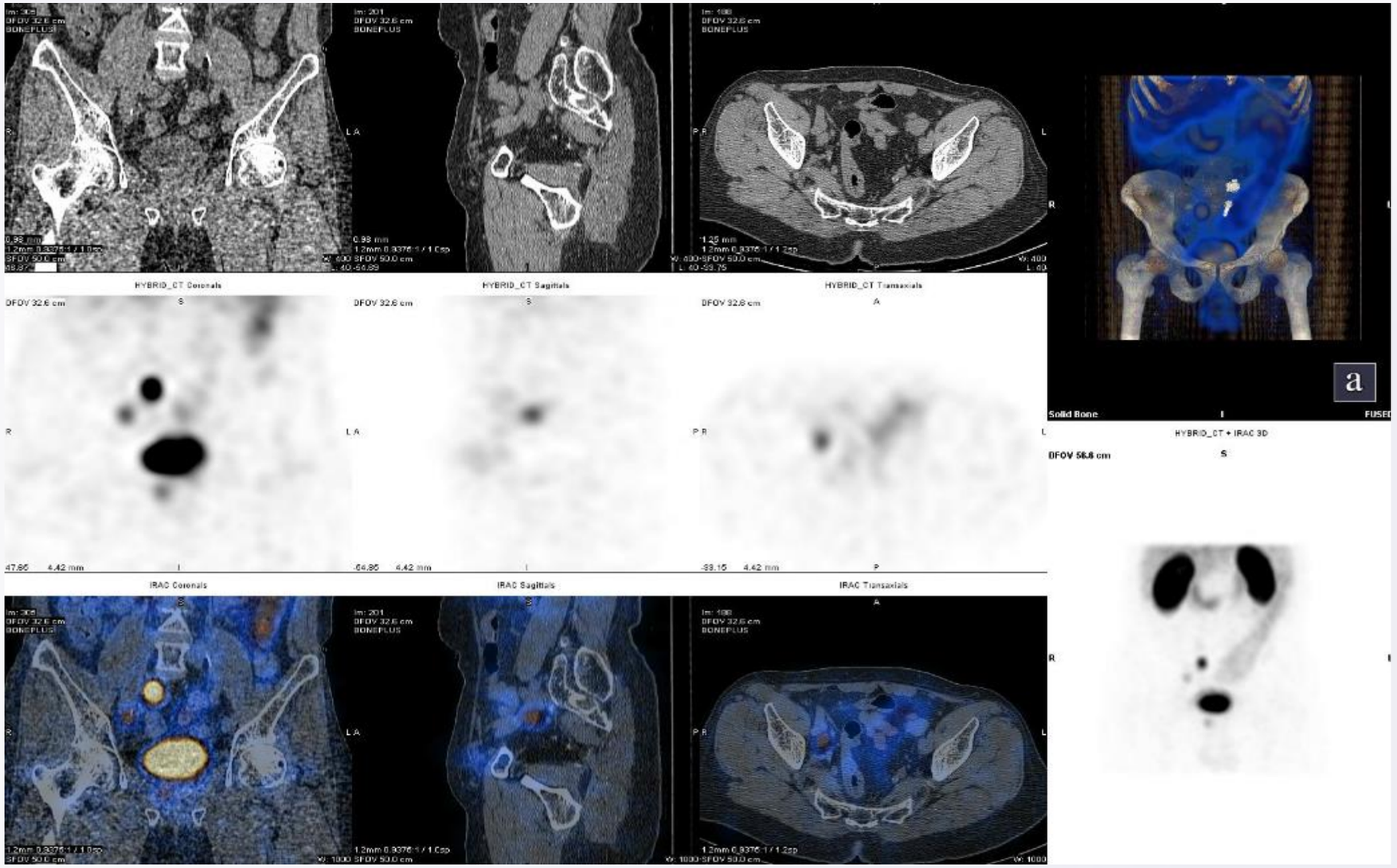
IRAC Sagittals
IRAC Transaxials

Lymph Node Involvement Assessment



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GHAEM HOSPITAL
Nuclear Medicine Department

RE: Mr. 1404/01/26

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Three hours after IV injection of 20mCi of Tc-99m-PSMA scanning was performed in routine views. SPECT/CT images were also performed from thoracic and abdominopelvic regions for better localization and attenuation correction.

The whole body images showed normal distribution of the radiotracer in the salivary and lacrimal glands, kidneys, bladder, liver, spleen and GI tract.

The SPECT/CT images showed diffuse tracer uptake throughout the prostate gland with a focus of increased tracer uptake in the apex with extension beyond the prostate capsule, although, no evident extra-prostatic extension was noted on the CT images.

The SPECT/CT images also revealed lymph nodes just after the bifurcation of the right common iliac artery and a right external iliac region with increased tracer uptake as well as a few lymph nodes in the aorto-caval region with faintly increased tracer uptake.

The SPECT/CT images also revealed cystic lesions in the bilateral femoral heads as well as bone islands in the right femoral head, left acetabulum and left iliac bone.

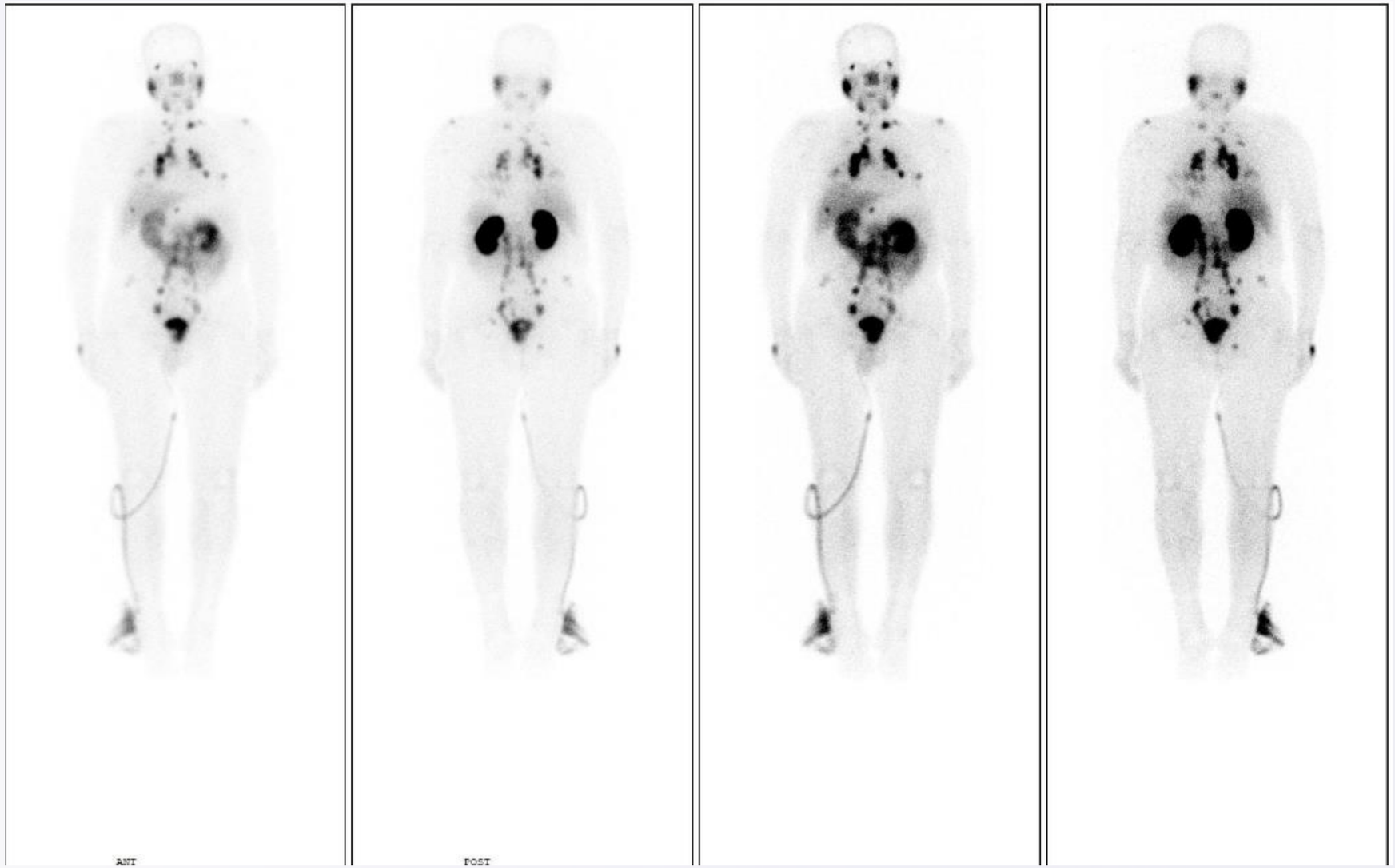
No other abnormal tracer uptake was noted throughout the body.

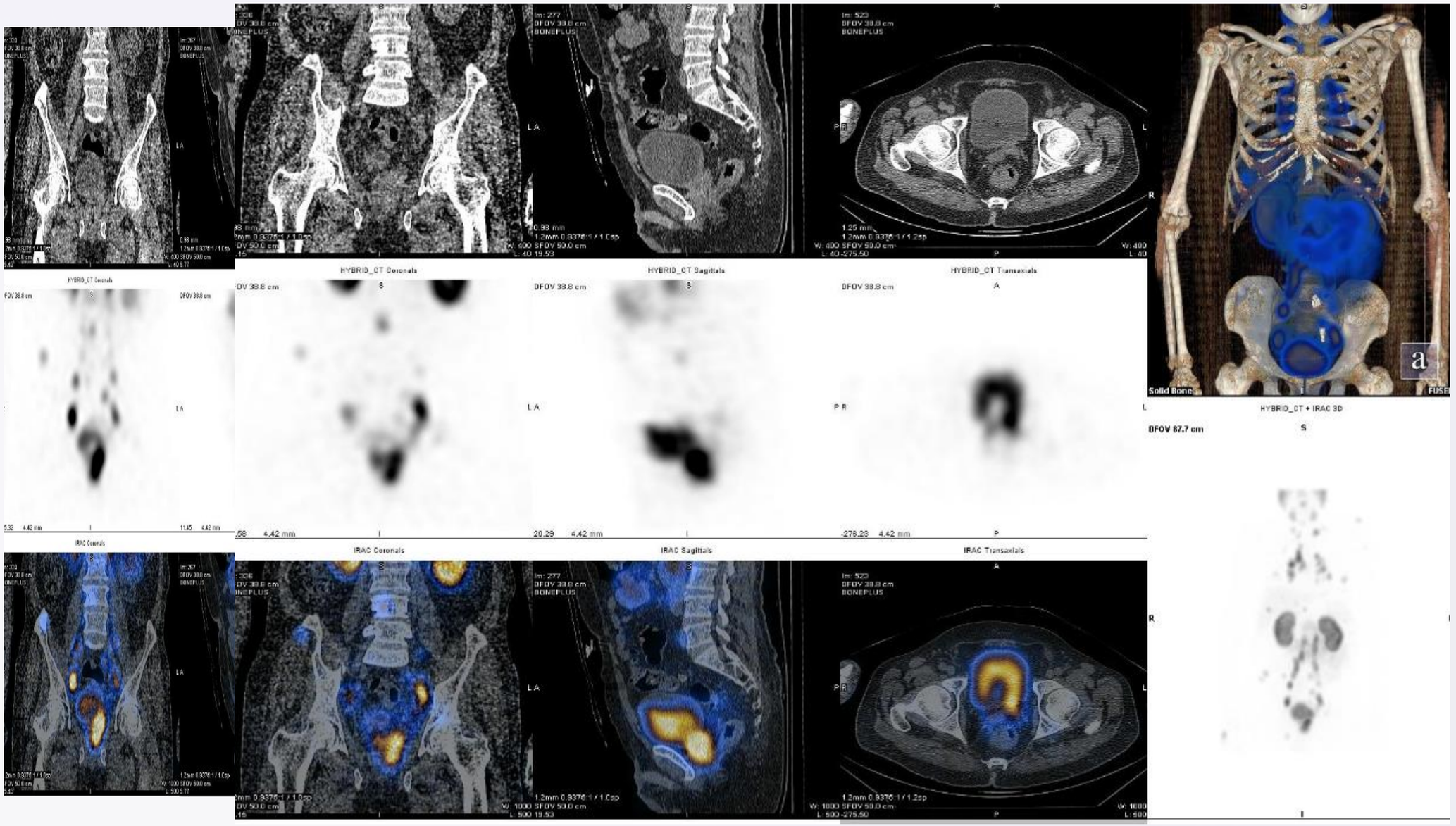
INTERPRETATION:

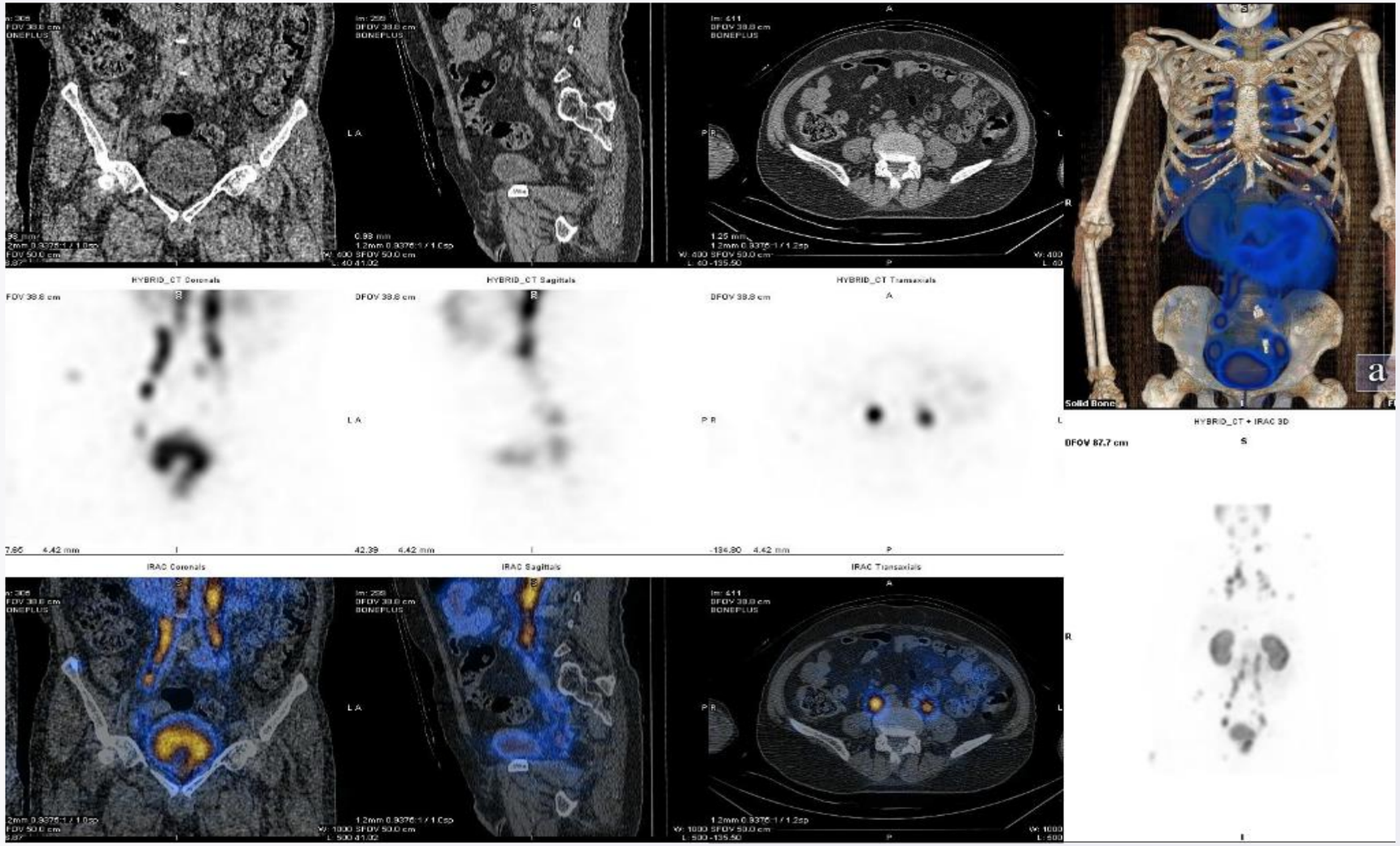
1. PSMA-avid tumoral lesion in the apex of the prostate gland with possibility of extra-prostatic extension.
2. Lymph node metastases just below the bifurcation of the right common iliac artery and in the right external iliac region with increased tracer uptake as well as a few small lymph nodes in the aorto-caval region with faint PSMA uptake.
3. Benign cystic degenerative lesions in the bilateral femoral heads as well as bone islands in the right femoral head, left acetabulum and left iliac bone.

- Molecular imaging TNM: $miT_{3a}N_{1(RE)}M_0$

Can you make assumptions about the TNM staging by whole body scan?



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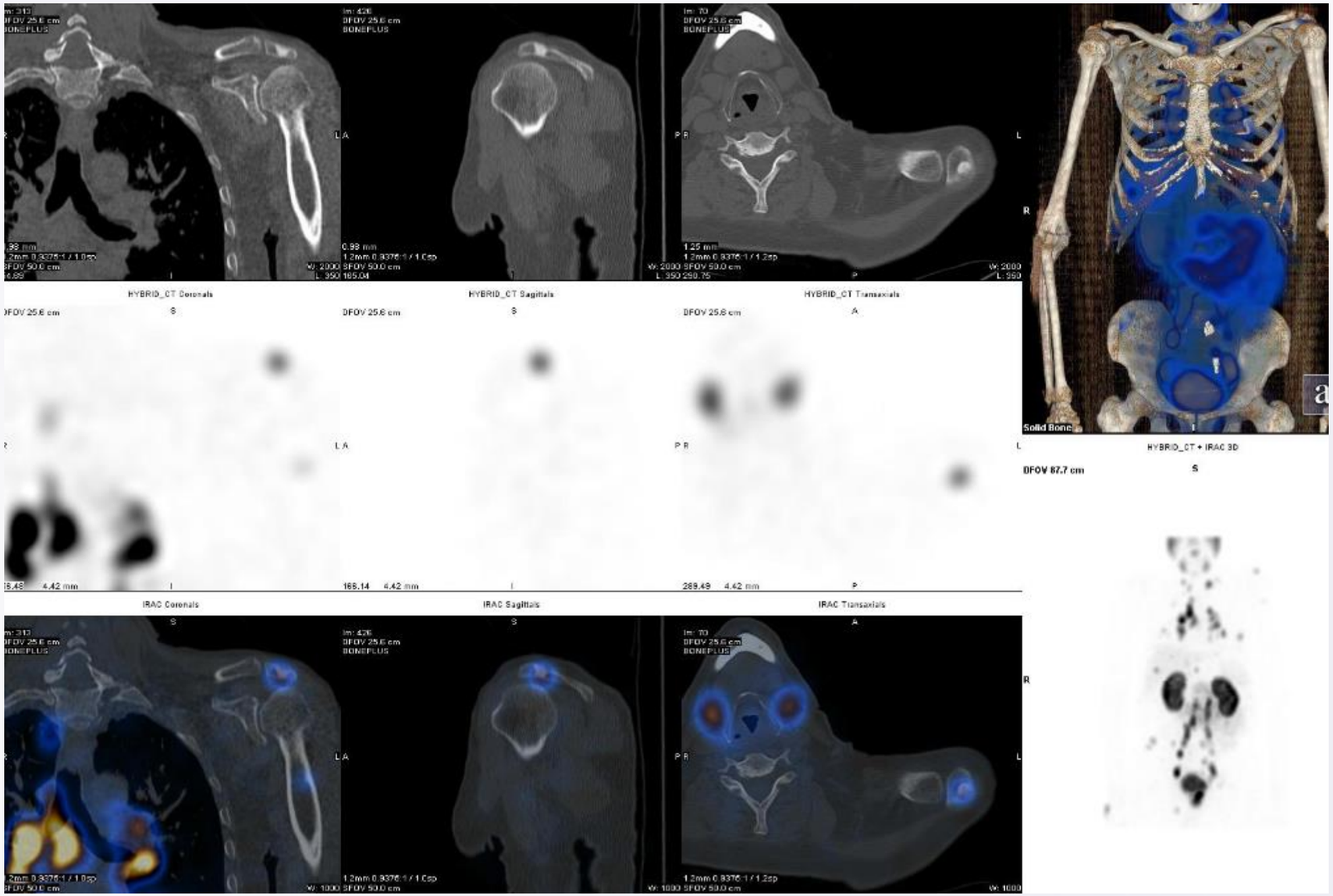
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DFOV 87.7 cm
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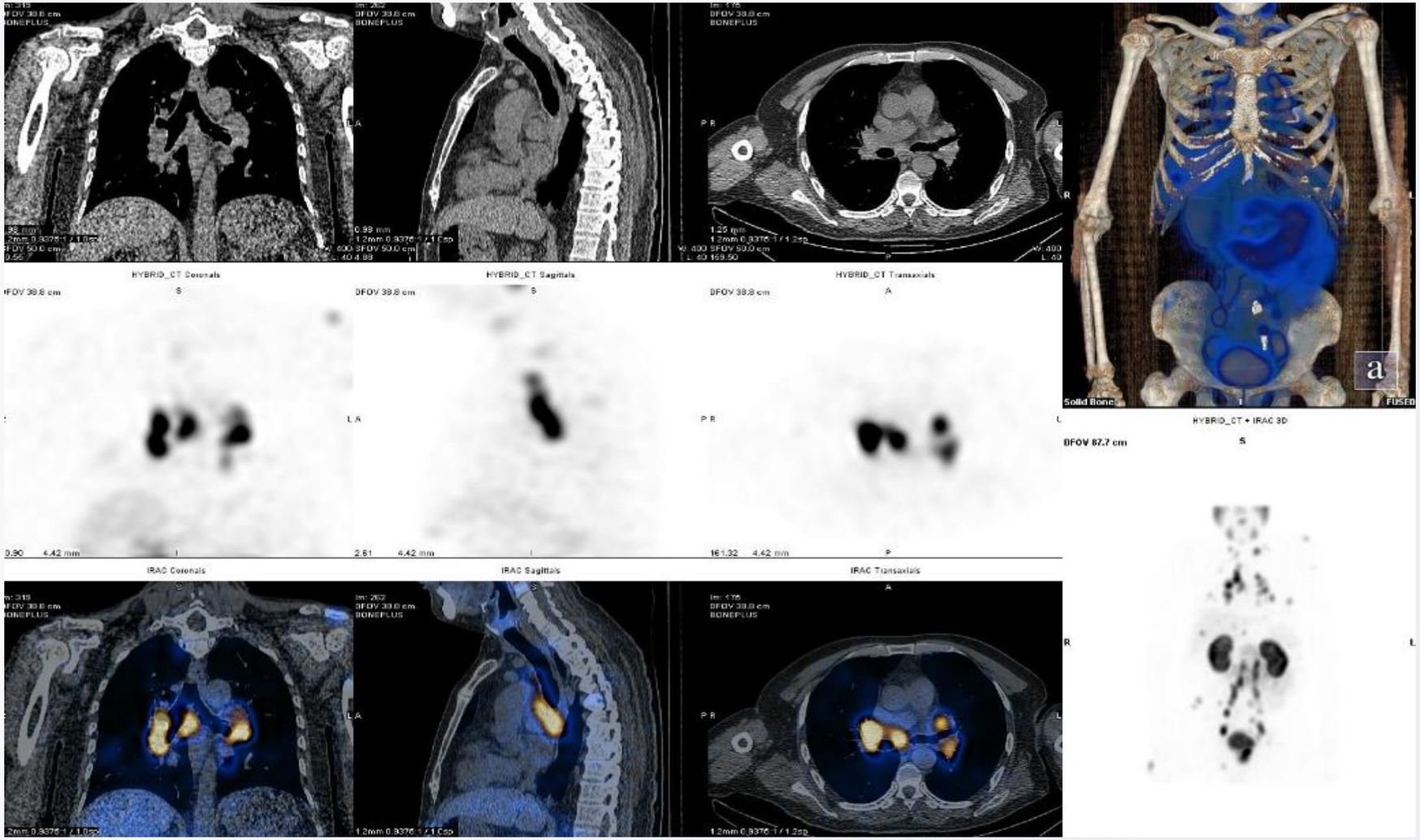
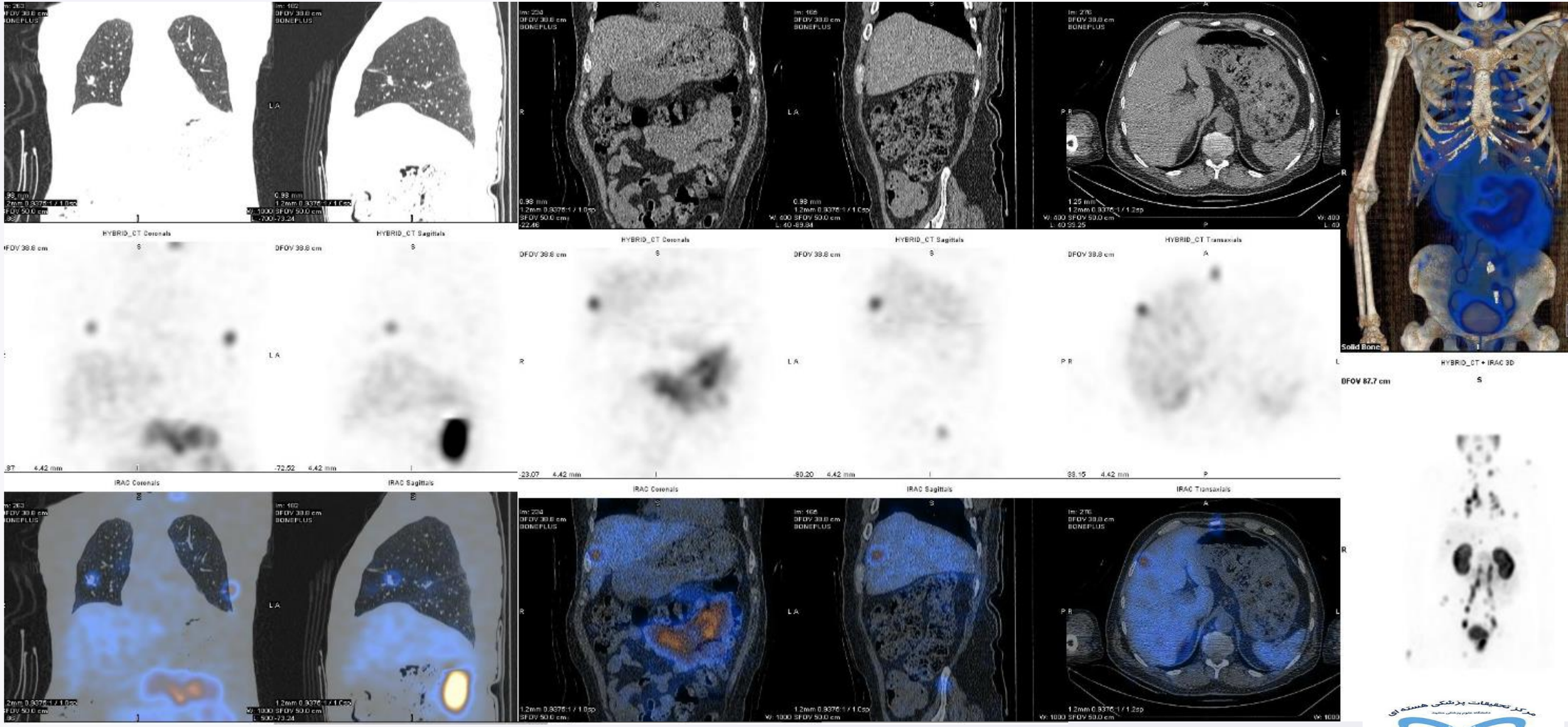
Impact of mediastinal lymph nodes on staging…



So, the TNM would be…



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GHAEM HOSPITAL

Nuclear Medicine Department

RE: Mr. Qorbanzadeh, Alireza *1403/11/28*

WHOLE BODY PSMA SCAN & SPECT/CT:

Four hours after IV injection of 20 mCi of Tc-99m-PSMA scanning was performed in routine views. SPECT/CT images were also performed from the thoracic and abdomino-pelvic regions for better localization and attenuation correction.

The whole body scan showed multiple foci of increased PSMA uptake in the thoracic and abdominopelvic regions.

The SPECT/CT images revealed multiple lymph nodes with increased tracer uptake in bilateral side of the neck (level IV), left supra-clavicular, right para-tracheal, right upper and lower paratracheal, bilateral hilar, sub-carinal, pre-carinal, bilateral peri-bronchial, right retro-crural, para-aortic, aorto-caval, para-caval, bilateral common iliac, bilateral obturator, left internal iliac, bilateral external iliac and left peri-rectal regions.

In addition, the SPECT/CT images revealed multiple foci of increased tracer uptake in the right frontal bone, C3 vertebra, left scapula, proximal portion of the left humerus, T4 vertebra, bilateral 4th and 5th left ribs, posterior aspect of the 5th right rib, right iliac bone, right ischium and L4 vertebra all with sclerotic changes on the CT slices. Also, sclerotic changes without increased PSMA uptake in the left ischium, left acetabulum, sacrum, right iliac, bilateral clavicle, posterior aspect of the 4th right rib,L1, L2, L3, T5, T6,T8, T10, T11 and T12 vertebrae were noted.

Moreover, the SPECT/CT images showed increased tracer uptake in the left apex and bilateral mid and base portions of the prostate gland with extension to both seminal vesicles and suspicion of invasion to the posterior bladder wall.

The lung window of the dedicated CT study revealed multiple pulmonary nodules in the lower lobes of both lungs and right middle lobe, all with increased tracer uptake on the SPECT images.

Furthermore, the SPECT/CT images showed three hypodense lesions in the segment I, VI and VIII of the liver with increased tracer uptake.

INTERPRETATION:

1. *Multiple PSMA-avid sclerotic skeletal metastases in the right frontal bone, C3 vertebra, left scapula, proximal portion of the left humerus, T4 vertebra, bilateral 4th and 5th left ribs, posterior aspect of the 5th right rib, right iliac bone, right ischium and L4 vertebra all with sclerotic changes on the CT slices. as well as multiple non-PSMA-avid sclerotic skeletal metastases in the left ischium, left acetabulum, sacrum, right iliac, bilateral clavicle, posterior aspect of the 4th right rib,L1, L2, L3, T5, T6,T8, T10, T11 and T12 vertebrae. Compared to the previous scan(dated on 1403/08/08) the lesions in the skull, T6 and T11 vertebrae were new. Also decreased PSMA uptake and increased sclerotic changes in some lesions were noted.*
2. *Multiple PSMA-avid metastatic lymph nodes in bilateral side of the neck (level IV), left supra-clavicular, right para-tracheal, right upper and lower paratracheal, bilateral hilar, sub-carinal, pre-carinal, bilateral peri-bronchial, right retro-crural, para-aortic, aorto-caval, para-caval, bilateral common iliac, bilateral obturator, left internal iliac, bilateral external iliac and left peri-rectal regions.*
3. *Three PSMA-avid metastatic lesions in the segment I, VI and VIII of the liver.*
4. *Multiple PSMA-avid pulmonary metastatic nodules in the lower lobes of both lungs and right middle lobe.*
5. *Focal increased PSMA uptake in the left apex and bilateral mid and base portions of the prostate gland with involvement of both seminal vesicles and suspicion of invasion to the posterior bladder wall.*

- *Molecular imaging TNM: $T_4N_2M_{1a}M_{1b\,(Mediastinum)}M_{1c\,(Lung,\,Ovary)}$*
- *Primary Score: 5*
- *PSMA expression score: 1-3*

- ✓ *Note: Compared to the previous scan (dated on: 1403/08/08), the presence of three new lesions (in the skull, T6 and T11 vertebrae) could indicate progressive disease based on PPP criteria, while stable disease is indicated based on PERCIST criteria.*

F.TAHERI, MD *S.BARASHTI, MD*

Any questions?

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Thank You for Your Attention

We value your time and attention today. Special thanks to our partners for their continued support and collaboration.

We're now open for questions and discussion.