# Precision Imaging in Uterine Cancer

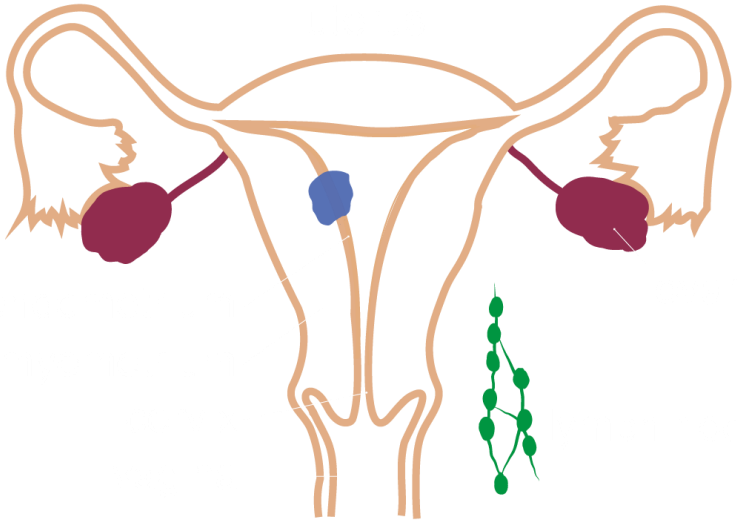
# The next frontier including radiomic profiling

**Ingfrid Salvesen Haldorsen**
Head of Dep. of Radiology, Haukeland University Hospital, Bergen, Norway
Professor at the University of Bergen, Norway

# Lecture outline – Imaging in Uterine Cancer: Endometrial cancer (EC) and cervical cancer (CC)

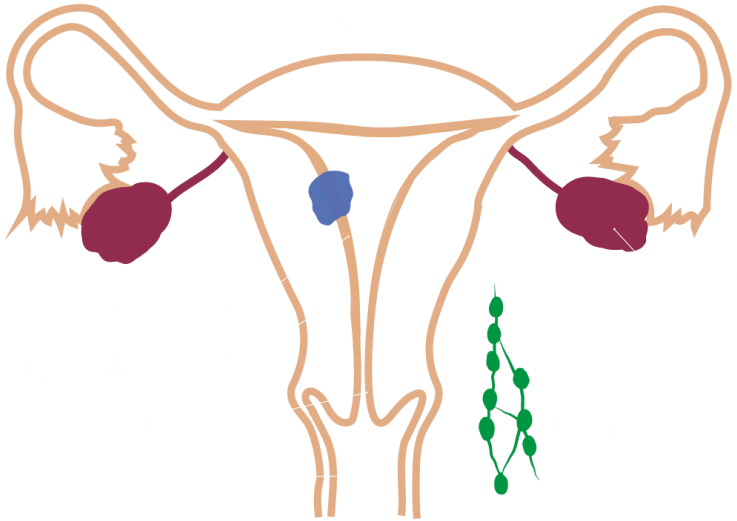
- Epidemiology and clinicopathologic characteristics
- FIGO 2023 (EC) and FIGO 2018 (CC) staging criteria and the role of diagnostic imaging
- Precision imaging by MRI and PET/CT: conventional and new approaches for enhancing staging accuracy, prognostication and tailoring of treatment
- Radiomics and radiogenomics – next frontiers?
- Summary

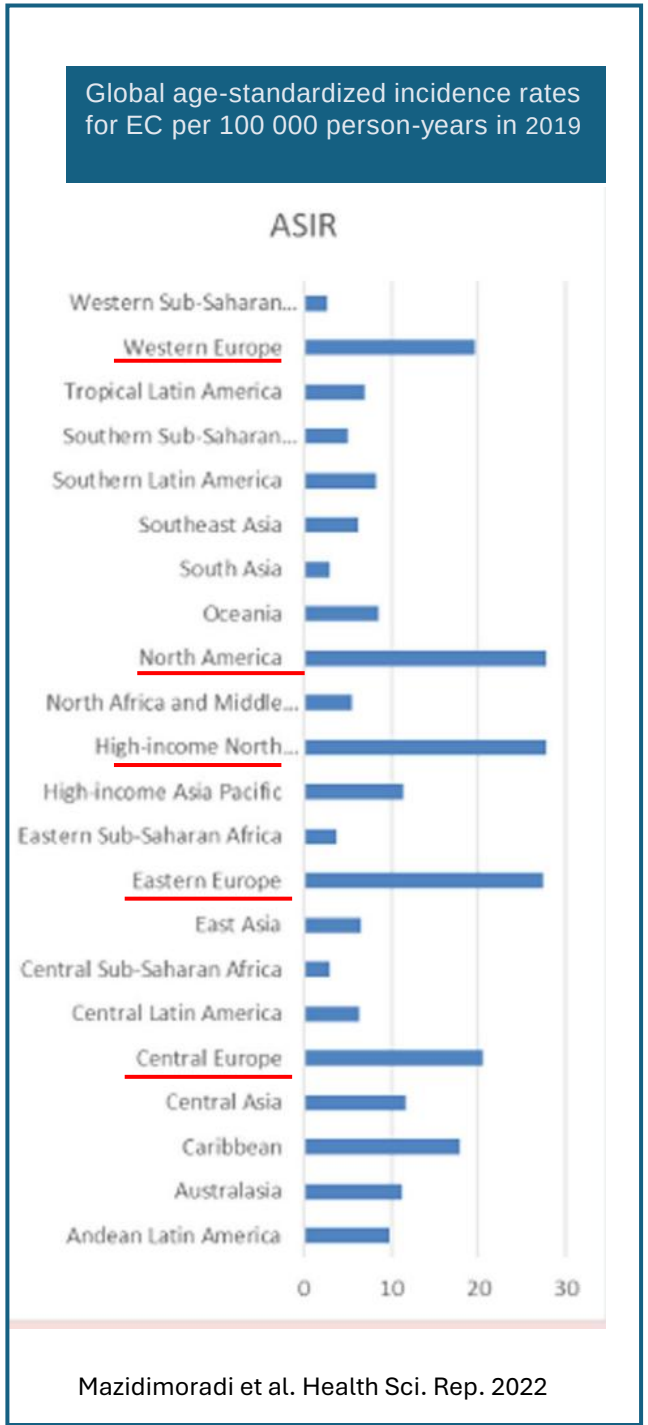
# Endometrial cancer (EC)



# Endometrial cancer (EC)

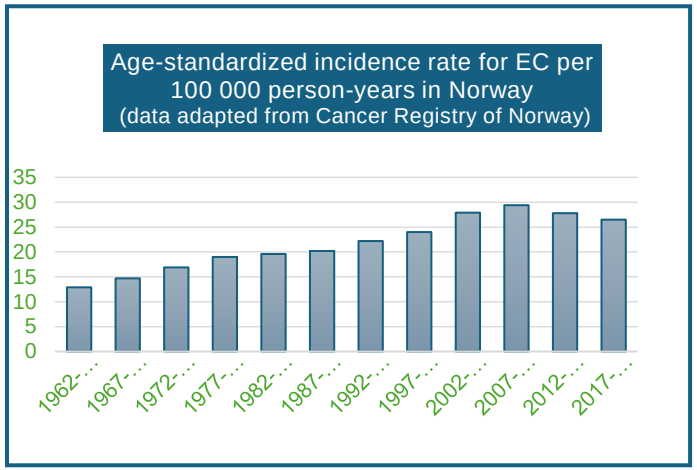
**Arises** from the epithelial lining (endometrium) of the uterine cavity






Mazidimoradi et al. Health Sci. Rep. 2022

One of the **most common gynecologic malignancies** in **high-income countries**




**Increasing incidence in Norway**

# Endometrial cancer (EC) – traditional histological classification

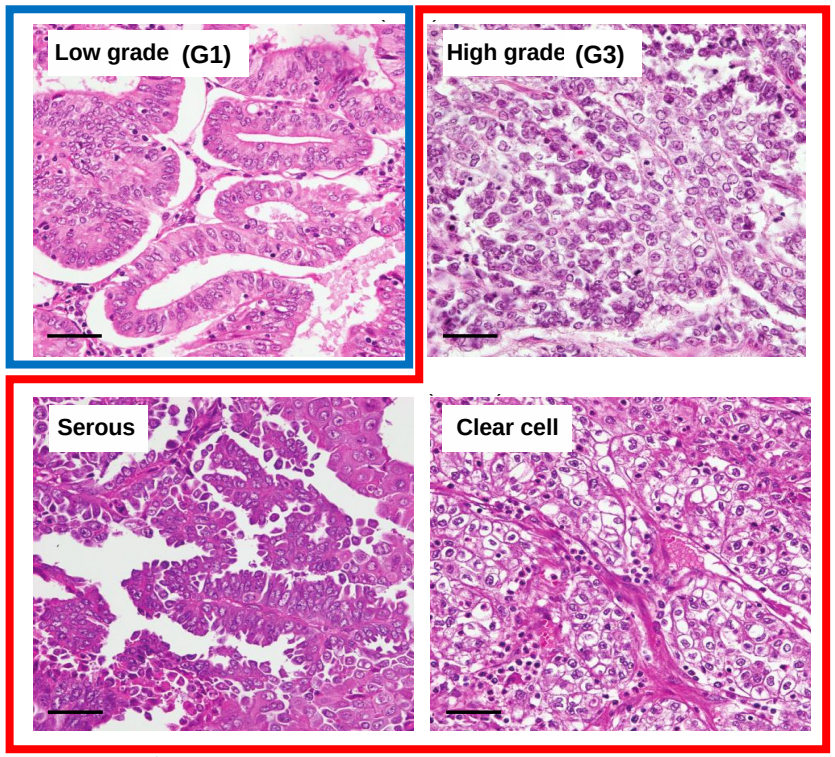
Endometrioid endometrial carcinoma (**EEC**):

~80% of cases

Non-endometrioid endometrial carcinomas (**NEEC**):

- ~20% of cases

EEC are graded 1-3 (**G1-G3**):




Courtesy of Hege Berg

**EEC G1-G2 → non-aggressive histological types**

**EEC G3 and NEEC → aggressive histological types**

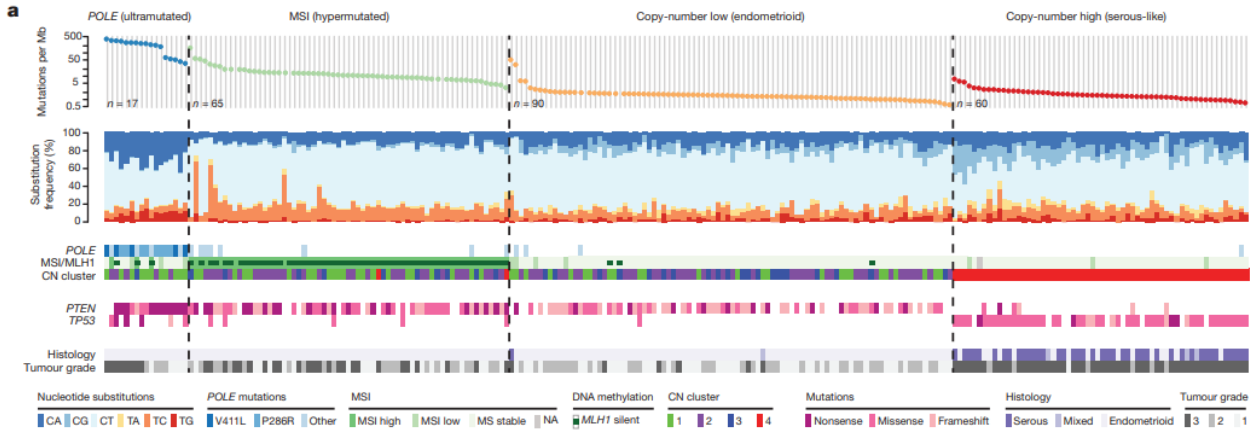
Berek J. et al
FIGO staging of endometrial cancer 2023
J Gynecol Oncol, 2023

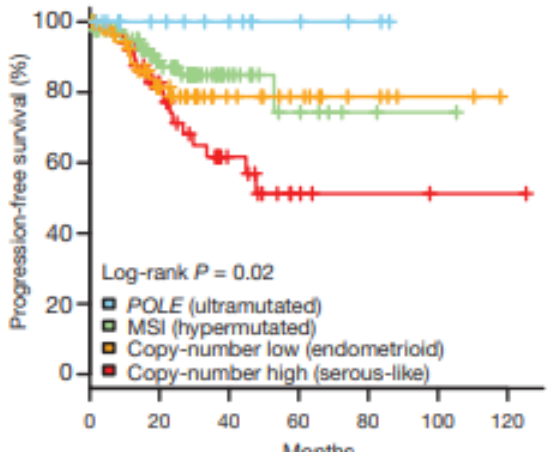
# Endometrial cancer (EC) – LVSI and molecular class incorporated into FIGO 2023

Lymphovascular space invasion (LVSI) (extensive/focal/no)

Molecular classes according to TCGA or TCGA-surrogate approach:

1. *POLE*/ultramutated – excellent prognosis
2. Microsatellite instability (MSI)-high/hypermutated – intermediate prognosis
3. Somatic copy-number high/serous like (95% *TP53*-mutated) – unfavorable prognosis
4. Somatic copy number low – intermediate prognosis

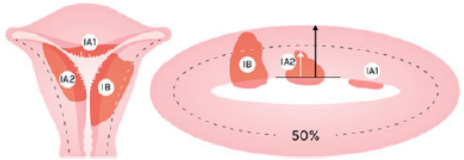


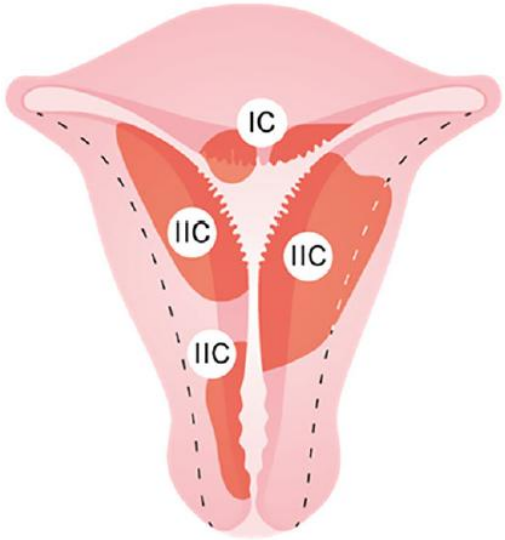




Kandoth C. et al; Nature 2013
TCGA = The Cancer Genome Atlas

Berek J. et al ; FIGO staging of endometrial cancer 2023; J. Gynecol Oncol, 2023

# FIGO (2023) 1&2 (limited to uterus)

| Stage | Non-aggressive histology type: FIGO grade 1 and 2 endometrioid. | Aggressive histology type: FIGO grade 3 endometrioid, serous, clear cell, undifferentiated, dedifferentiated, mesonephric-like, gastrointestinal-type mucinous, carcinosarcoma. |
|---|---|---|
| I | IA1 tumor limited to an endometrial polyp OR confined to the endometrium<br>IA2 tumor involving less than half of the myometrium<br>IA3 tumor limited to the uterus (limited to superficial myometrial invasion and without substantial LVSI) and ovary<br>IB tumor invasion of half or more of the myometrium<br>  | IC limited to a polyp or confined to the endometrium |
| II | IIA Invasion of the cervical stroma<br>IIB Substantial LVSI | IIC any myometrial invasion |



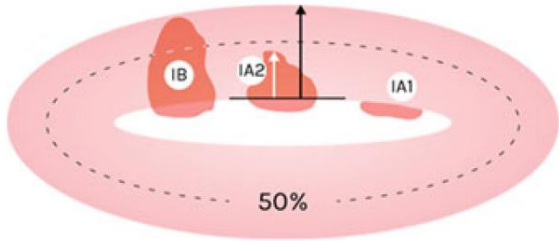

Two molecular subtypes will lead to down-/upstaging within FIGO stages 1&2:
If *POLEmut:* Stage $IAm_{POLEmut}$ regardless of LVSI and histological type (downstaging)
If p53abn: Stage $IICm_{p53abn}$ regardless of LVSI and histological type (upstaging)

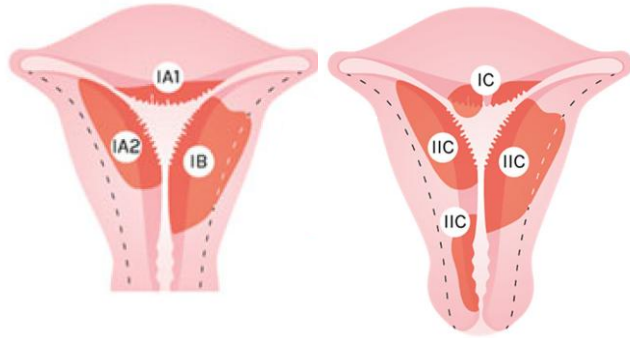
Nougaret et al,; Updated ESUR Guidelines for Endometrial Cancer: integrating MRI with the 2023 FIGO Staging Revolution, Eur Radiol, 2025
Berek J. et al ; FIGO staging of endometrial cancer 2023; J. Gynecol Oncol, 2023
FIGO, The International Federation of Gynecology and Obstetrics

## Imaging

Pelvic MRI or US enables preoperative depiction of:

- Myometrial invasion
- Depth (</≥50%) of myometrial invasion
- Cervical stroma invasion



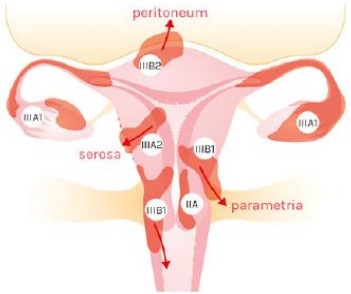



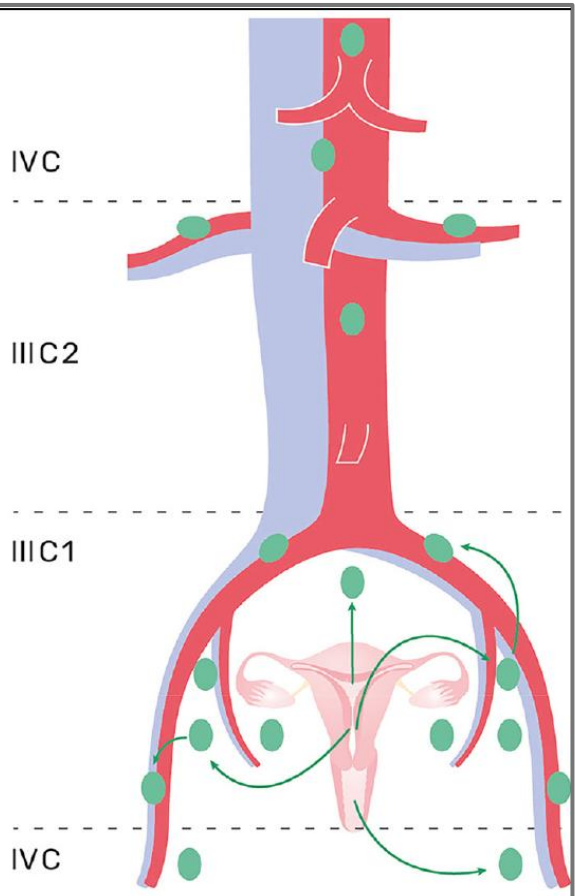
# FIGO (2023) 3&4 (beyond uterus)

III IIIA Invasion of uterine serosa, adnexa, or both by direct extension or metastasis
- IIIA1 Spread to ovary or fallopian tube (except when meeting stage IA3 criteria)
- IIIA2 Involvement of uterine subserosa or spread through the uterine serosa

IIIB Metastasis or direct spread to the vagina and/or to the parametria or pelvic peritoneum
- IIIB1 Metastasis or direct spread to the vagina and/or the parametria
- IIIB2 Metastasis to the pelvic peritoneum

IIIC Metastasis to the pelvic or para-aortic lymph nodes or both
- IIIC1 Metastasis to the pelvic lymph nodes
  - IIIC1i Micrometastasis
  - IIIC1i Macrometastasis
- IIIC2 Metastasis to para-aortic lymph nodes up to the renal vessels, with or without metastasis to the pelvic lymph nodes
  - IIIC2i Micrometastasis
  - IIIC2ii Macrometastasis

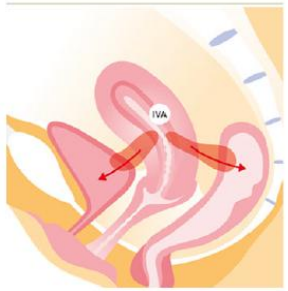



IV IVA Invasion of the bladder mucosa and/or the intestinal/bowel mucosa

IVB Abdominal peritoneal metastasis beyond the pelvis

IVC Distant metastasis, including metastasis to any extra- or intra-abdominal lymph nodes above the renal vessels, lungs, liver, brain




## Imaging

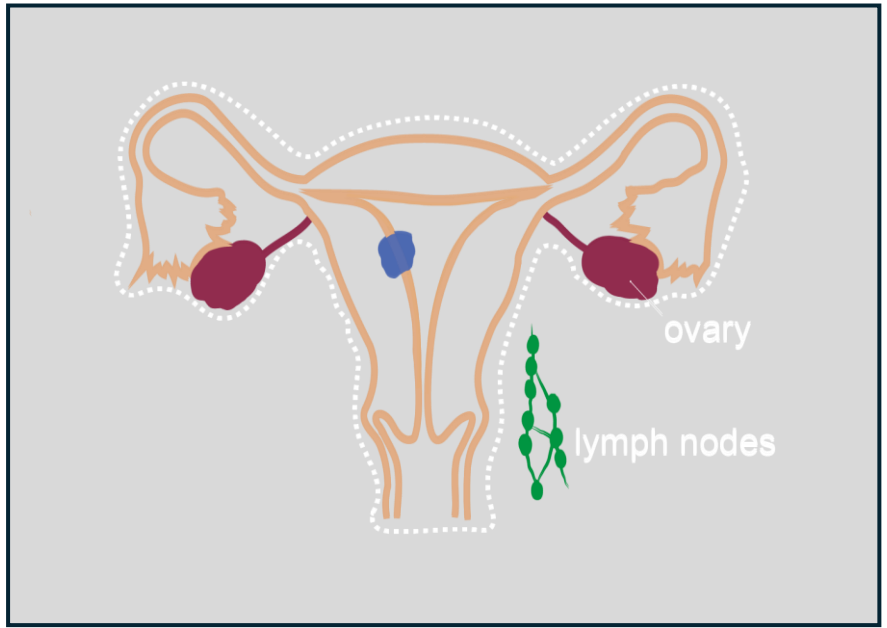
MRI, US, CT or PET/CT allow preoperative depiction of tumor extension and/or metastases to:

- Serosa
- Adnexa/ovaries/fallopian tubes
- Vagina
- Parametria
- Peritoneum
- Lymph nodes in the pelvis, paraaortic or extra-abdominal
- Bladder
- Rectum/bowel
- Distant sites (e.g. lung, liver, brain)

Nougaret et al,; Updated ESUR Guidelines for Endometrial Cancer: integrating MRI with the 2023 FIGO Staging Revolution, Eur Radiol, 2025

# Primary surgical treatment is guided by preoperative FIGO stage (imaging and biopsy) and adjuvant treatment guided by final (surgicopathological) FIGO stage

**Hysterectomy** with **bilateral salpingo-oophorectomy** is standard




**Lymph node sampling** in patients with presumed advanced or aggressive disease

**Adjuvant treatment in high-risk disease**:

- Chemotherapy
- External/internal radiation therapy
- Hormonal therapy

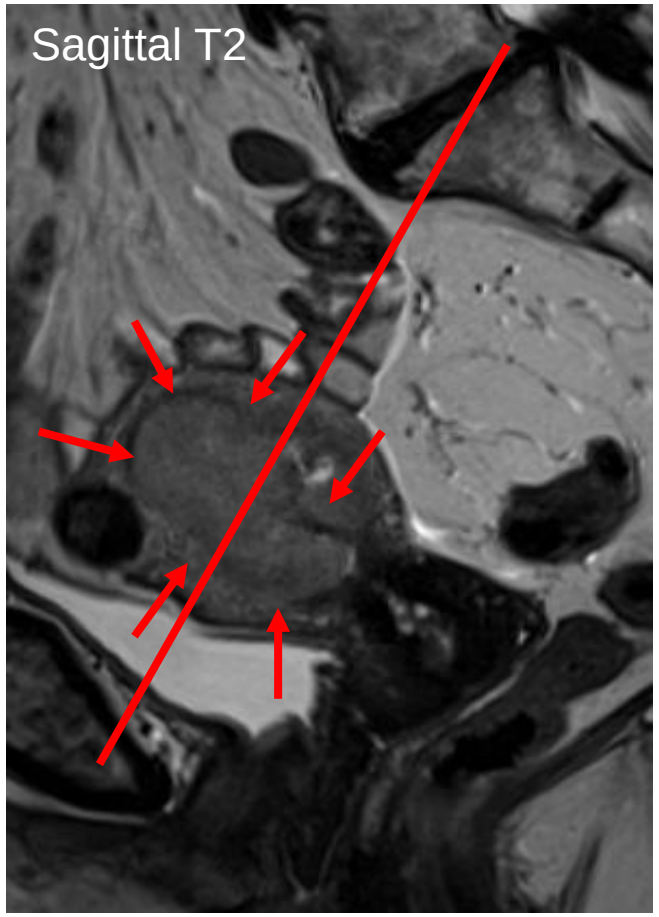
# Standard preoperative diagnostic workup in EC

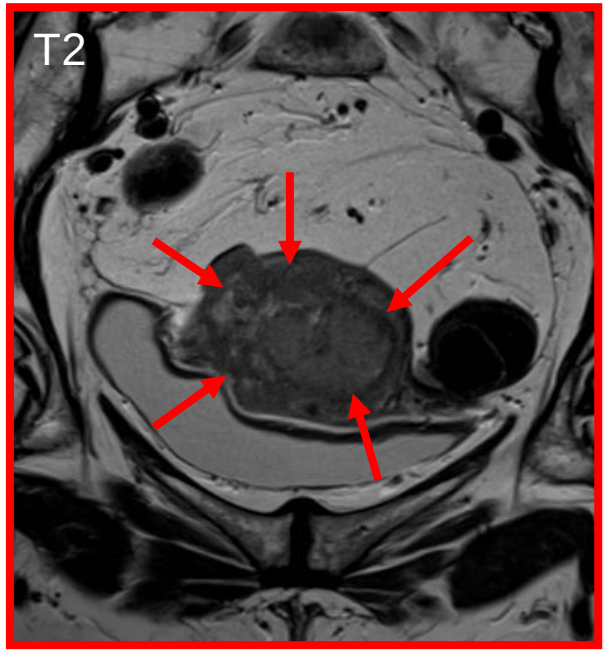
- Symptoms (postmenopausal vaginal bleeding)
- Clinical examination with transvaginal ultrasound
- Biopsy/currettage histology:
  - Non-aggressive histology type: EEC G1–2
  - Aggressive histology type: EEC G3+NEEC
- Pelvic MRI or ultrasound for local staging and abdominal/thoracic CT or whole-body [$^{18}$F]FDG-PET/CT for assessing distant spread

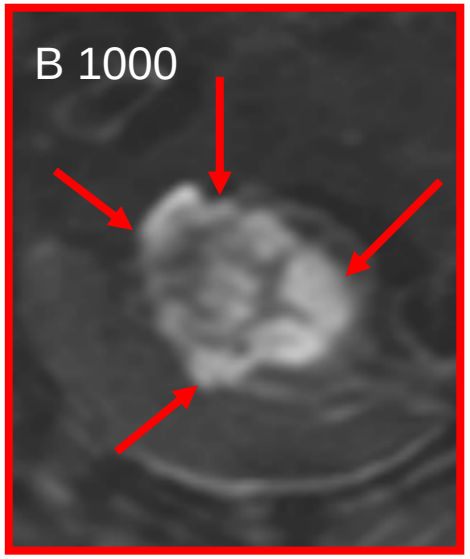
EEC endometrioid endometrial cancer; G, grade, NEEC, non-endometrioid endometrial cancer
FIGO, The International Federation of Gynecology and Obstetrics
Haldorsen et al, Curr Oncol Rep, 2016

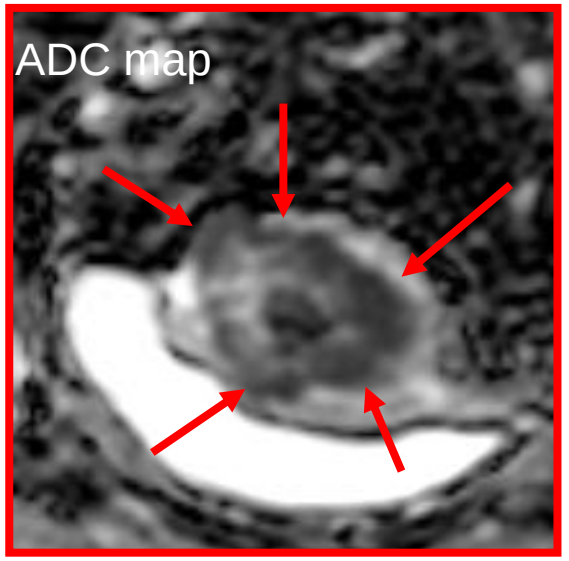
# EC FIGO (2009/23) IB/IIC (EEC grade 3)

♀ 80 yrs, adjuvant chemo, no recurrence after 10 yrs.

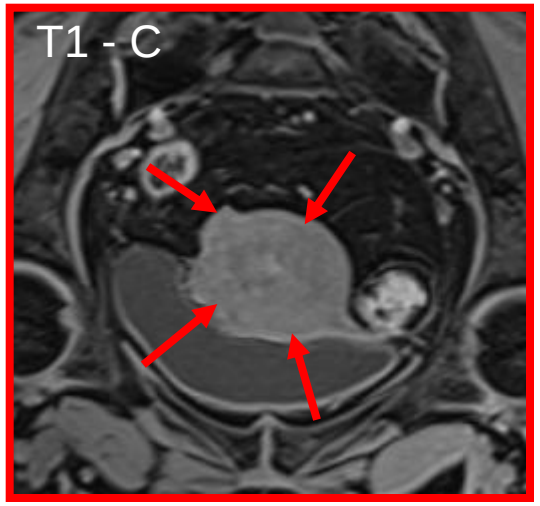


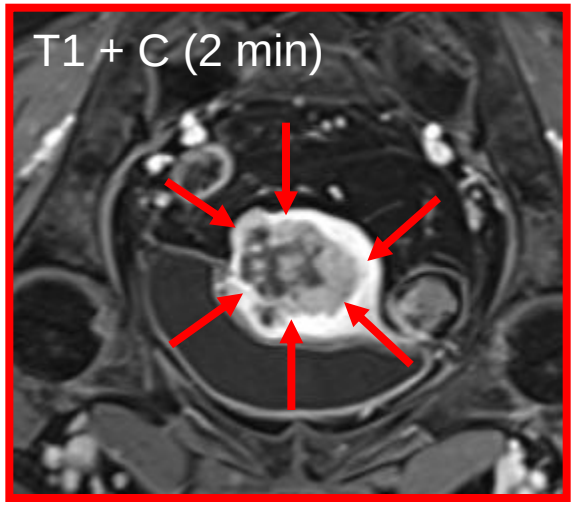



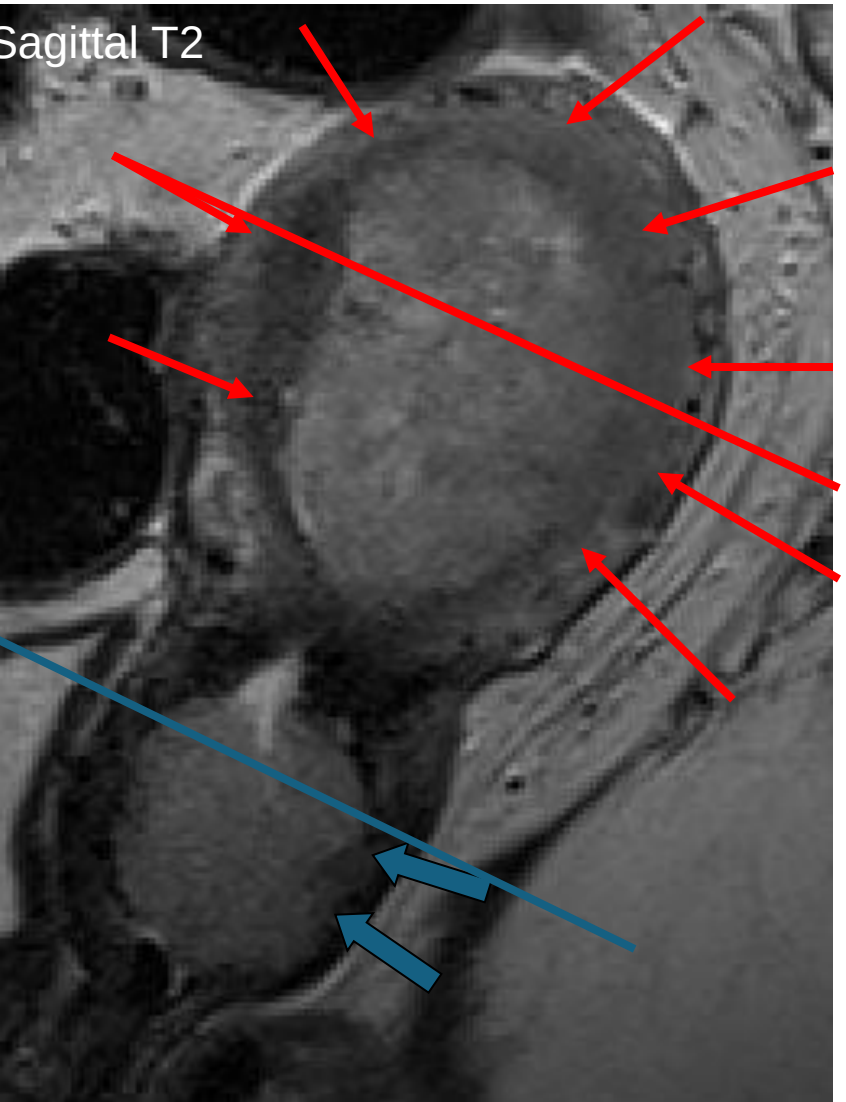

Endometrial cancers typically:
Iso- or hyperintense on T2, restricted diffusion at DWI and hypointense on T1 + C (2 min)



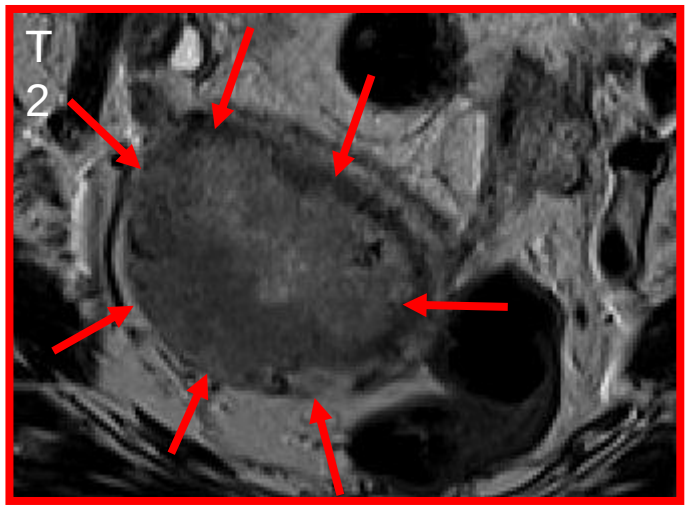
# EC (2009/23) FIGO II/IIC (cervical stroma invasion, clear cell adenocarcinoma)

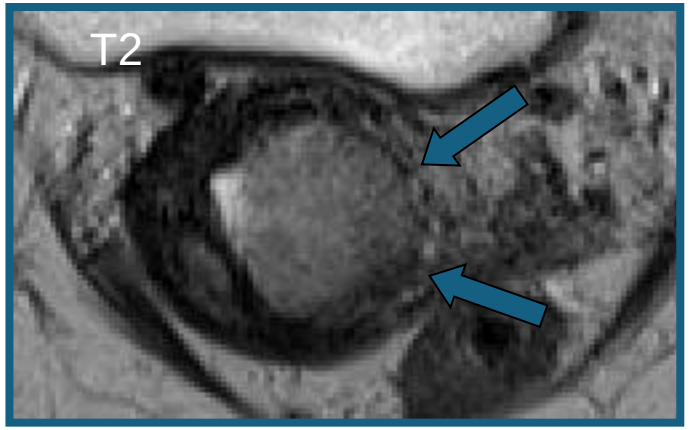
♀ 70 yrs, recurrence/death from EC after 5/7 yrs.

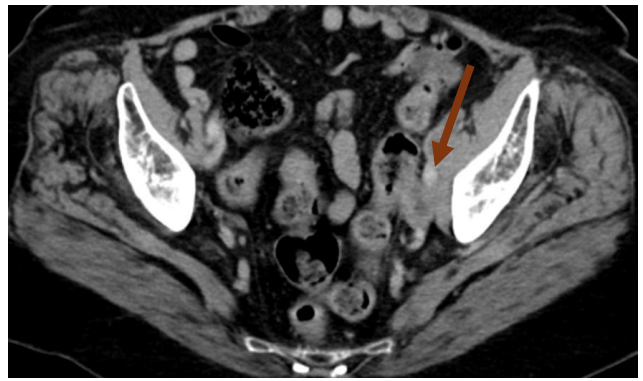



Large uterine lesion invading ≥50% of the myometrial wall

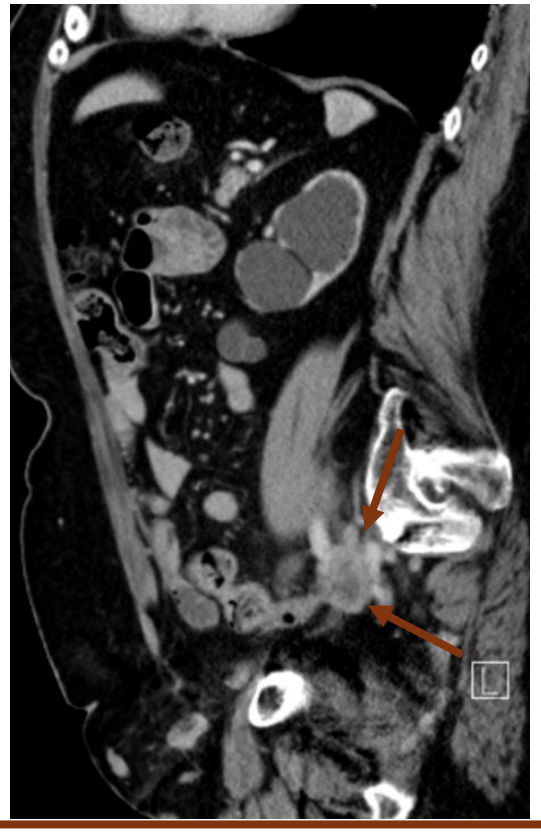
Cervical tumor extension with cervical stroma invasion



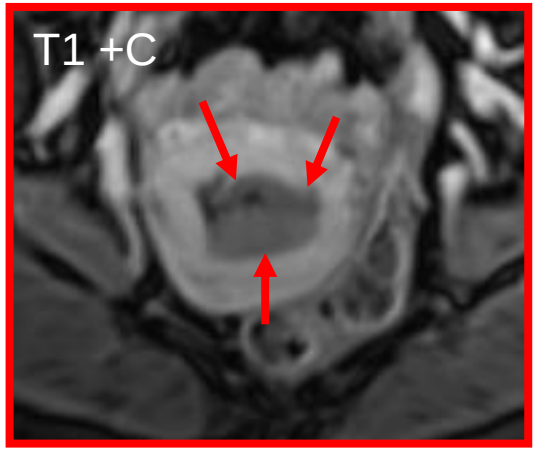



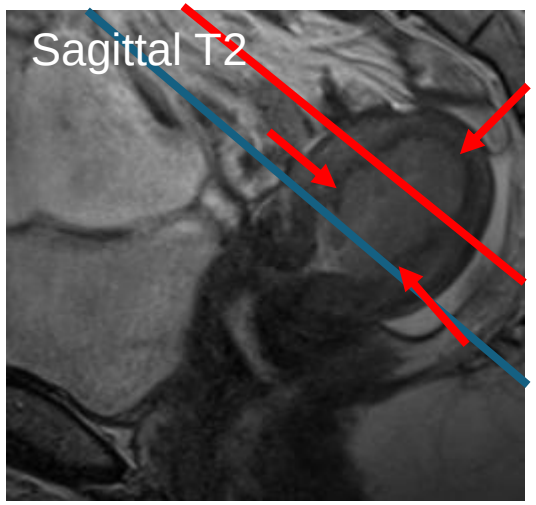
Pelvic recurrence after 5 yrs

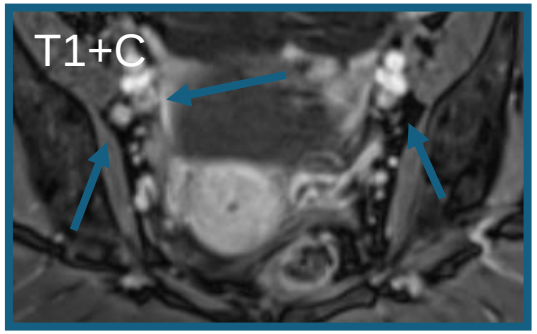


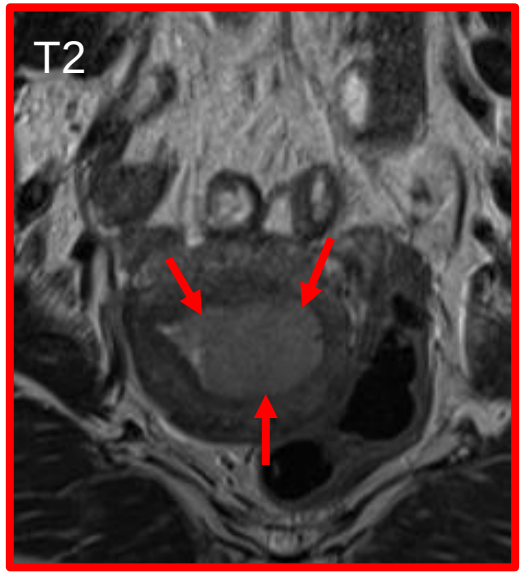
# EC FIGO (2009/23) IIIC2 (paraaortic LNM) EEC grade 3

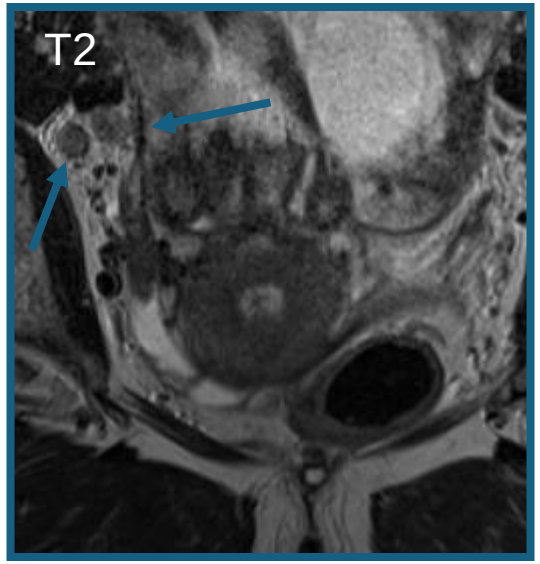
60 yrs; HBSO + chemo, recurrence/death from EC after 1/3 yrs.

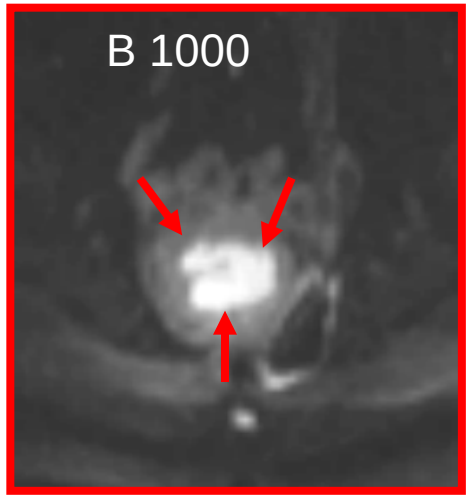


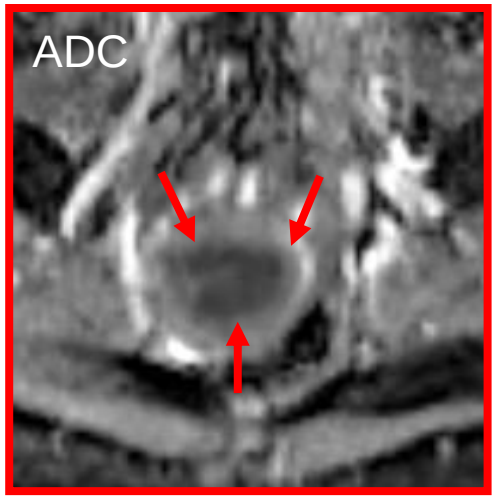



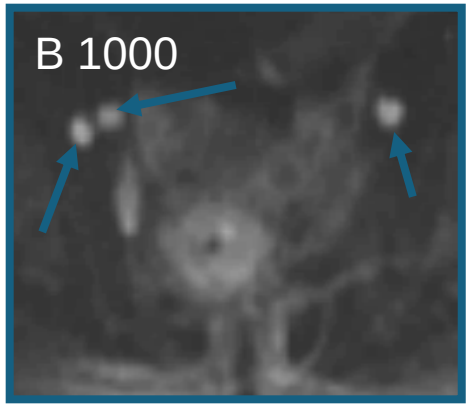



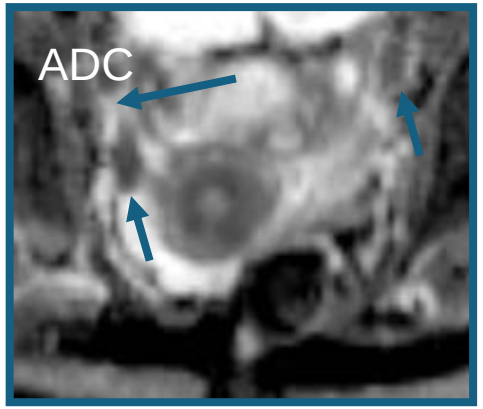



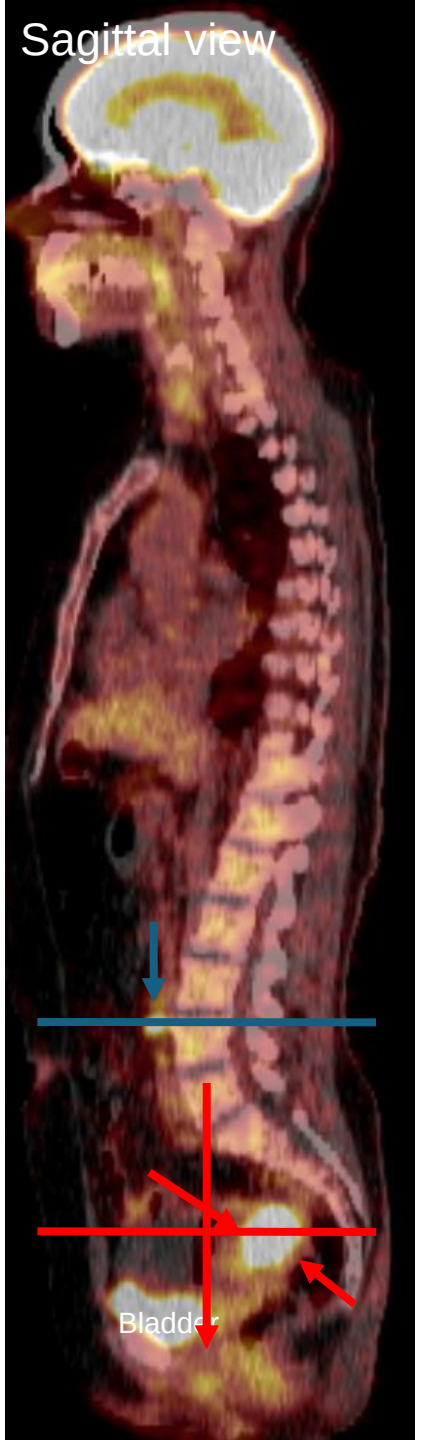




Uterine lesion (with restricted diffusion) invading <50% of the myometrial wall

Iliac lymph node metastases



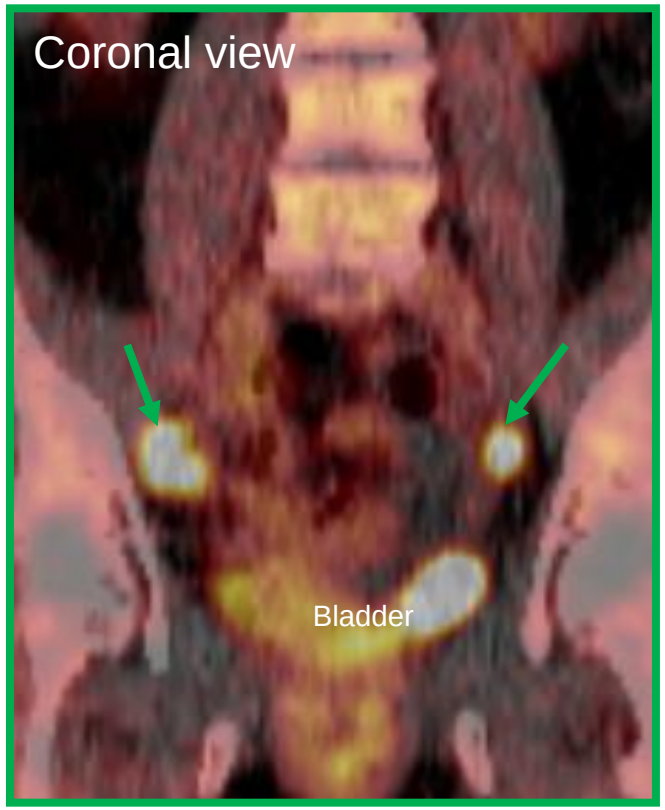



# Same patient: EC FIGO (2009/23) IIIC2 (paraaortic LNM), EEC grade 3

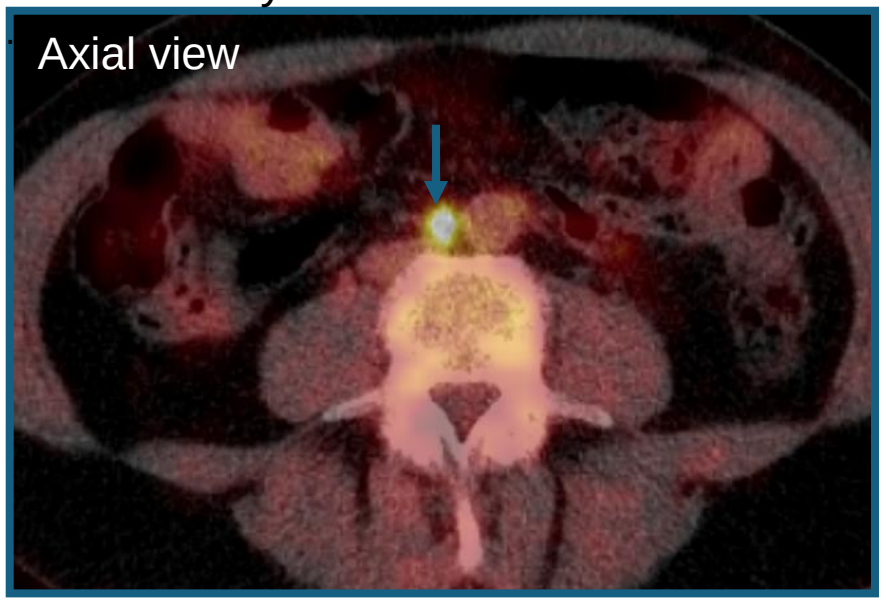
Highly FDG avid endometrial lesion

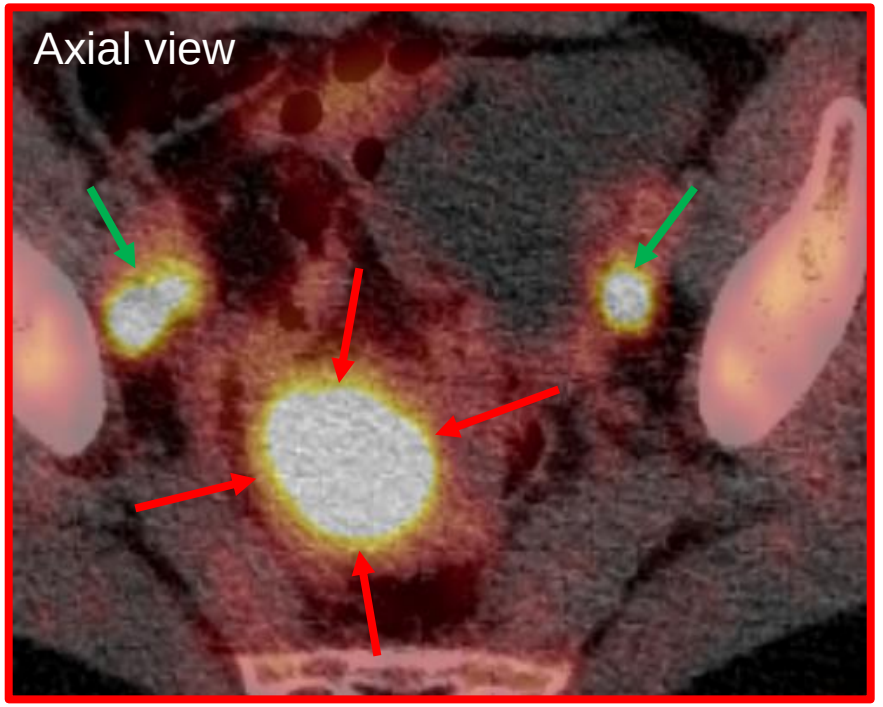
Iliac FDG avid lymph nodes

Paraaortic FDG avid lymph node



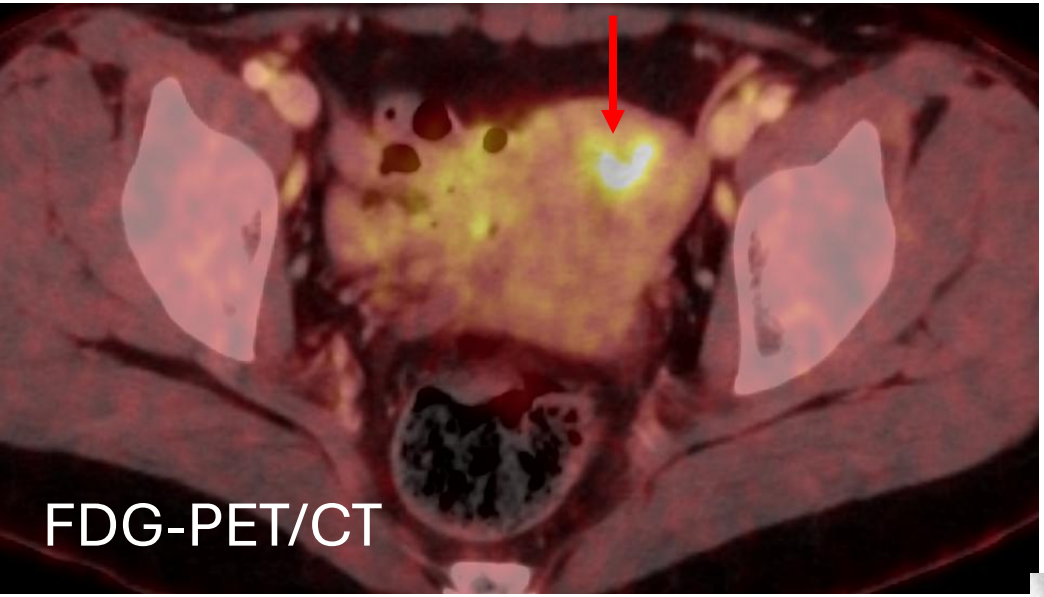

60 yrs; HBSO + chemo, recurrence/death from EC after 1/3 yrs.

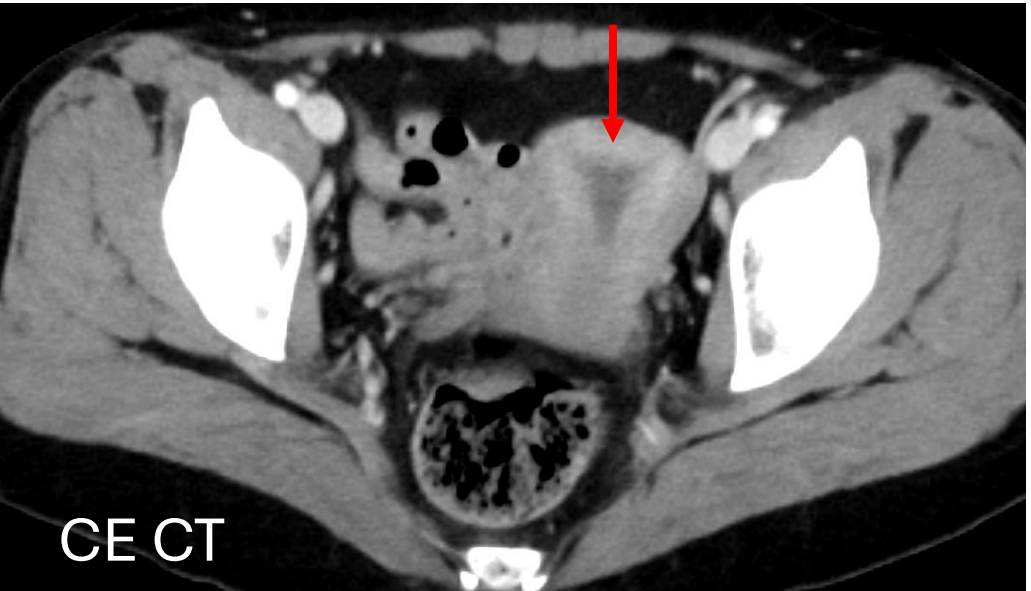


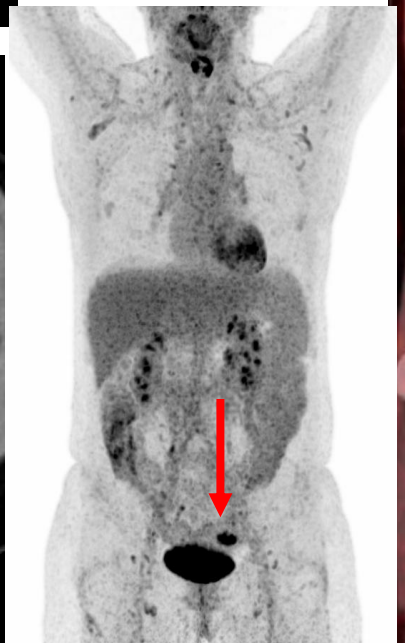



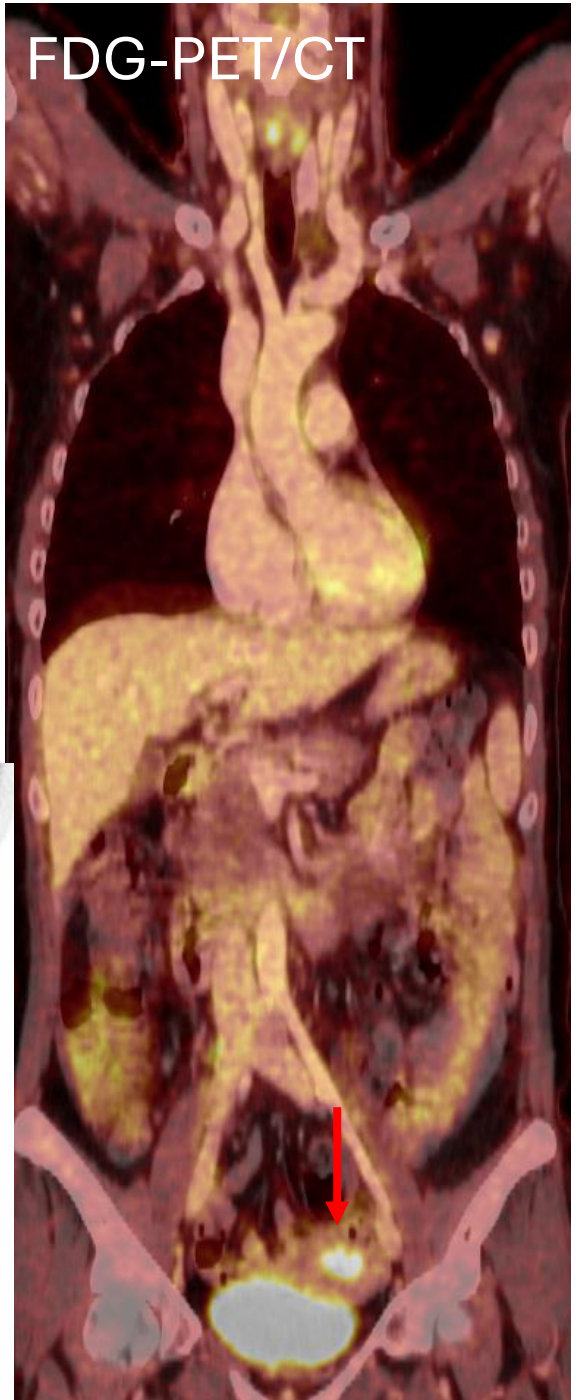
# EC FIGO (2009/23): IB, EEC G2

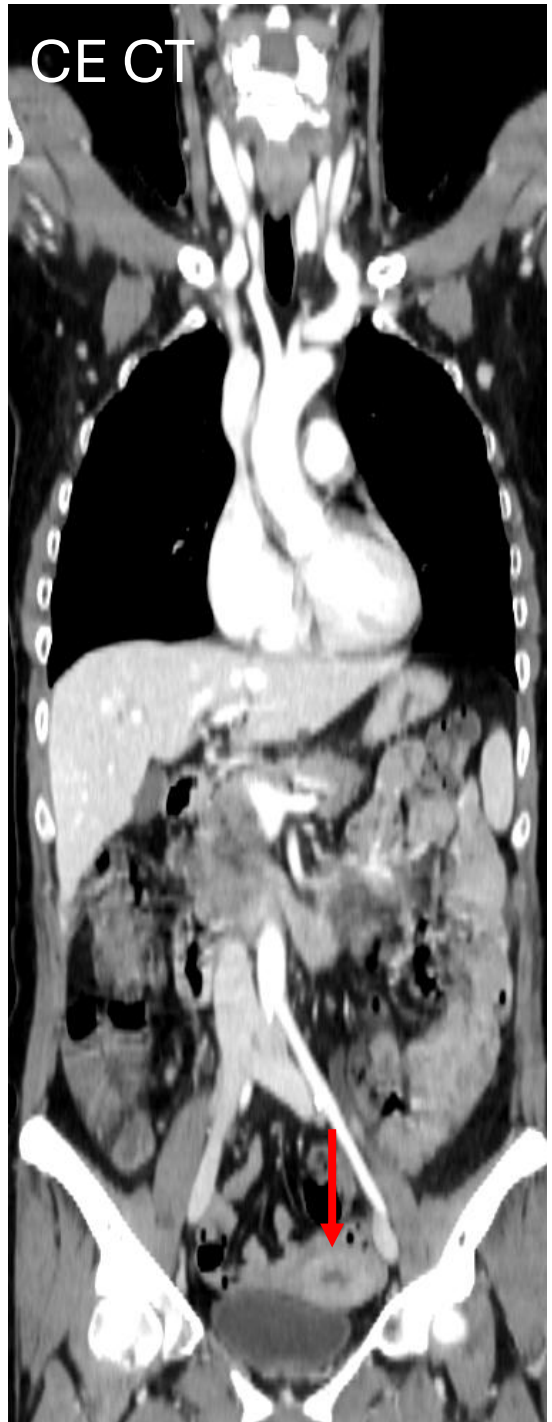
52 yrs., no recurrence (5 yrs)



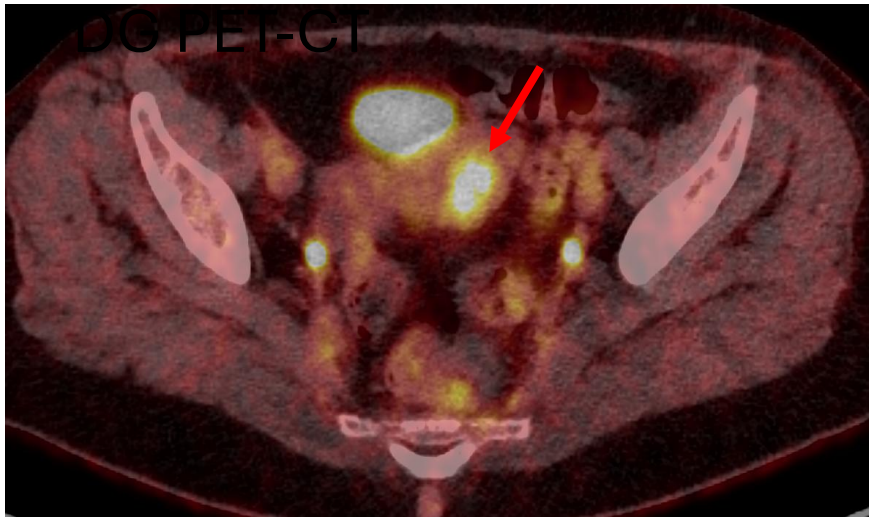



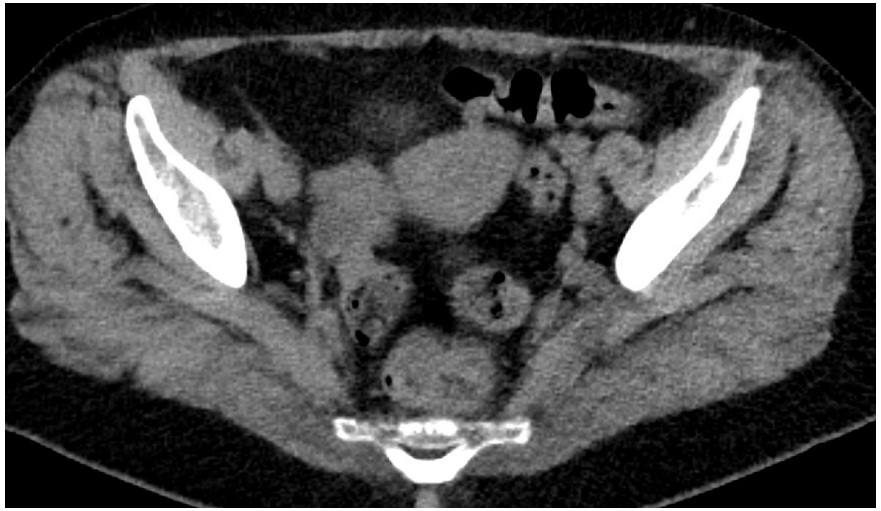


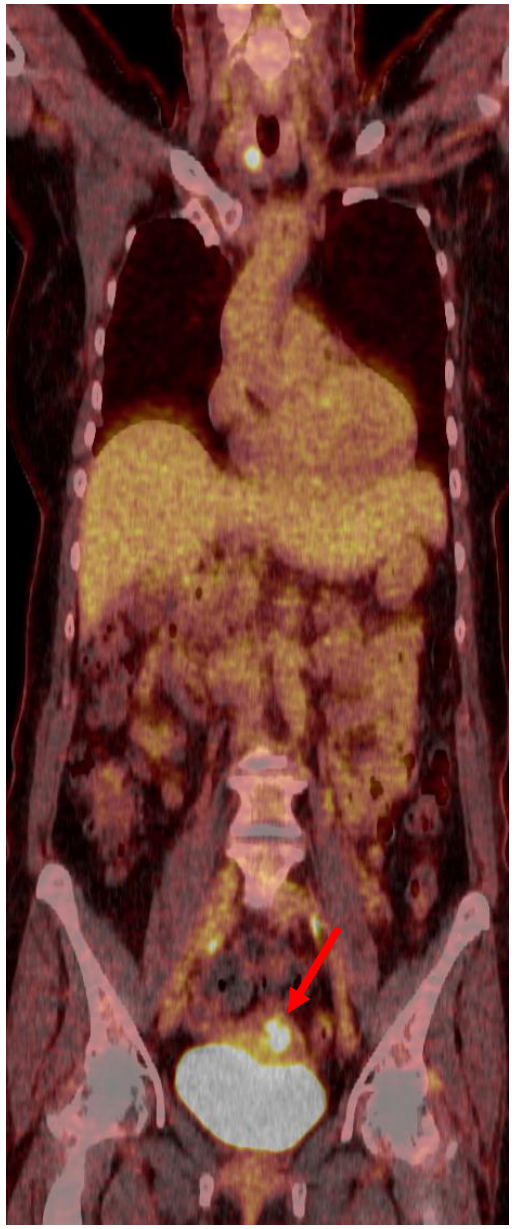



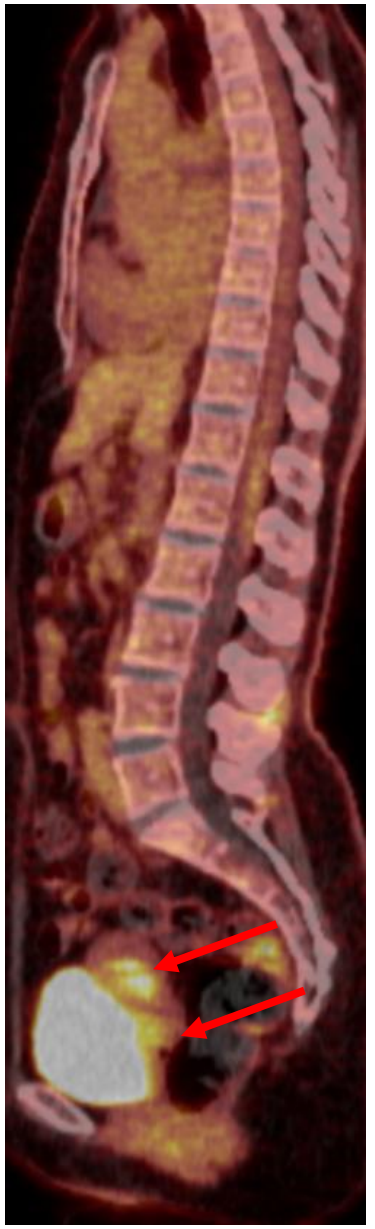
# EC FIGO (2009/23) II/IIC, serous carcinoma

66 yrs, HBSO + chemo, recurrence/death from EC after 7 months/2 yrs.

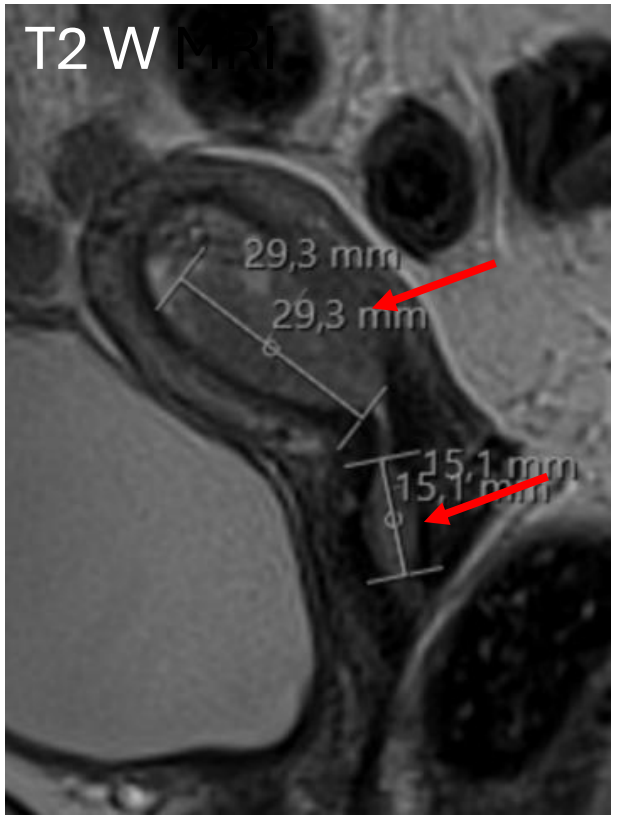


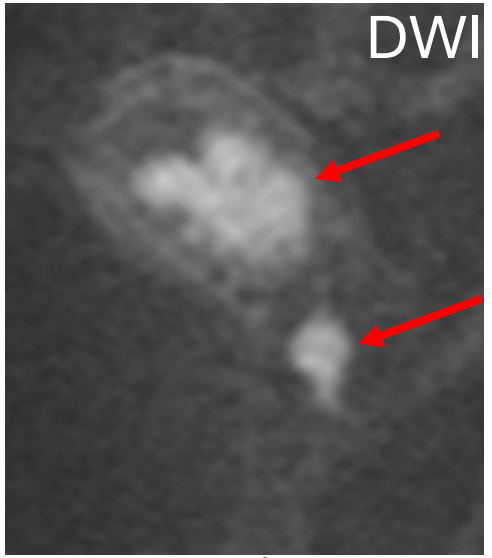







PET/CT at primary diagnosis



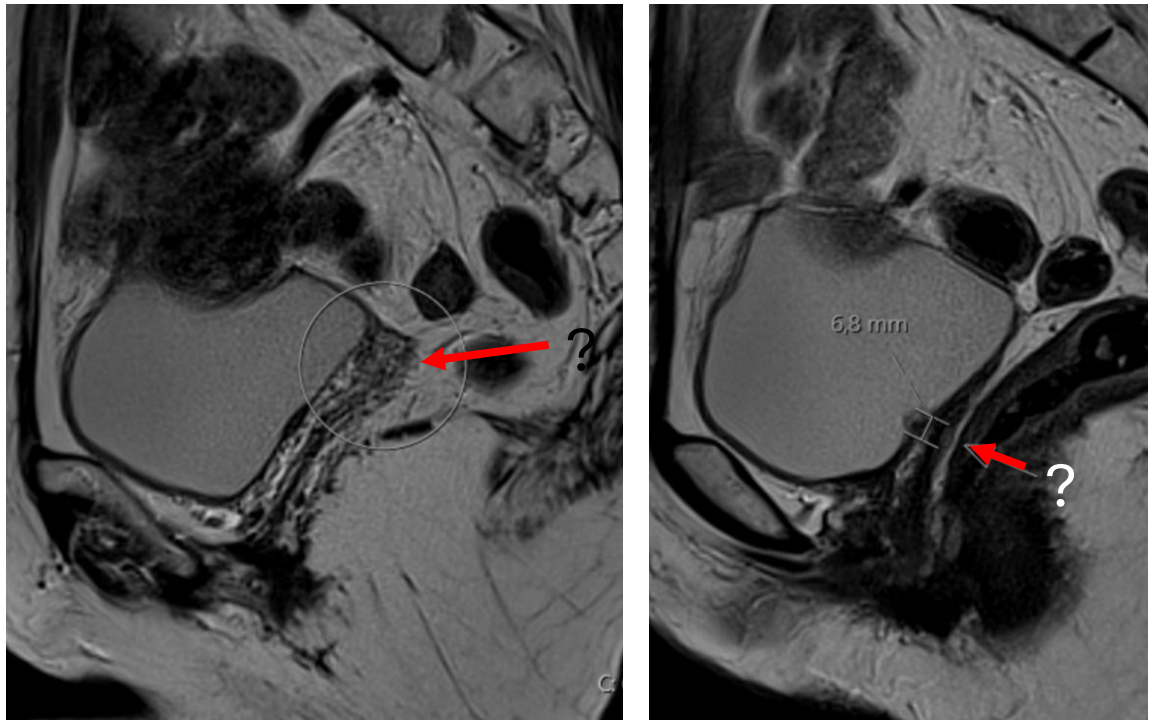



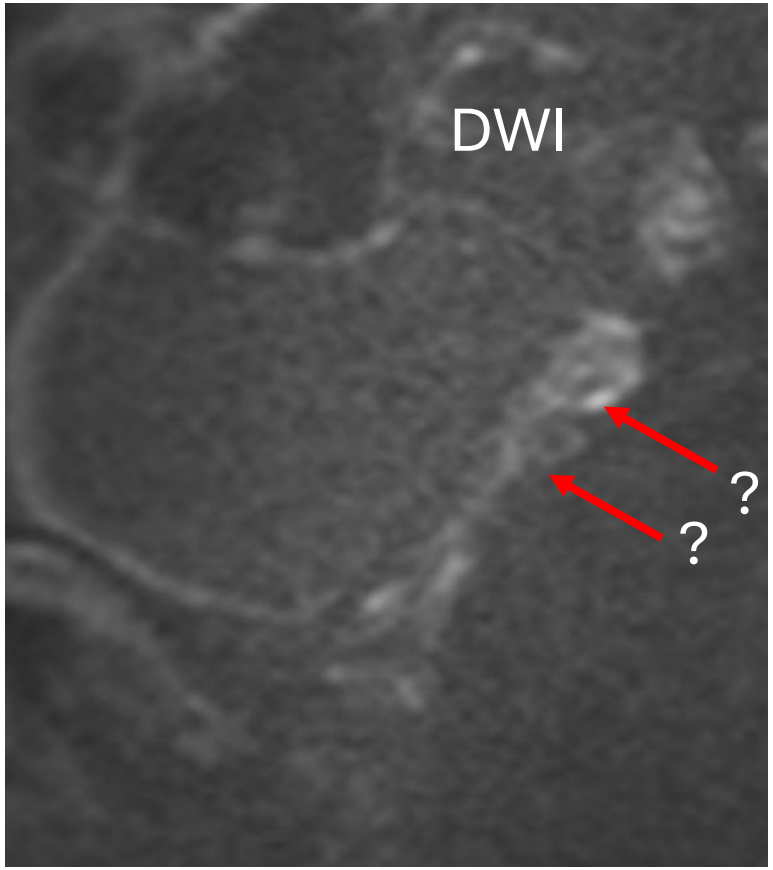

MRI at primary diagnosis

# Same patient:
# EC FIGO (2009/23) II/IIC, serous carcinoma, at recurrence

66 yrs, HBSO and chemo, recurrence (7 months), death (2 yrs)

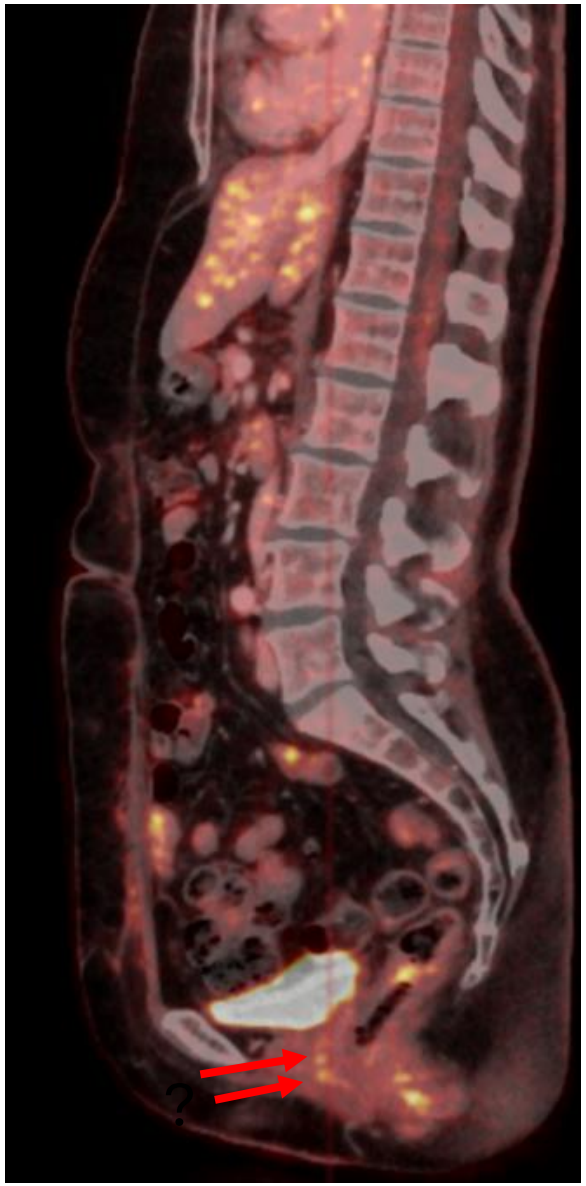
T2 W MRI



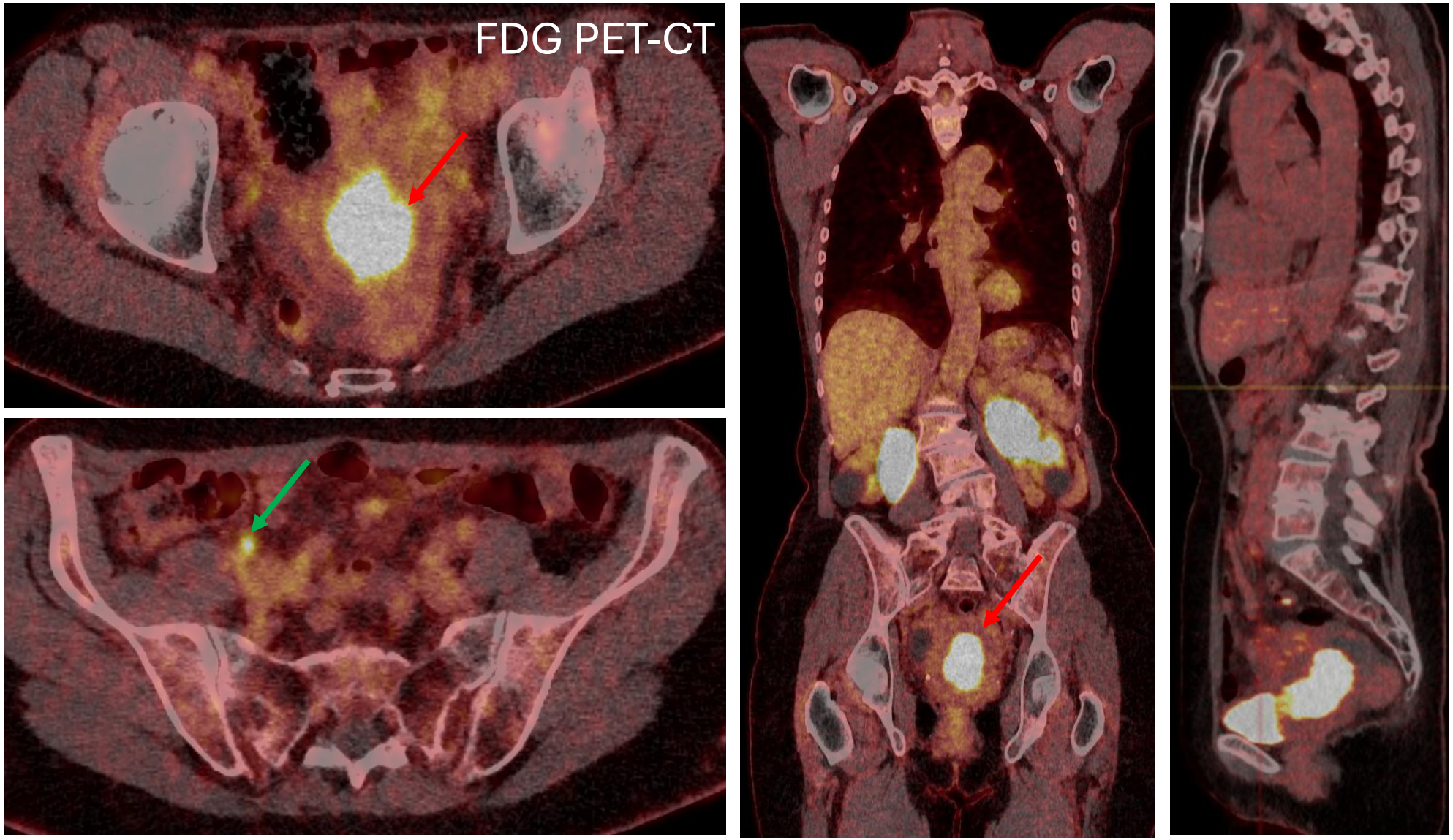

Clinical suspicion of recurrence in the vaginal vault

FDG PET-CT

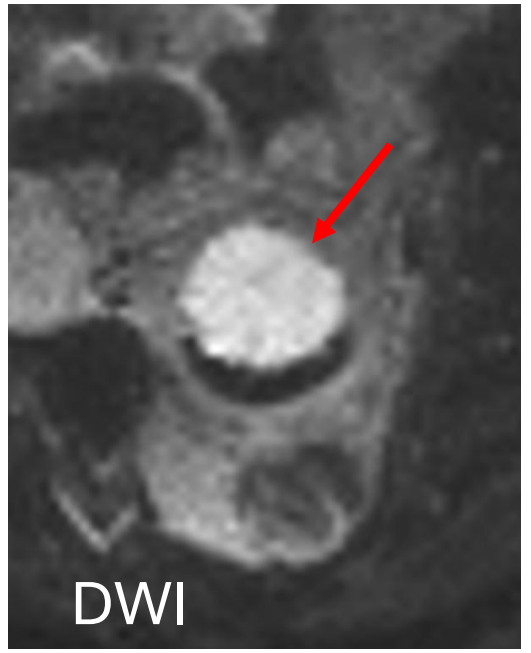


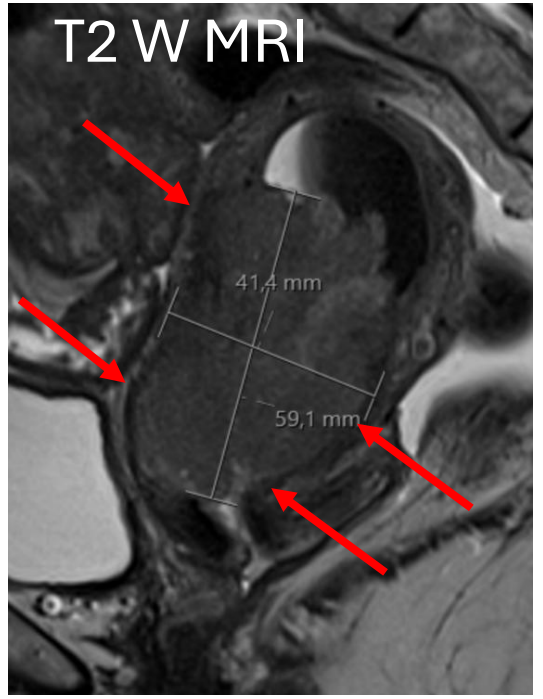
# EC FIGO (2009/23) IIIC2, EEC G2

73 yrs, HBSO + lymphadenectomy and chemo, recurrence/death after 22 months/5 yrs.




PET/CT at primary diagnosis



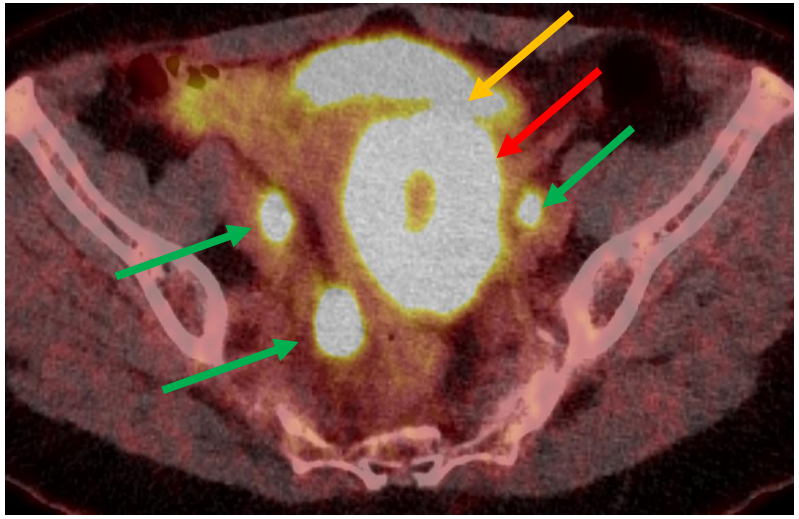



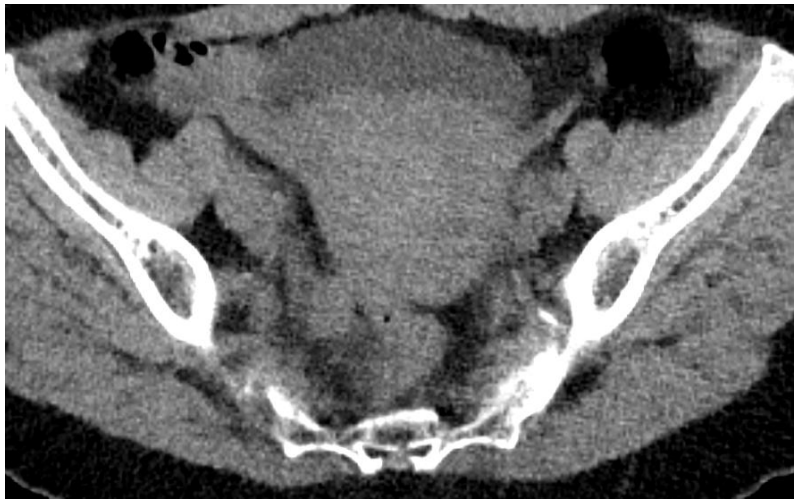

MRI at primary diagnosis

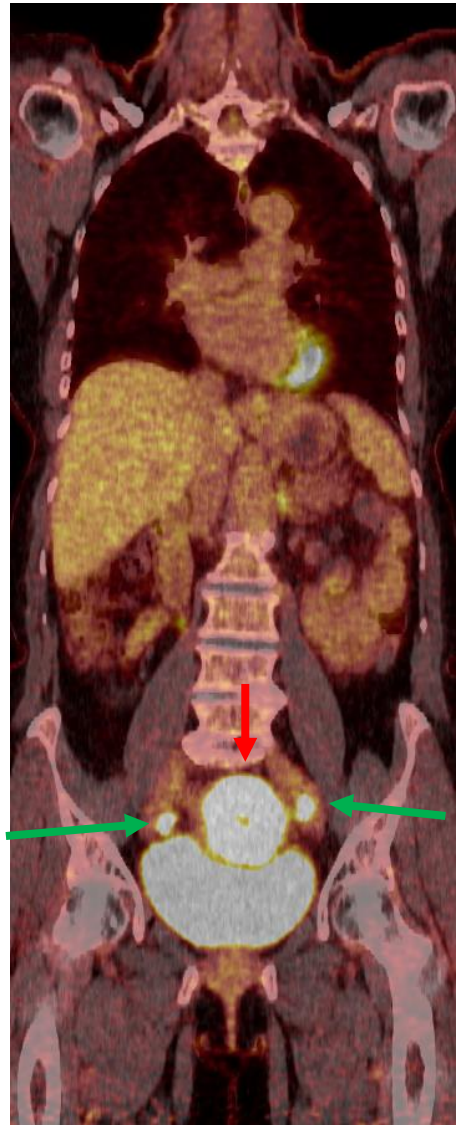
# EC FIGO (2009/23) IVA, EEC G2

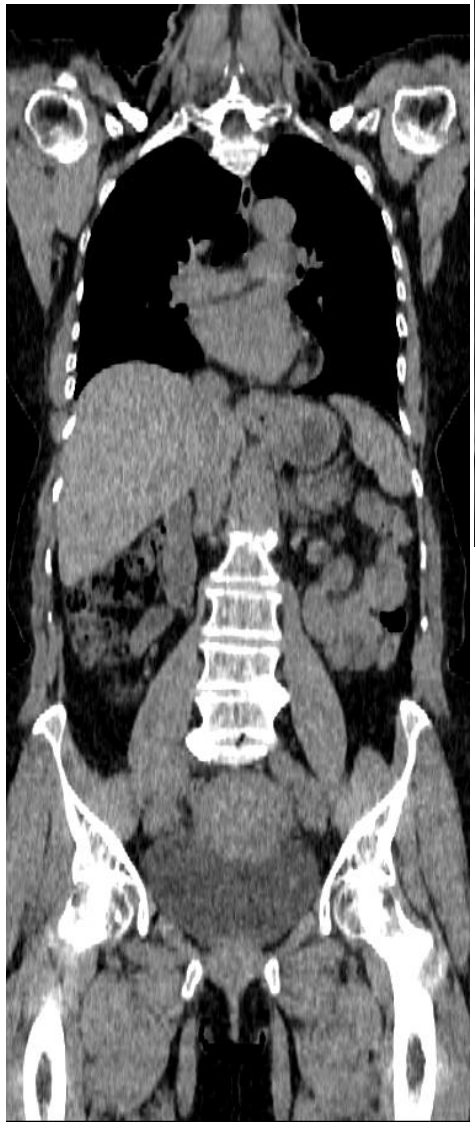
76 yrs., large tumor with bladder invasion and lymph node metastases; tumor reduction and chemo, death after 1.5 yrs.

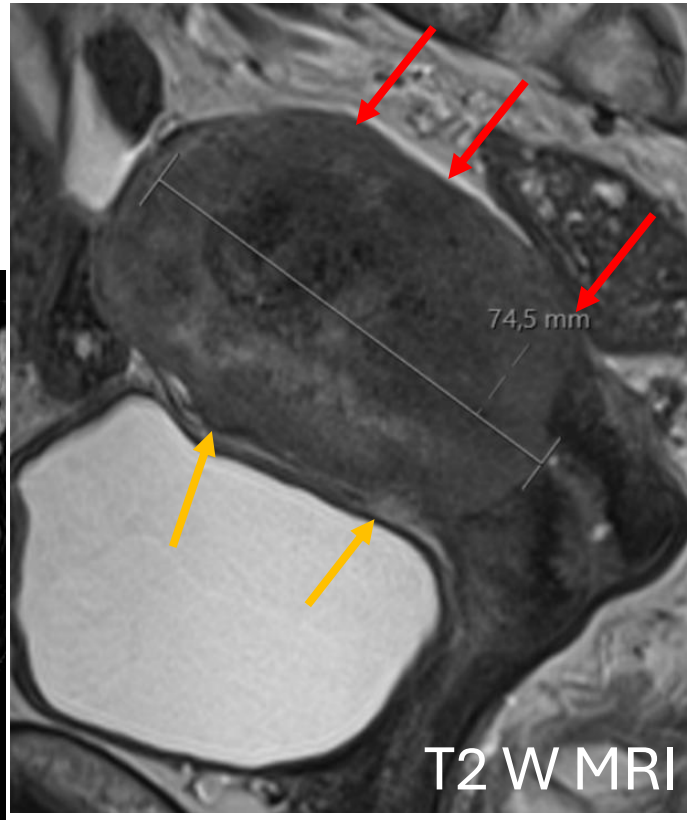
FDG-PET/CT and MRI at primary diagnosis

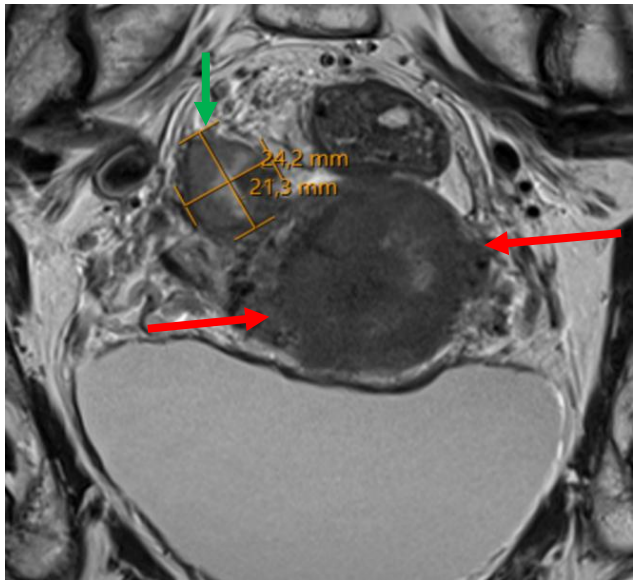




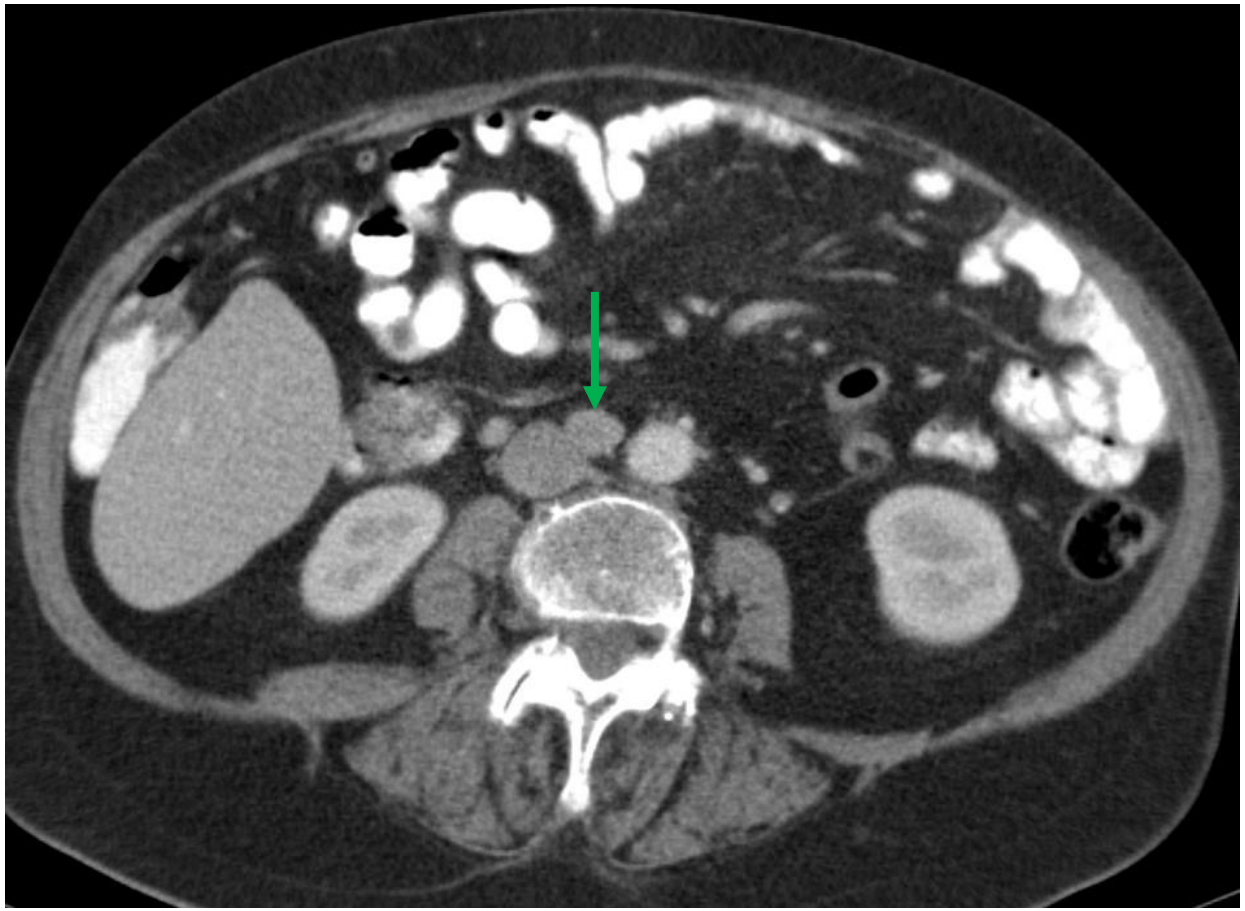




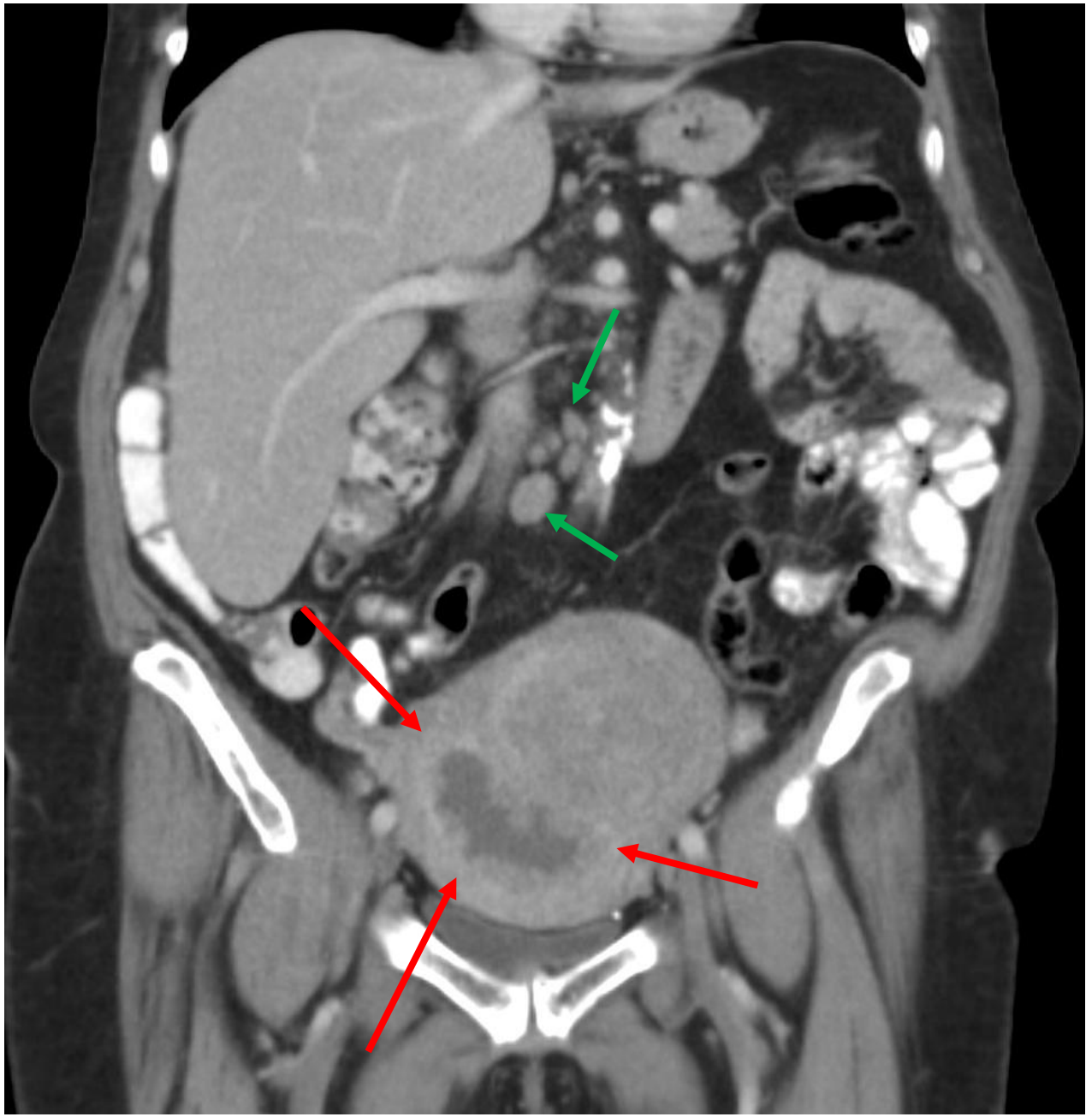


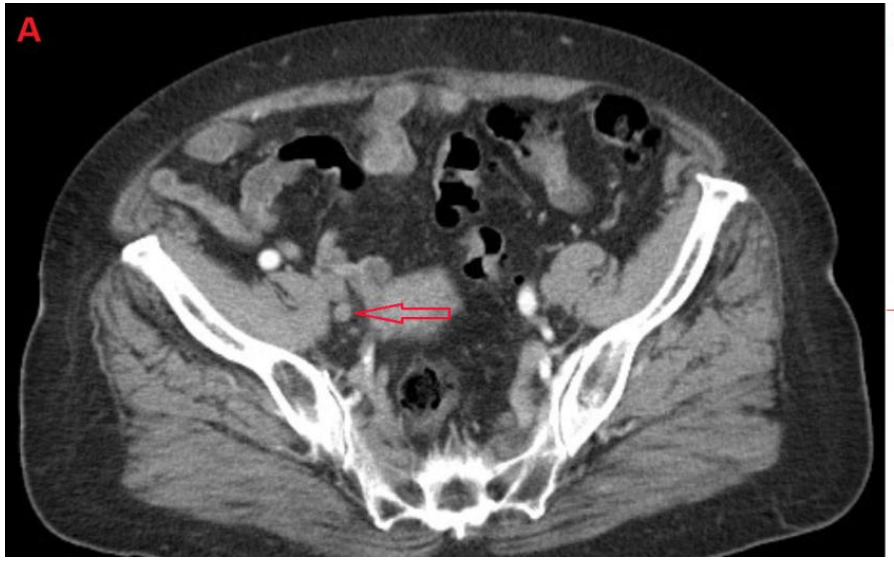
# EC FIGO (2009/23) IIIC2 (pelvic and paraaortic LNM)

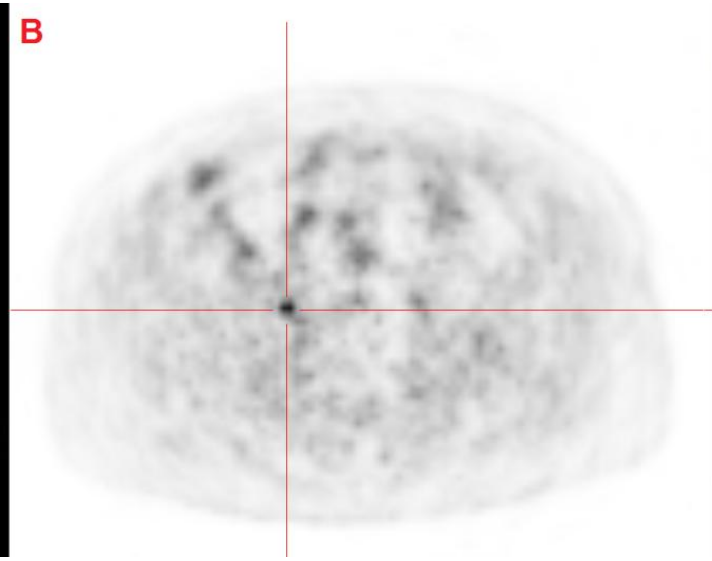


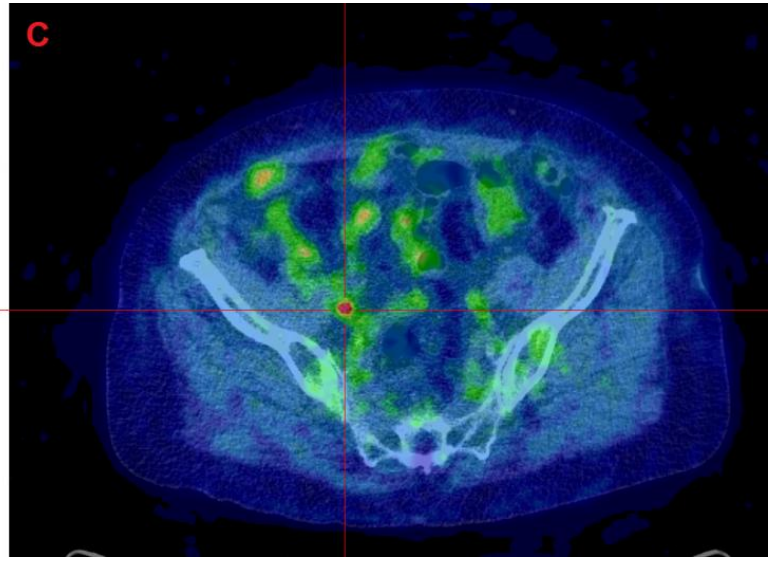
Contrast-enhanced CT at primary diagnosis



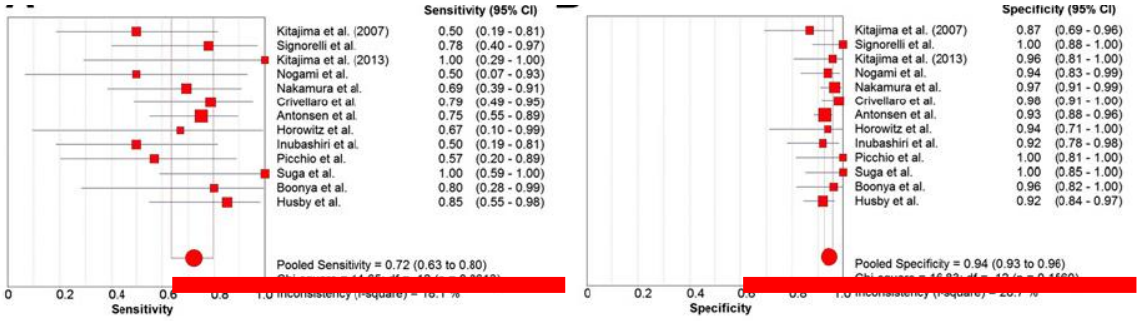
# FDG PET/CT/MRI: excellent and better (than CE CT) diagnostic performance for detecting LNM and disease recurrence in EC



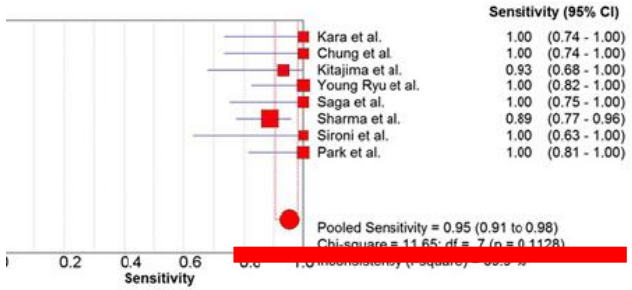

## Meta-analysis

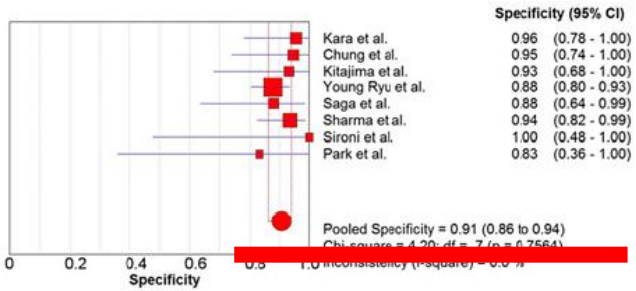






LNM in EC

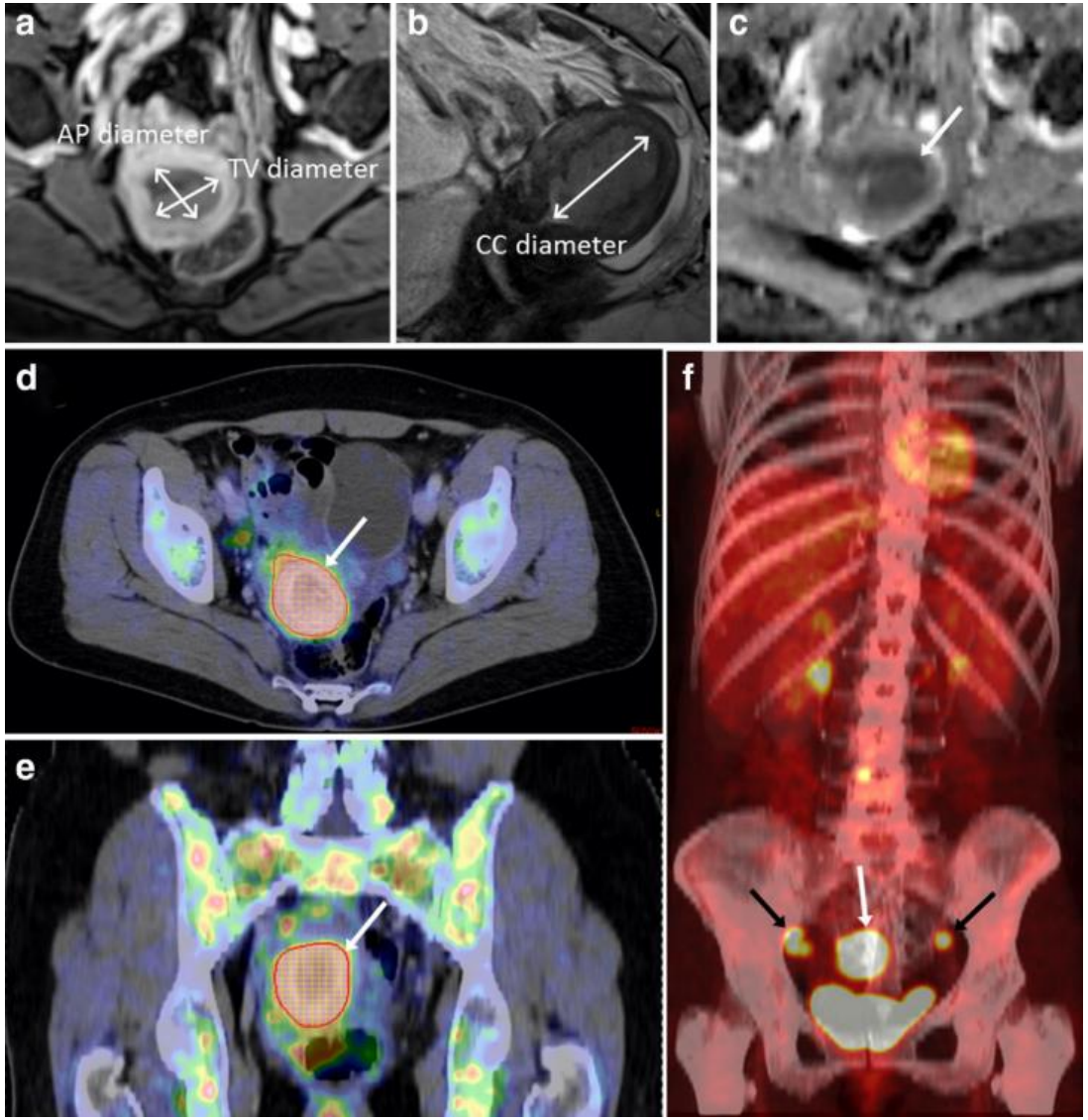


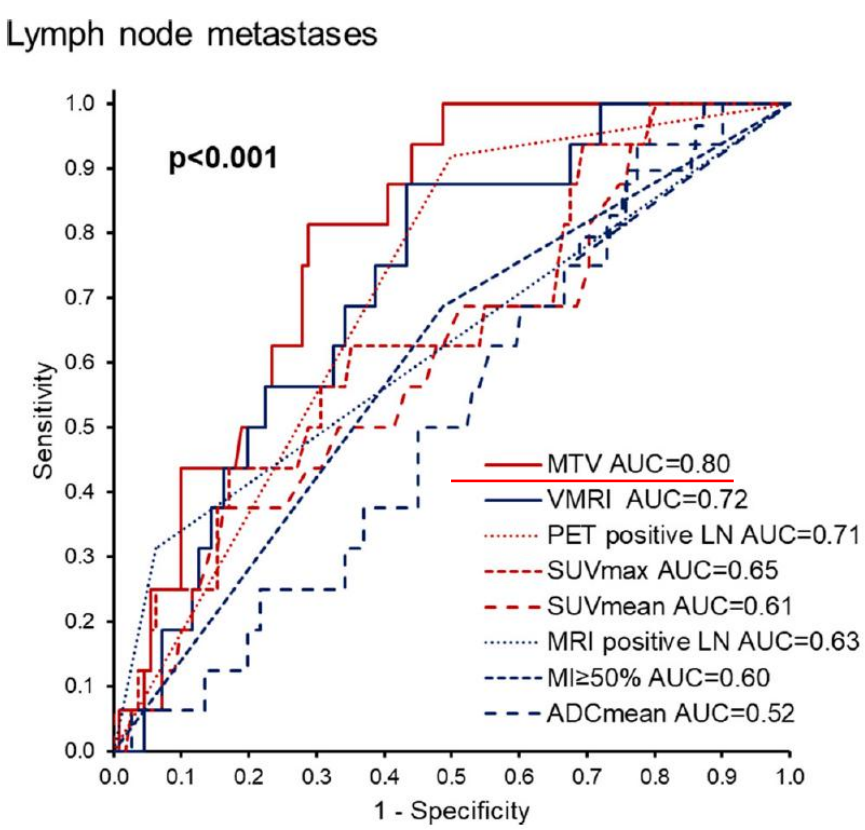



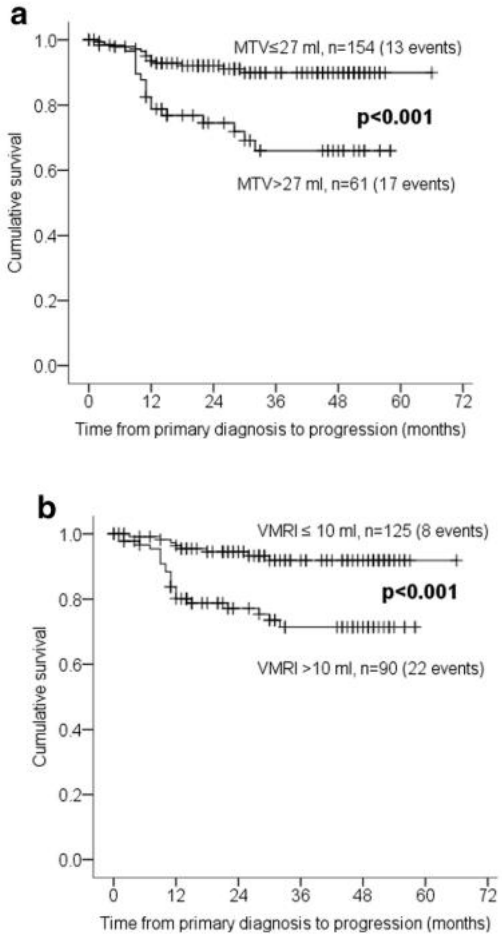

Disease recurrence in EC

Bollineni,….,Haldorsen, J Nucl Med, 2016; ACR Appropriateness Criteria, J Am Coll Radiol 2020

# Metabolic tumor volume from FDG-PET/CT: better than conventional PET- and MRI markers (positive LN) for predicting LNM

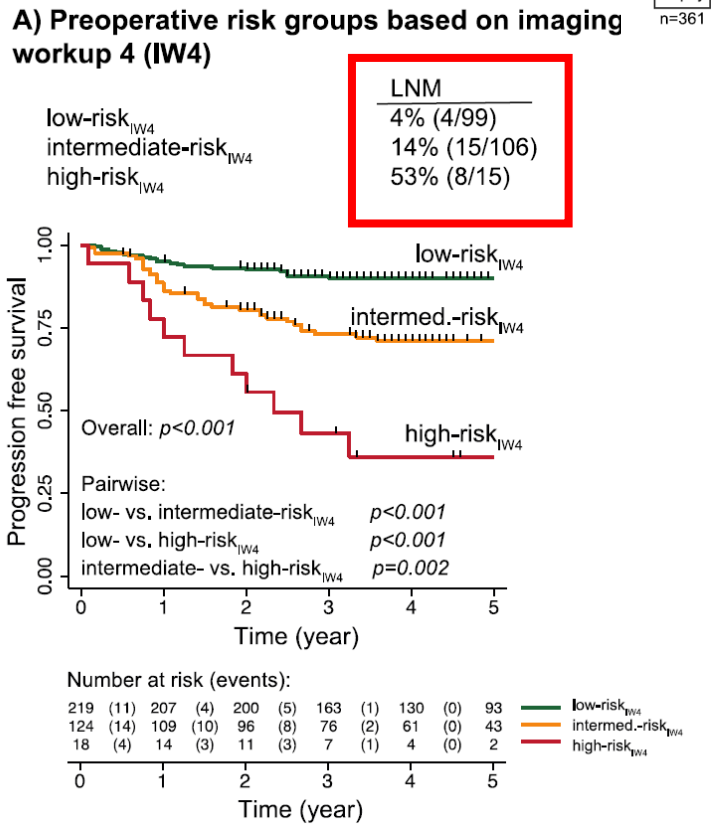


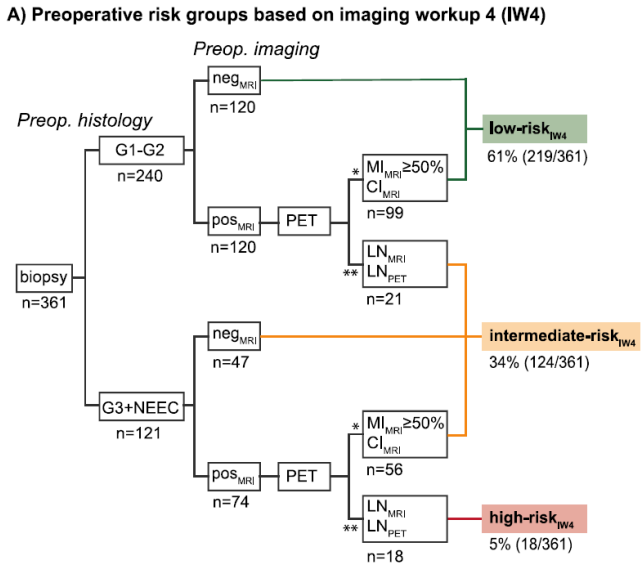



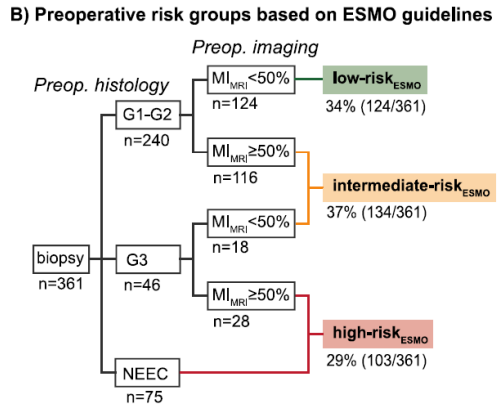




Fasmer et al, Eur Radiol, 2020

# Selective PET in EC if high-risk MRI findings yields **refined detection of LNM** and **better prognostication** than MRI alone

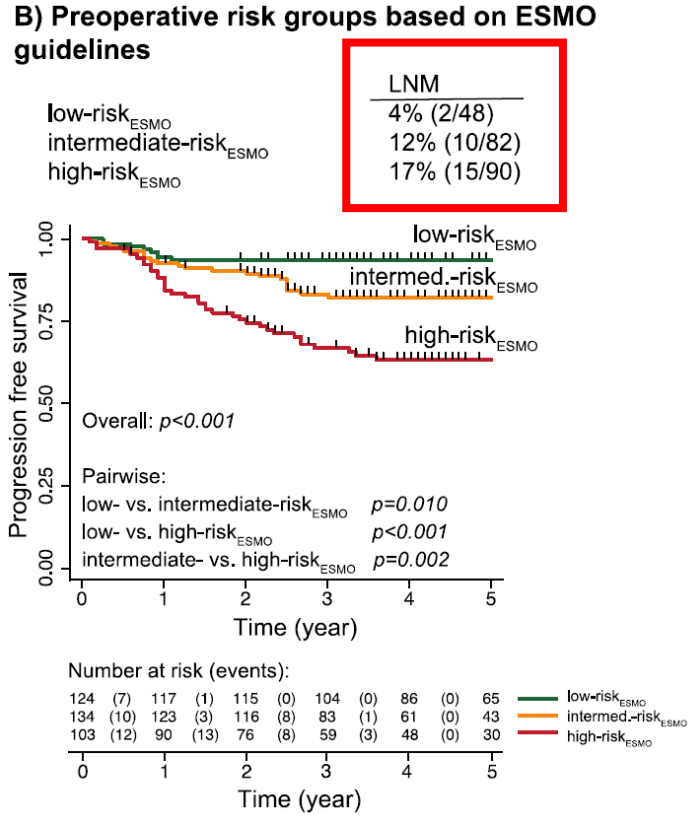



**Abbreviations:**

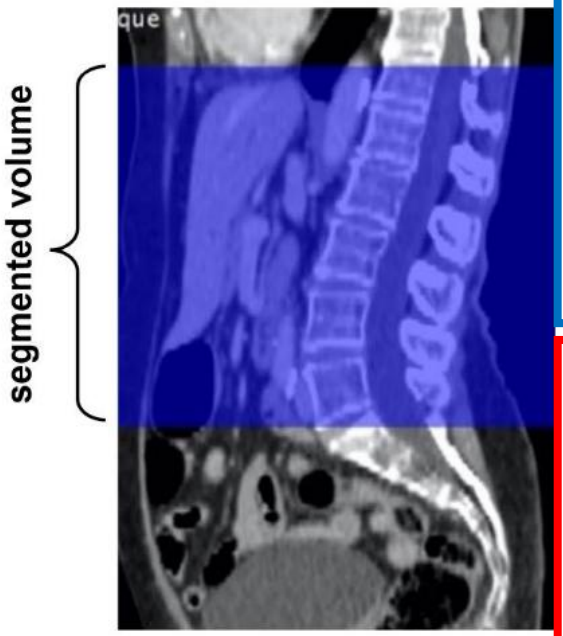
| | |
|---|---|
| G1-3 | endometrioid grade 1-3 |
| NEEC | non-endometrioid |
| $MI_{MRI}$ | myometrial invasion on MRI |
| $CI_{MRI}$ | cervical invasion on MRI |
| $LN_{MRI}$ | enlarged pelvic lymph nodes (≥10 mm) on MRI |
| $LN_{PET}$ | lymph nodes with elevated [$^{18}$F]FDG uptake |
| $neg_{MRI}$ | $MI_{MRI}$ <50%, no $CI_{MRI}$, and no $LN_{MRI}$ |
| $pos_{MRI}$ | $MI_{MRI}$ ≥50% and/or $CI_{MRI}$ and/or $LN_{MRI}$ |




An imaging work-up, selecting ~54% of patients to PET/CT based on MRI findings, yields better detection of LNM than MRI alone and similar detection to that based on MRI and PET/CT in all.

Fasmer et al, Eur Radiol, 2022

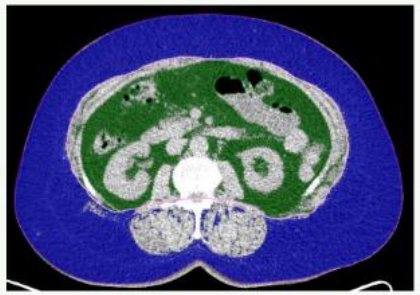
# Abdominal fat distribution predicts EC outcome



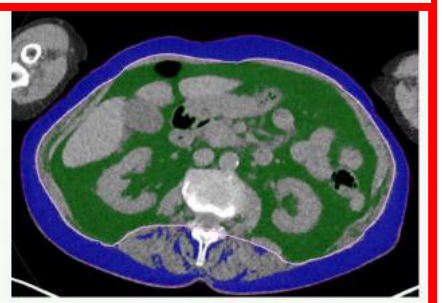

## Low-risk body composition

pre-operative CT

**patient A:**
TAV= 13171 ml
VAV= 3375 ml
SAV= 9796 ml
VAV%= 26%
WC= 105 cm
BMI= 40 kg/m²

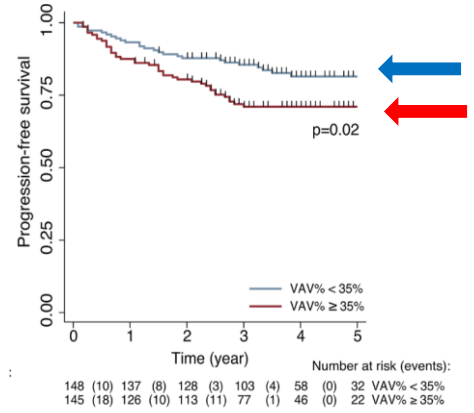


**patient B:**
TAV= 6059 ml
VAV= 3052 ml
SAV= 3007 ml
VAV%= 50%
WC= 91 cm
BMI= 25 kg/m²



## High-risk body composition

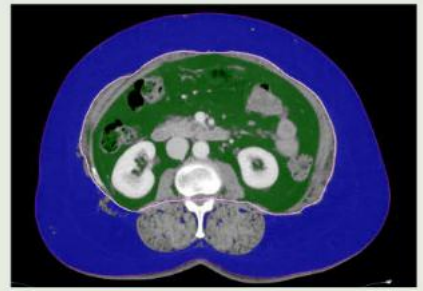
Visceral adiposity (high VAV%) is associated with ↓prognosis



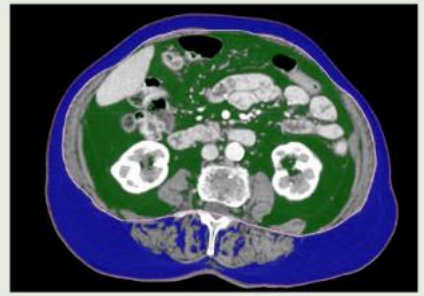

Mauland et al, Oncotarget, 2017

follow-up CT

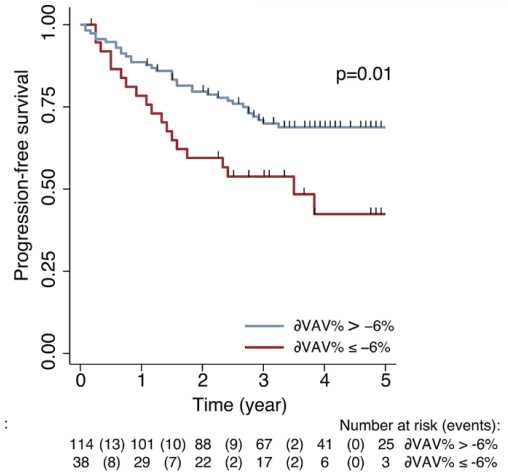
**patient A:**
δTAV= -1%
δVAV= -8%
δSAV= 2%
δVAV%= -2%
δWC= 7%
Prog./recur.: no



**patient B:**
δTAV= -17%
δVAV= -26%
δSAV= -7%
δVAV%= -6%
δWC= -3%
Prog./recur.: yes



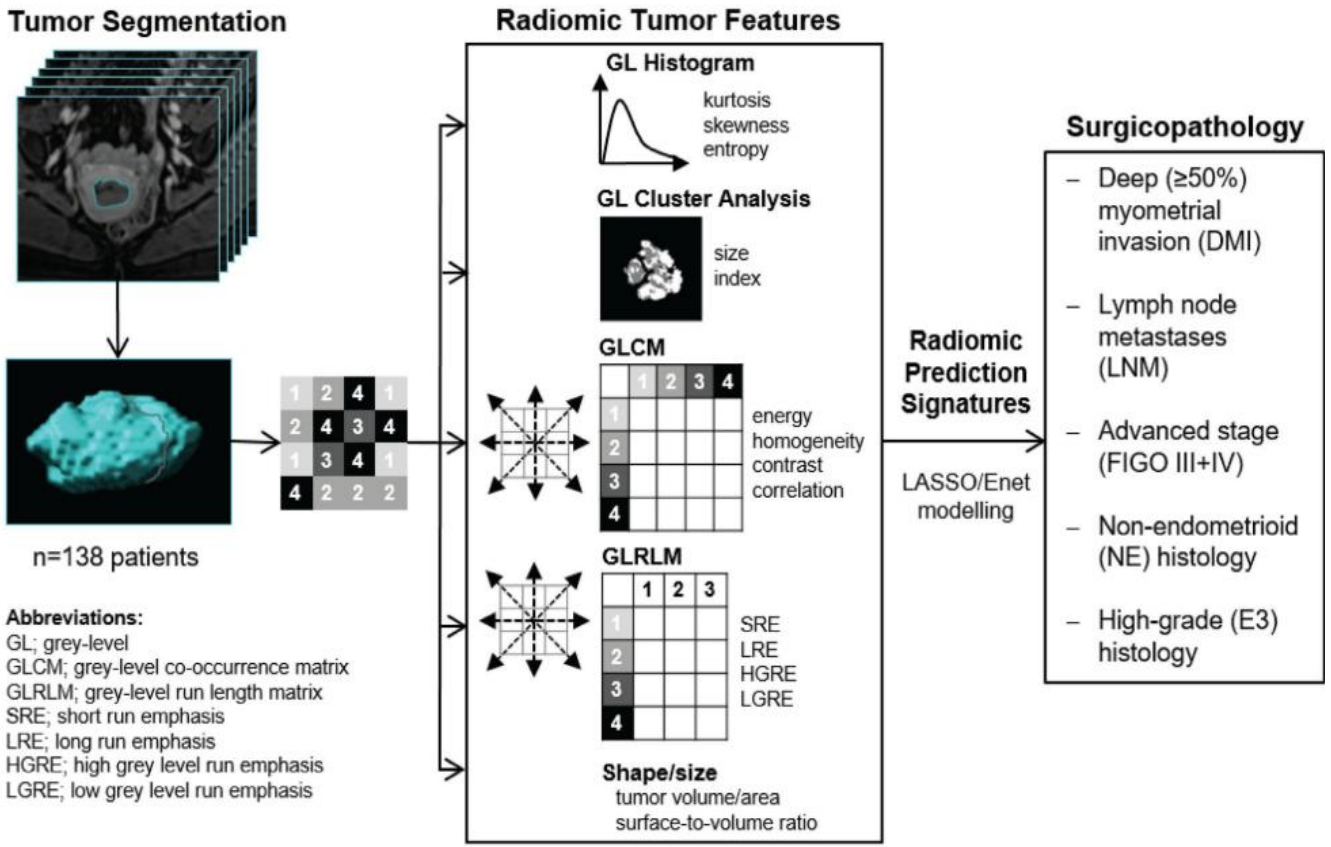
VAV= visceral abdominal fat volume
TAV= total abdominal fat volume
SAV= subcutaneous abdominal fat volume
WC= waist circumference

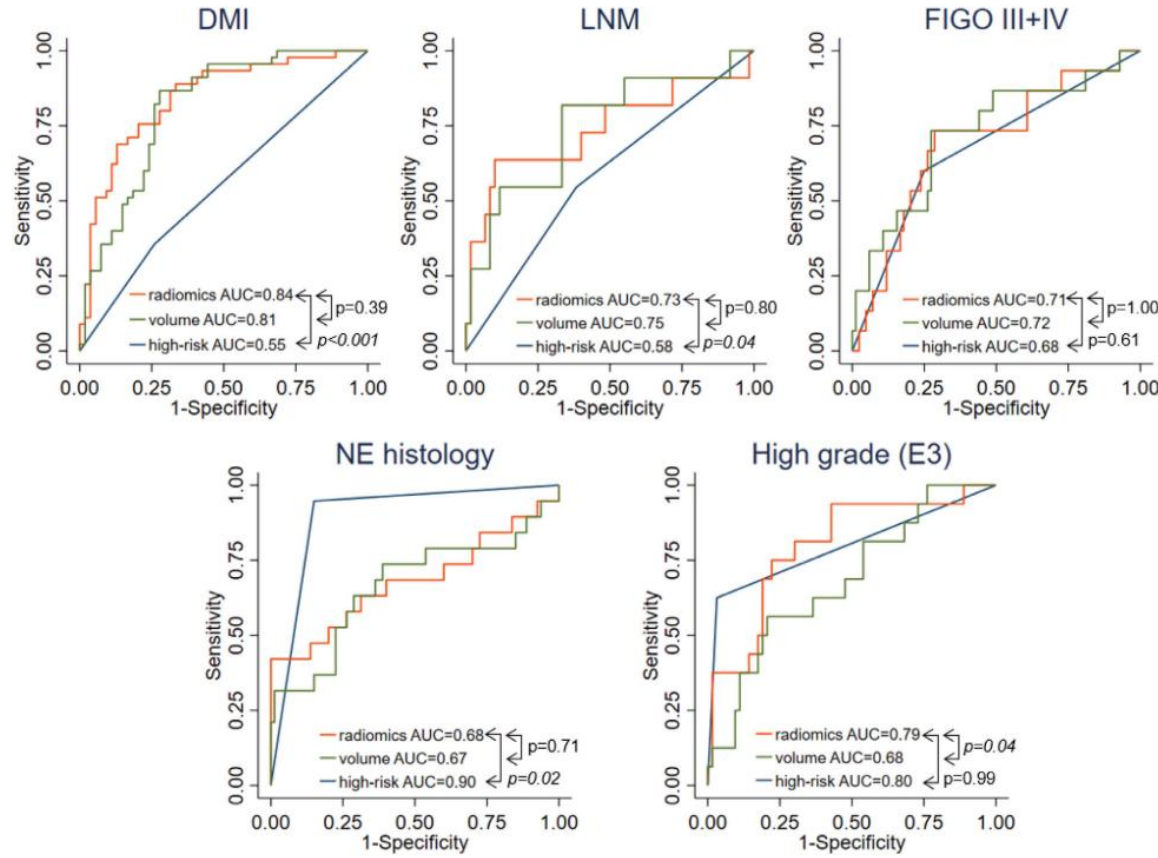



High visceral fat loss during therapy is associated with ↓prognosis

Fasmer et al, BMC Cancer, 2025

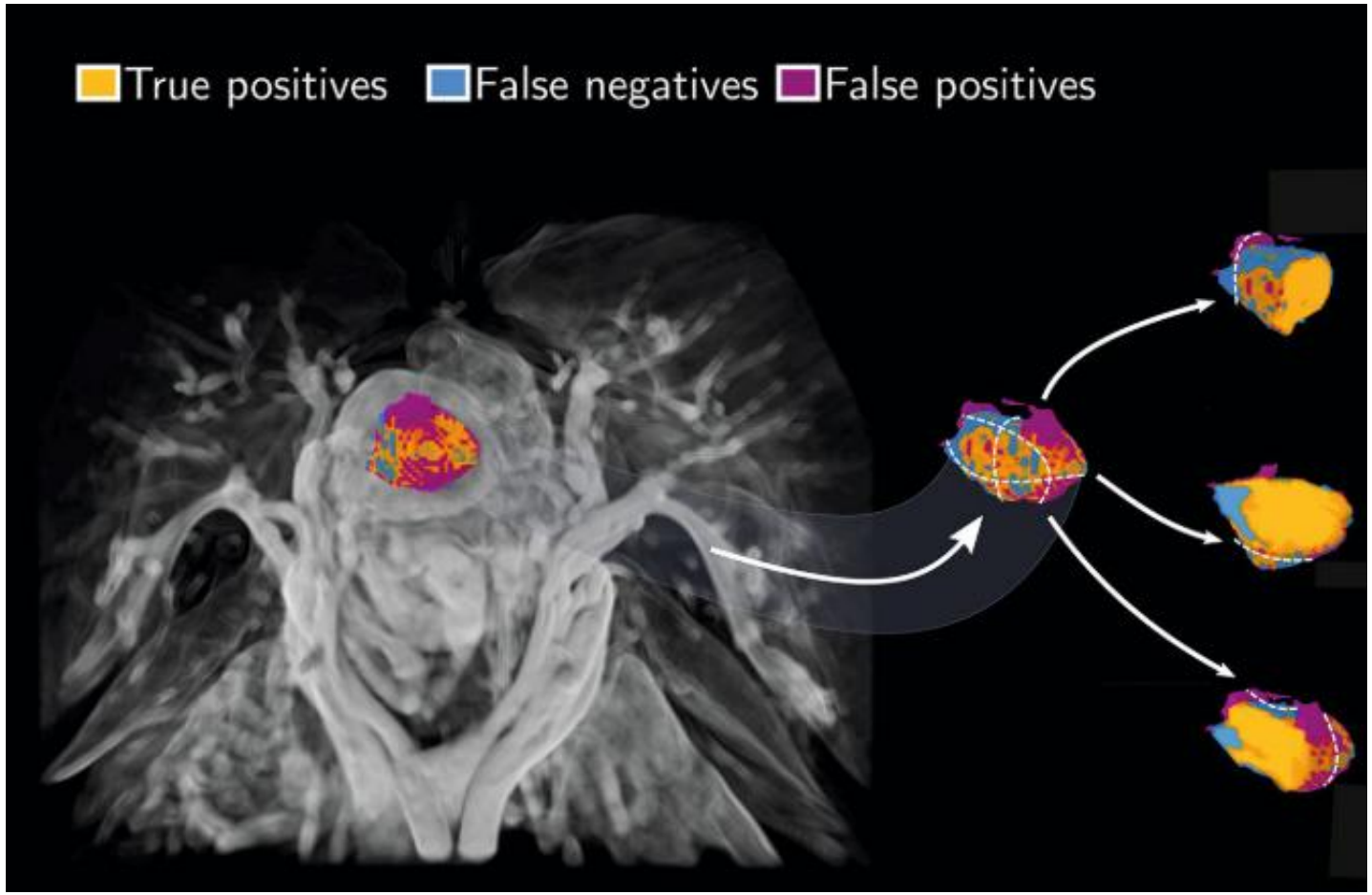
# Pretreatment MRI radiomics (whole volume) enhances prognostic modeling in EC

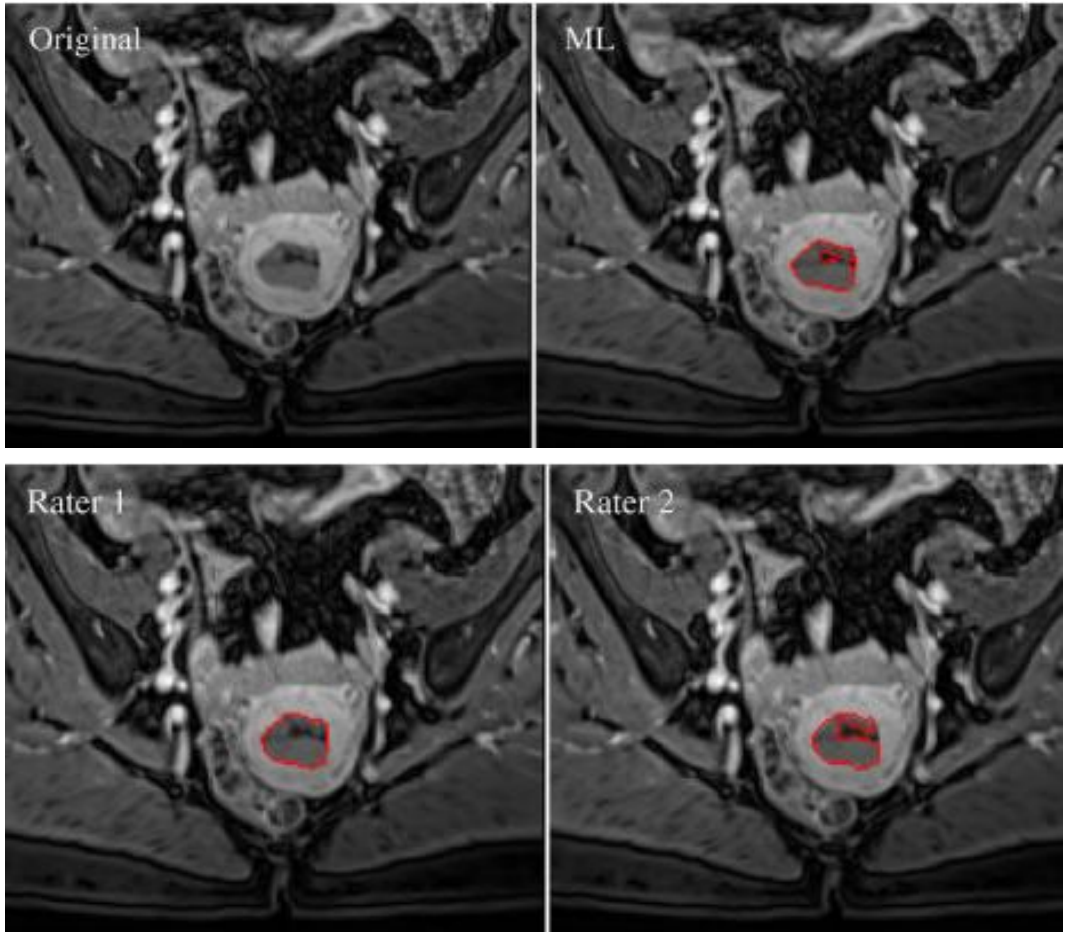



Fasmer et al, JMRI, 2021

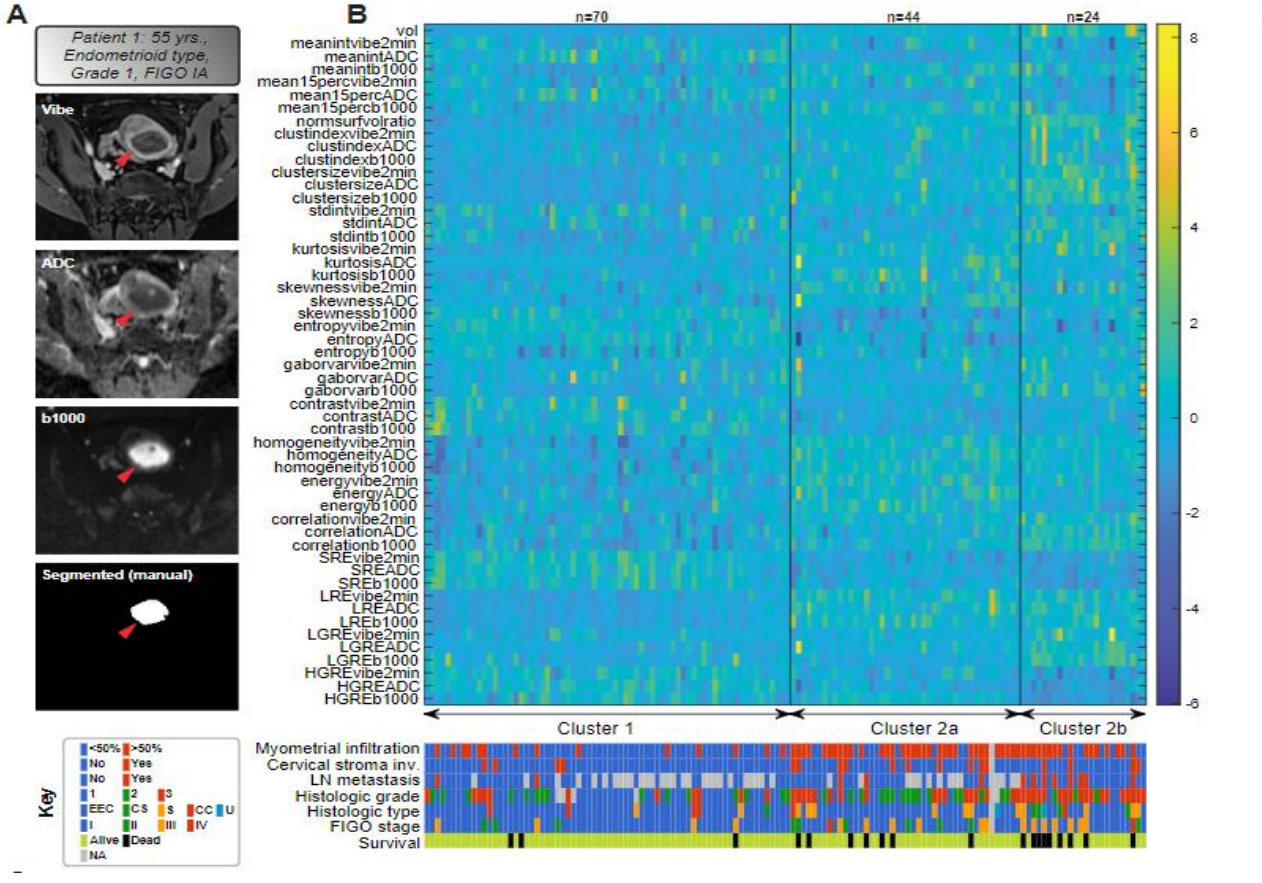
# AI-guided automated segmentation of EC on MRI

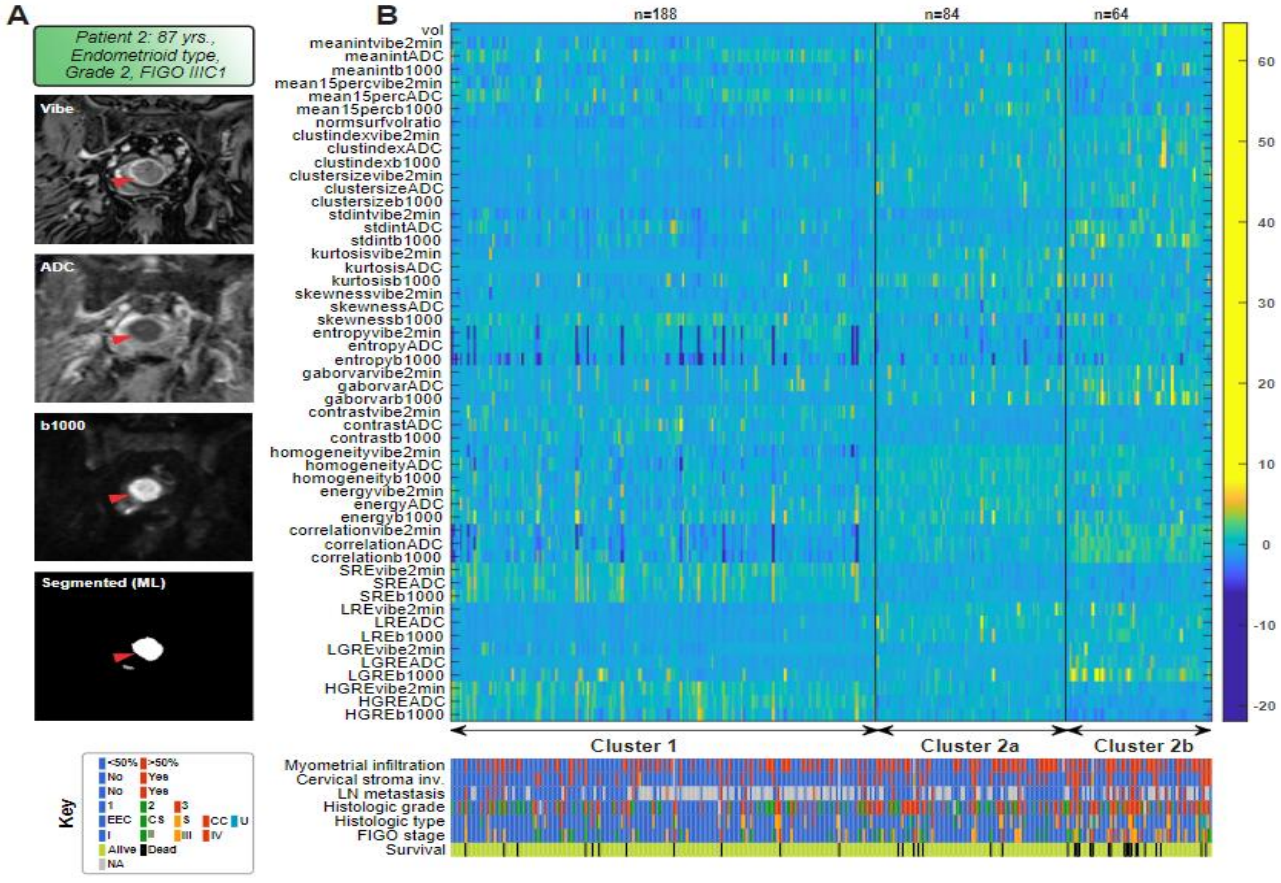


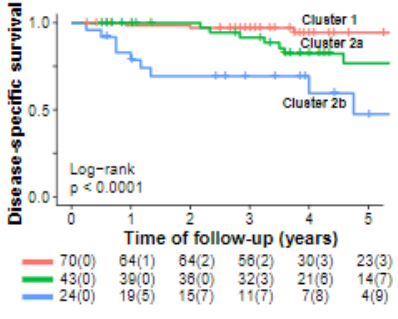

Hodneland et al, Scientific Reports, 2021

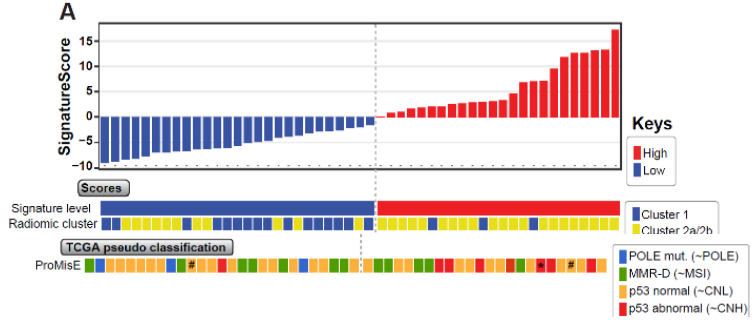
# MRI radiomic profiles define patient clusters exhibiting distinct differences in molecular class and survival and identifies targets for treatment



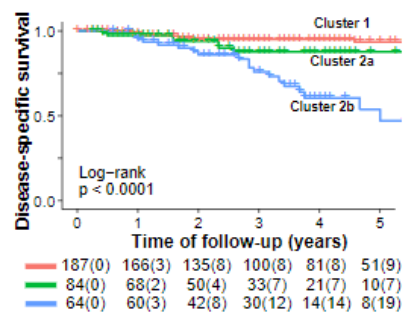

**Radiomic profiling from radiologists' segmentations**



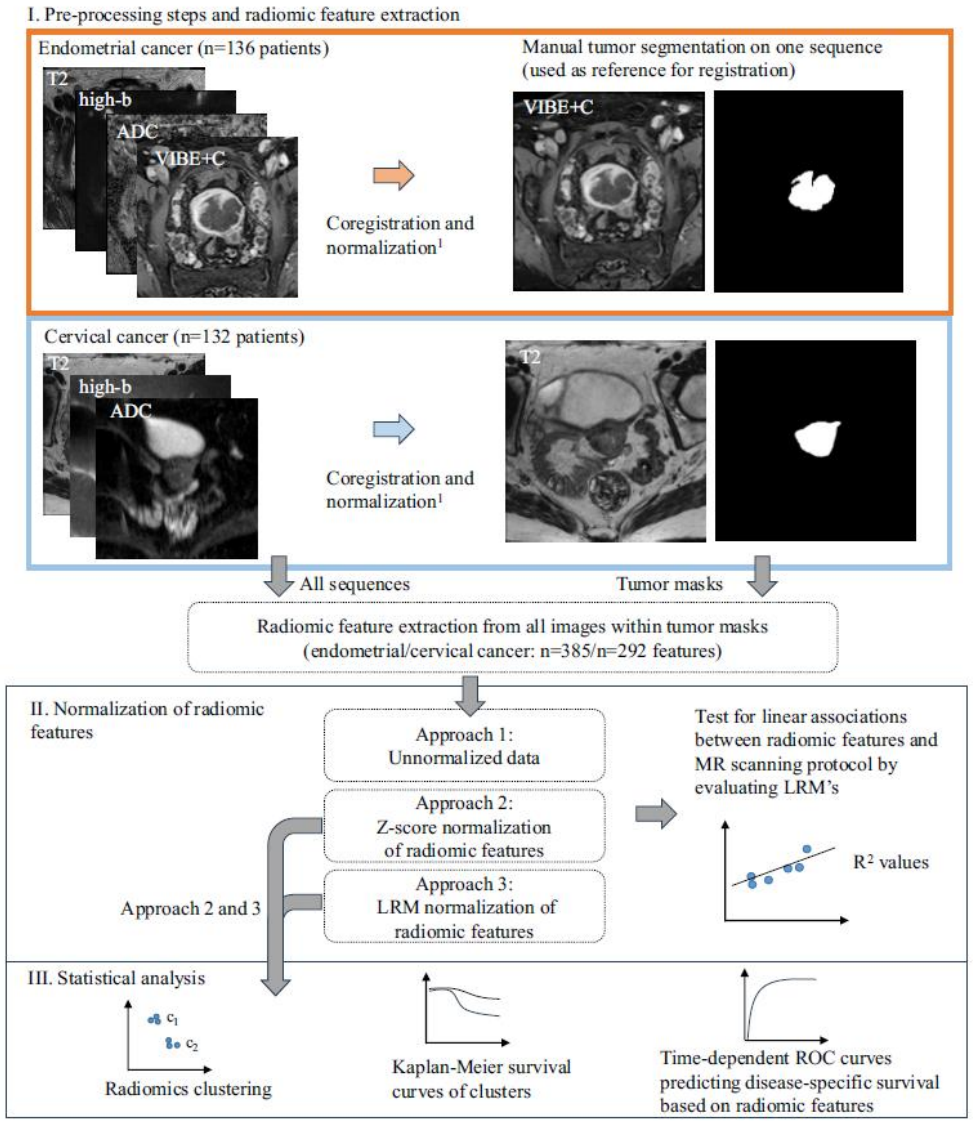




Høivik et al, Communications Biology, 2021

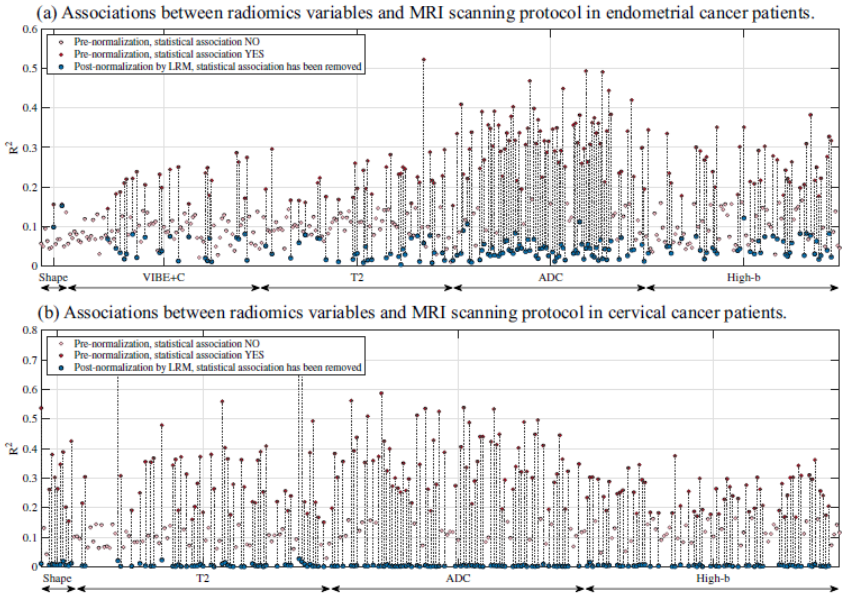
**Radiomic profiling from ML based segmentations**



# Do MRI radiomic features need normalization prior to modelling in uterine endometrial and cervical cancer?

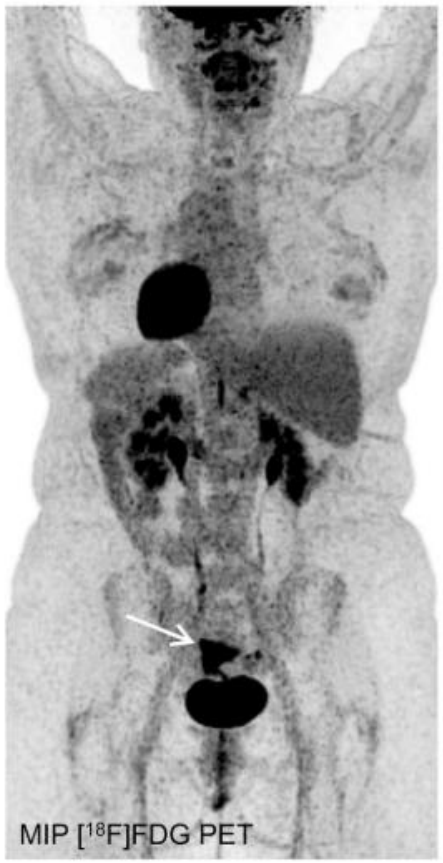


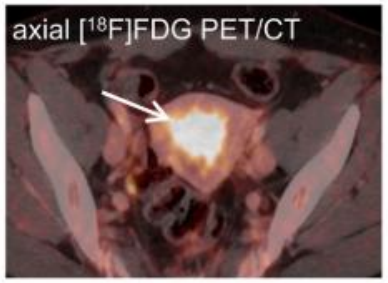

- **Severe biases in tumor radiomics data exist due to (variable) MRI scanning parameters**
- **Z-score normalization does not eliminate these biases, whereas Linear Regression Model (LRM) normalization does**

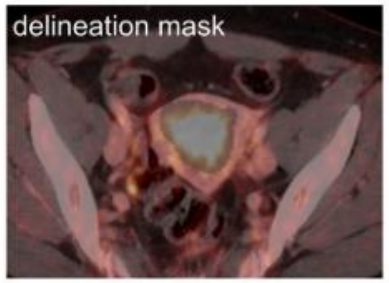


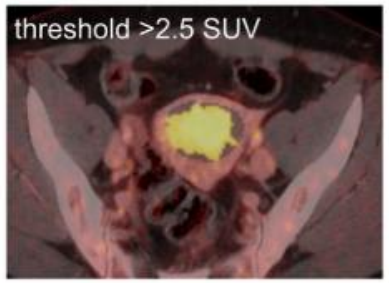

Hodneland et al., Scientific Reports, 2024

# PET-radiomics predicts aggressive disease in EC



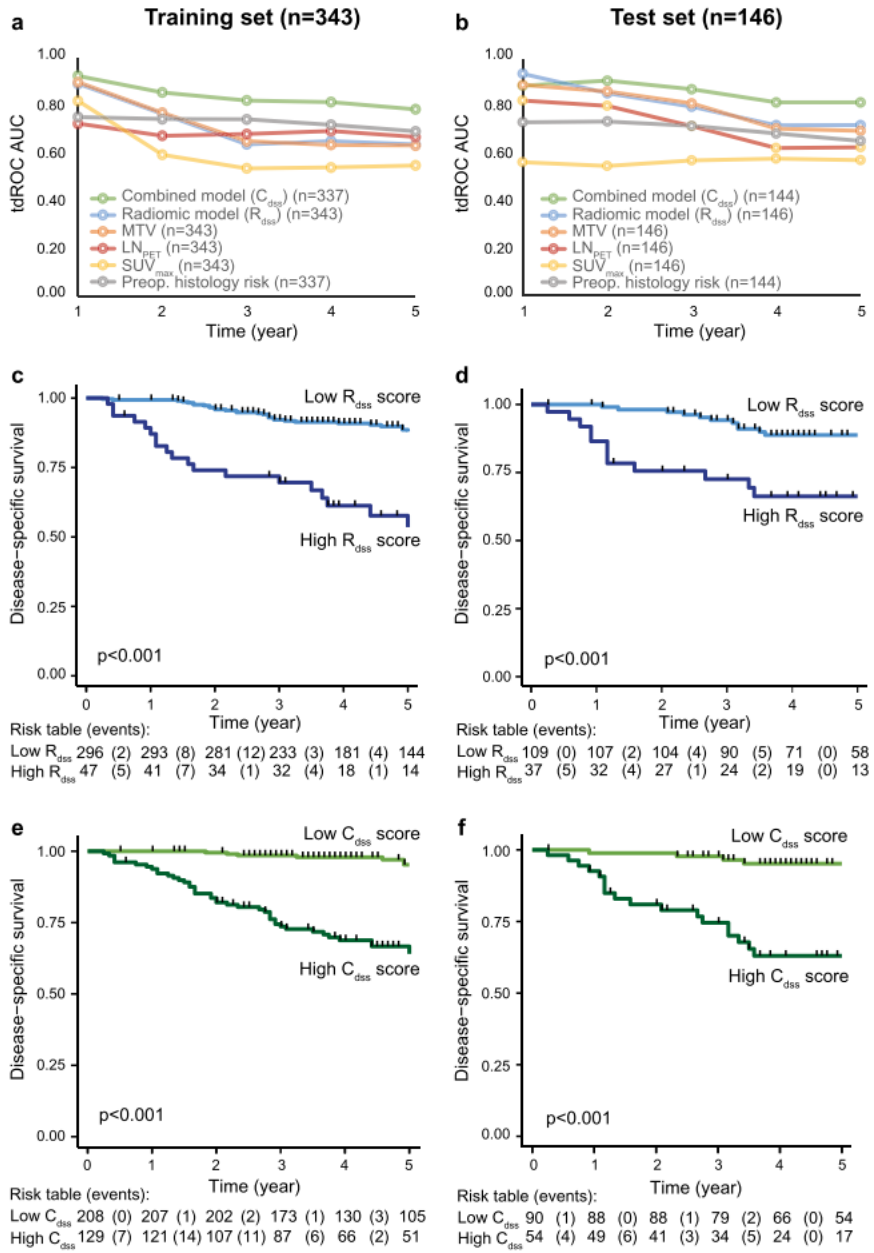

**radiomic features: 108**
shape: 12
intensity: 18
intensity histogram: 23
GLCM: 23
GLRLM: 11
NGTDM: 5
GLSZM: 16

**ICC>0.75**

**radiomic features: 98**
shape: 11
intensity: 16
intensity histogram: 19
GLCM: 21
GLRLM: 11
NGTDM: 4
GLSZM: 16

**ComBat feature harmonization**
TruePoint n=348
Vision n=141

**LASSO radiomic modelling**
train n=343
test n=146

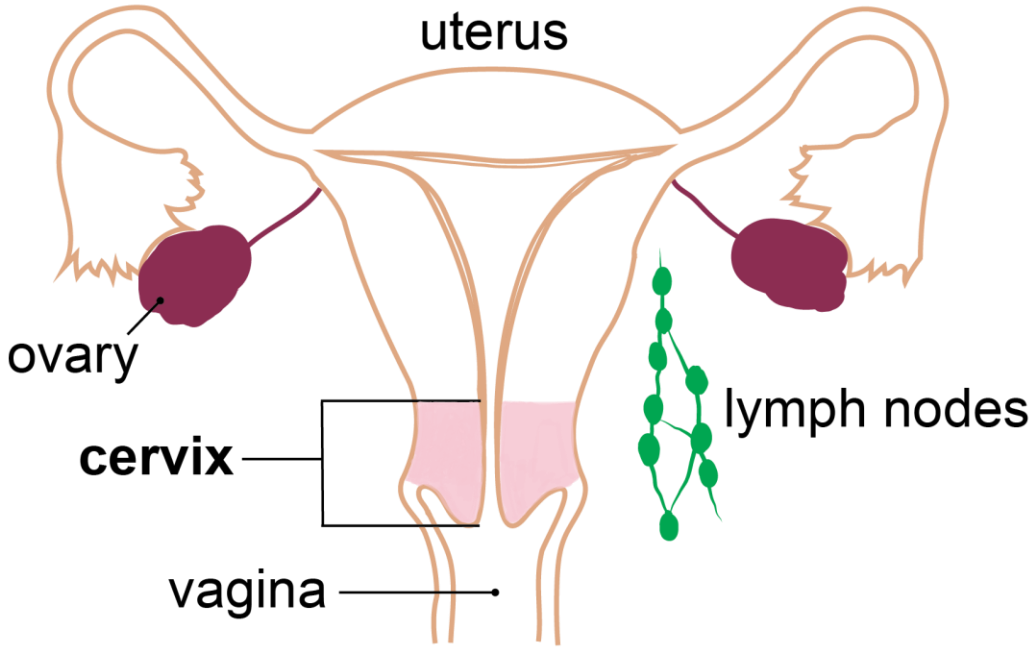



Fasmer et al, Eur J Nucl Med and Mol Imaging, 2025

# Endometrial Cancer - Summary

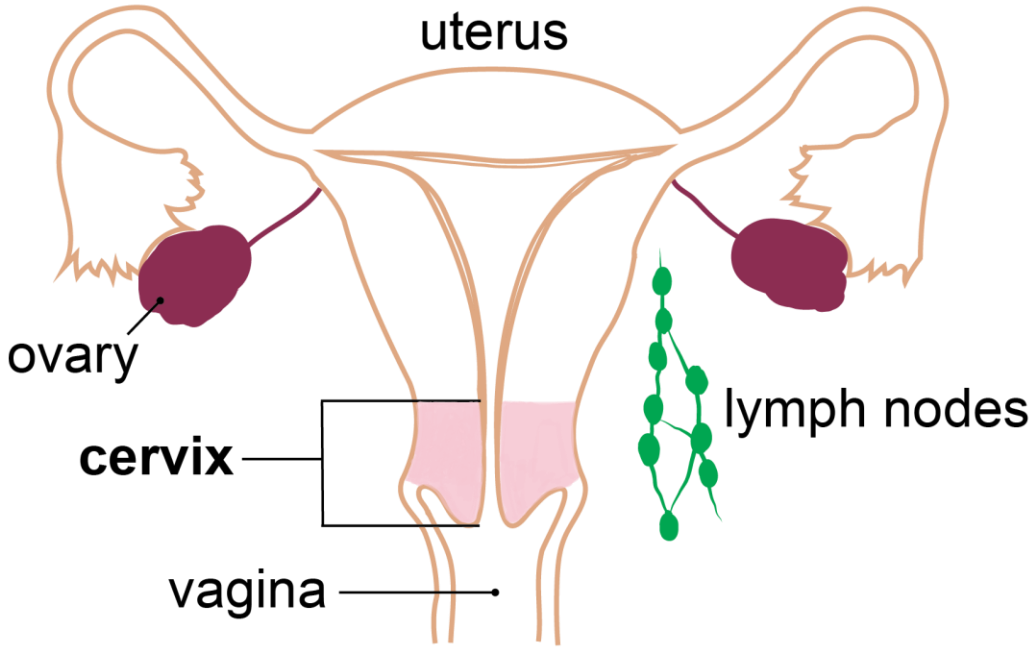
- Imaging is recommended prior to surgicopathologic staging according to FIGO (2023) criteria:
  - MRI (or ultrasound) for local staging
  - CT or PET/CT for detecting lymph node metastases or distant spread
- Characteristic imaging findings yield high accuracy for central staging parameters, predict outcome and detect recurrence
- Novel imaging techniques e.g. radiomics and radiogenomics for tumor characterization may improve staging accuracies, prognostication and reveal targets for treatment
- Radiomics and radiogenomics: although promising – role not yet defined

# Cervical cancer (CC)




Cohen et al. Lancet 2019

# Cervical cancer (CC)




**Arises** from the epithelial lining of the uterine cervix

Almost all caused by human papilloma virus (HPV)

HPV vaccination, screening, and treatment of pre-cancer lesions effective in disease prevention

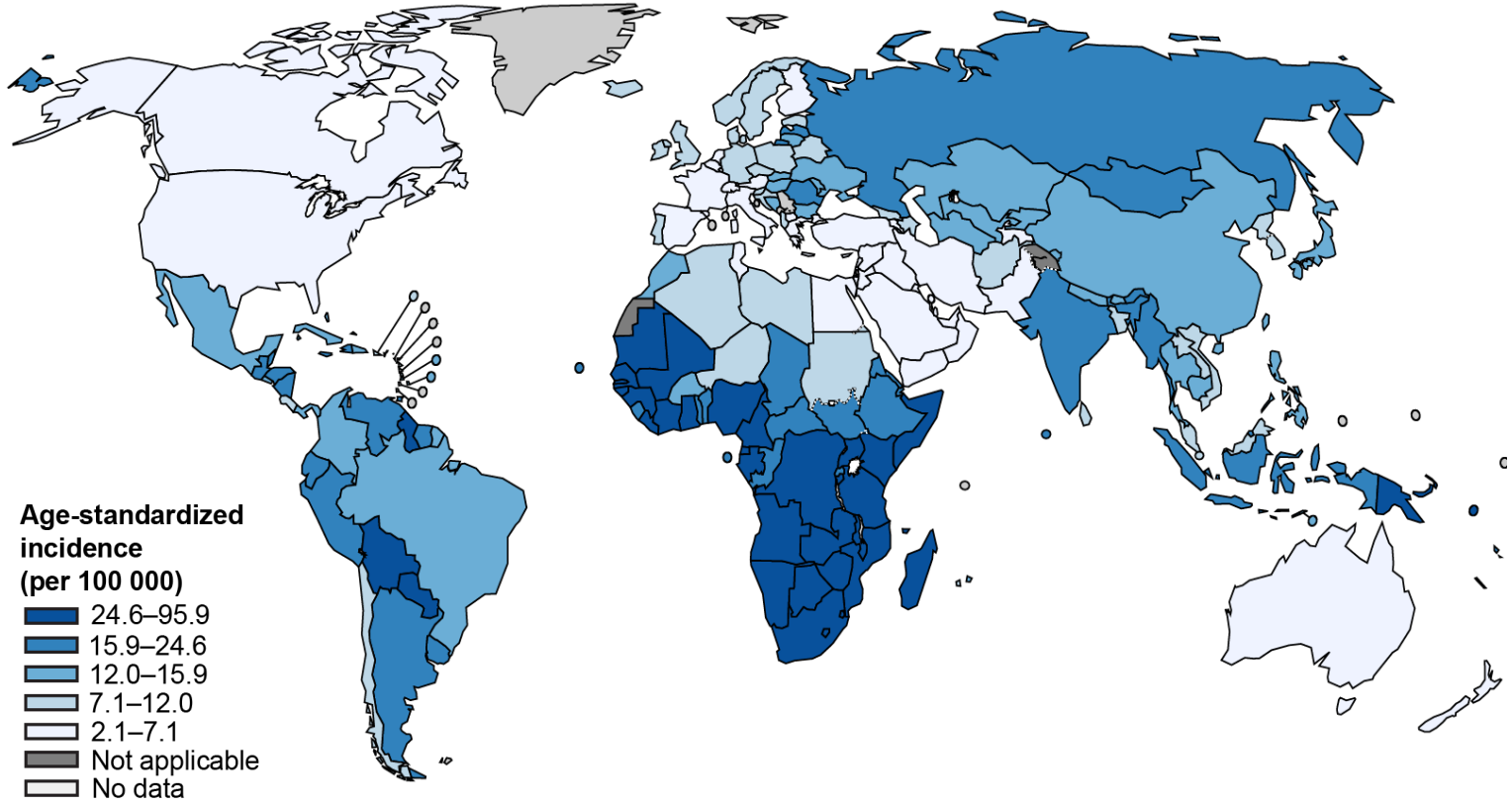
Squamous cell carcinoma (SCC) ~70% or adenocarcinoma (AC) ~25%

Cohen et al. Lancet 2019

# Cervical cancer (CC)

**Globally:**
Fourth most common female cancer and cause of cancer death

Substantial reduction in incidence and mortality rates due to screening and prevention



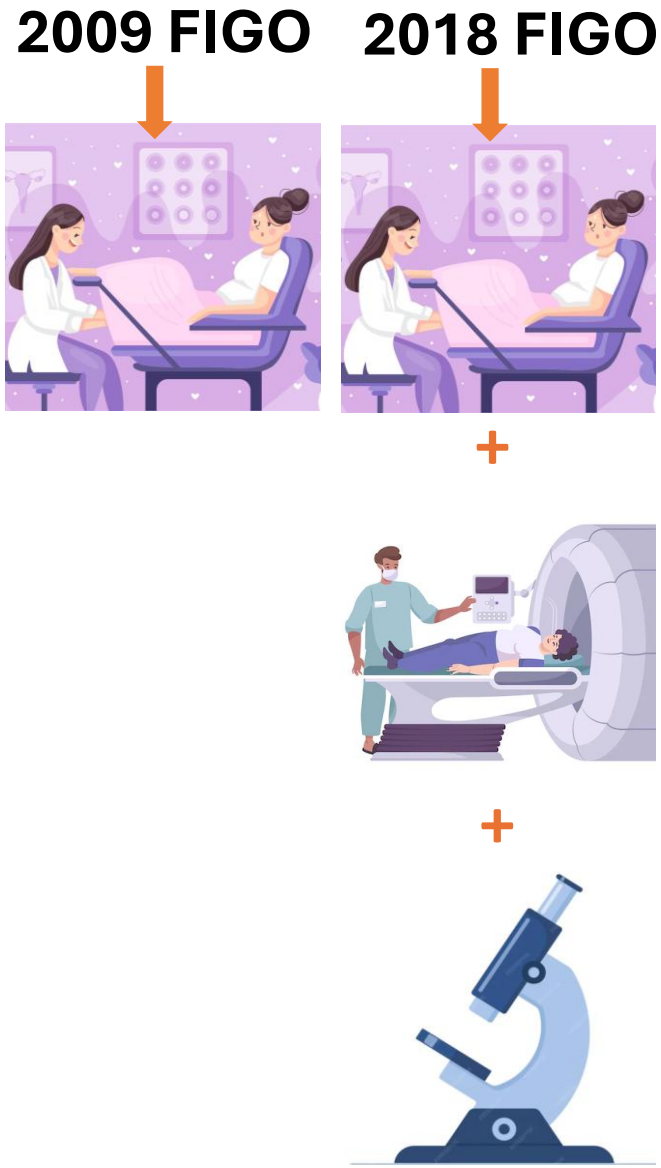

International Agency for Research on Cancer (IARC) 2024

# CC FIGO Staging System

FIGO 2018 incorporates imaging findings in stage classification

Pelvic MRI and CT/PET-CT:

- assess local and regional tumor extent (MRI)
- assess regional and/or distant spread (CT/PET-CT)




Images: freepik.com

Bhatla, Int J Gynaecol Obstet 2019

FIGO, The International Federation of Gynecology and Obstetrics

# 2018 FIGO STAGING SYSTEM FOR CERVICAL CANCER

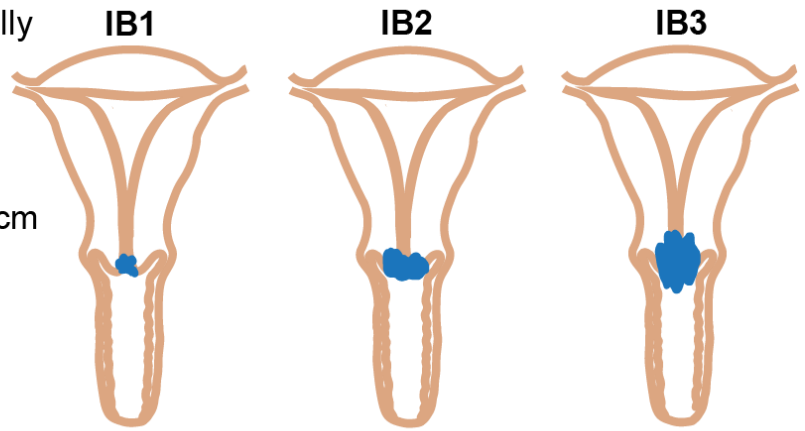
## STAGE I

**IA**: microscopically visible only

**IB1**: <2 cm

**IB2**: >2 and ≤4 cm

**IB3**: >4 cm

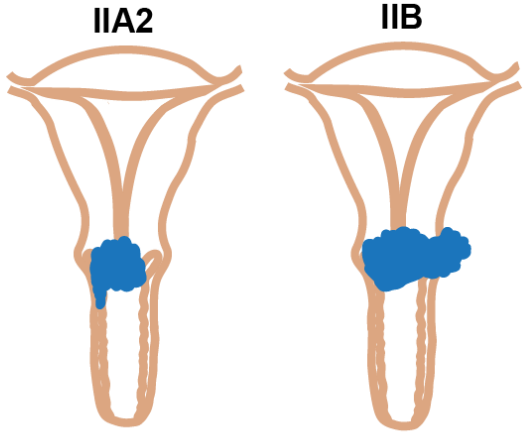



## STAGE II

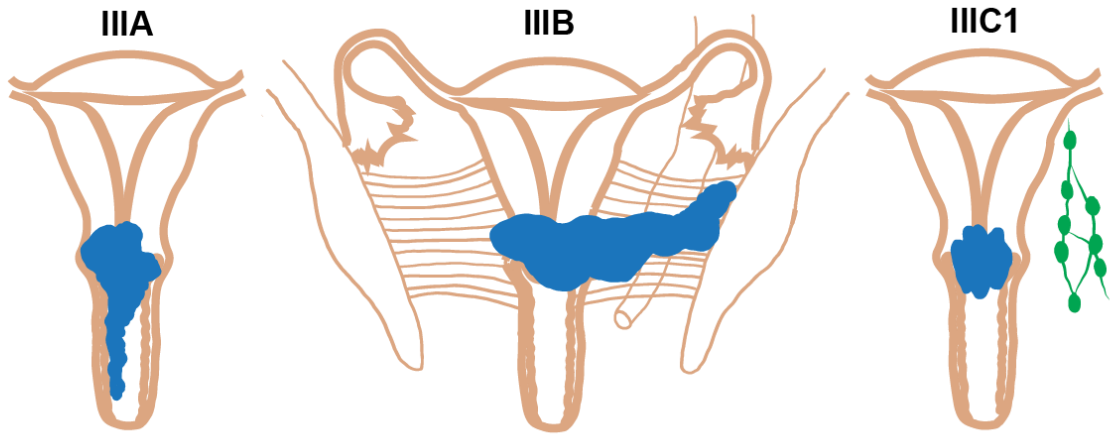
**IIA1**: involvement upper 2/3 of vagina; ≤4 cm

**IIA2**: involvement upper 2/3 of vagina; >4 cm

**IIB**: parametrial invasion




## STAGE III




**IIIA**: involvement lower 1/3 of vagina

**IIIB**: extension pelvic wall/ hydronephrosis/ non-functioning kidney

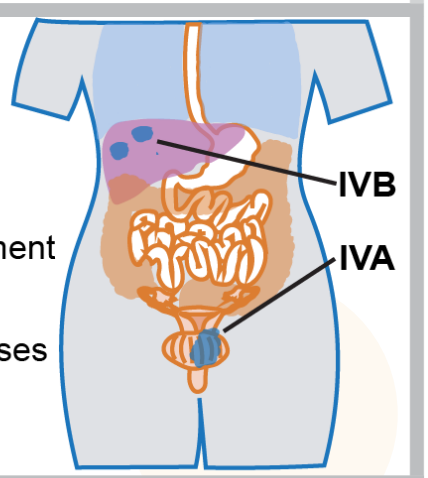
**IIIC1**: pelvic lymph node involvement

**IIIC2**: paraaotic lymph node involvement

## STAGE IV

**IVA**: bladder/ rectum involvement

**IVB**: distant metastases



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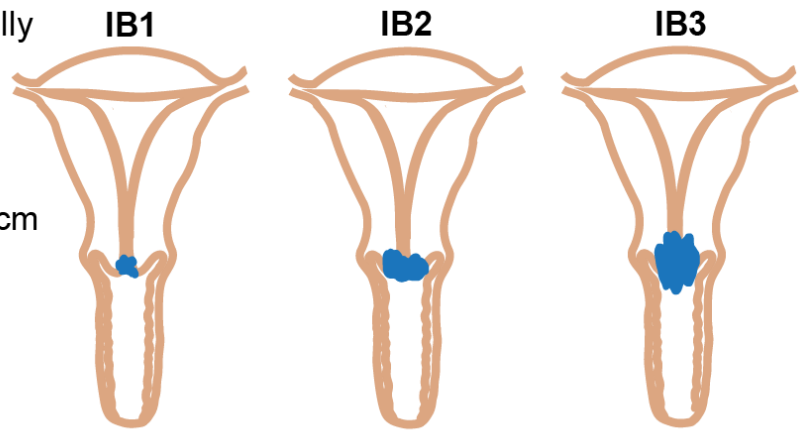


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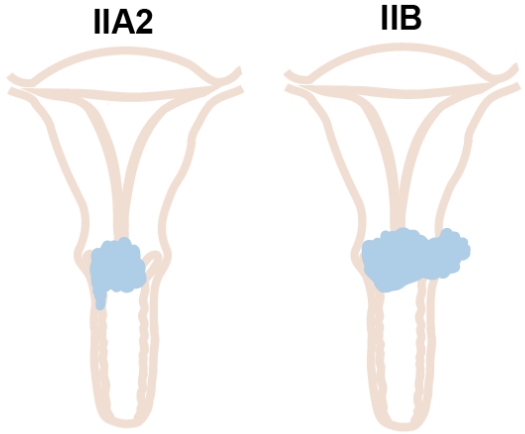


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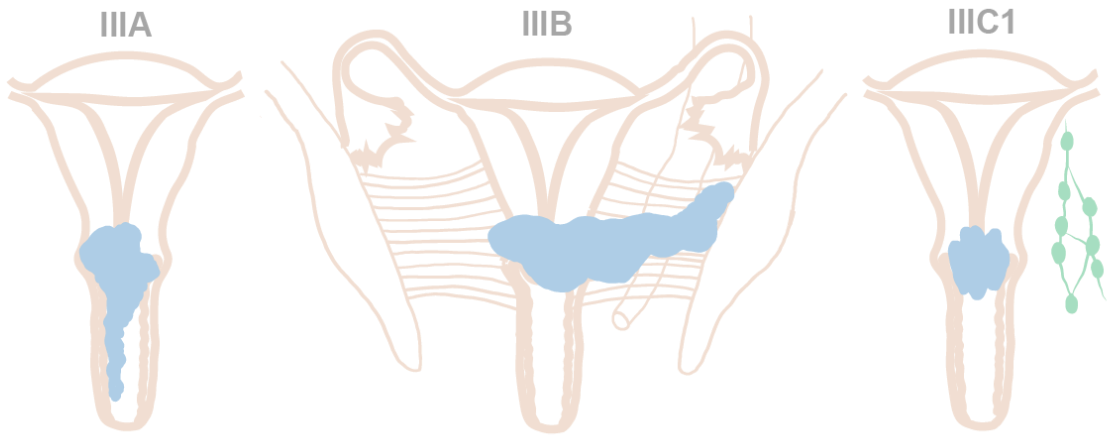


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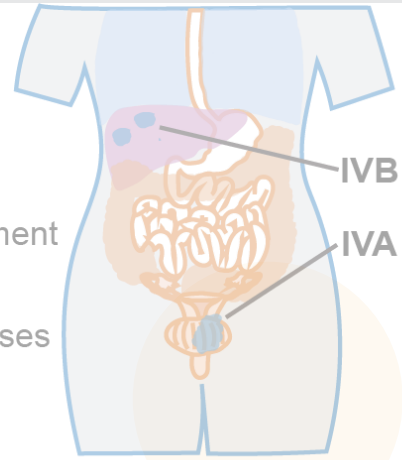
**IVA**: bladder/ rectum involvement

**IVB**: distant metastases



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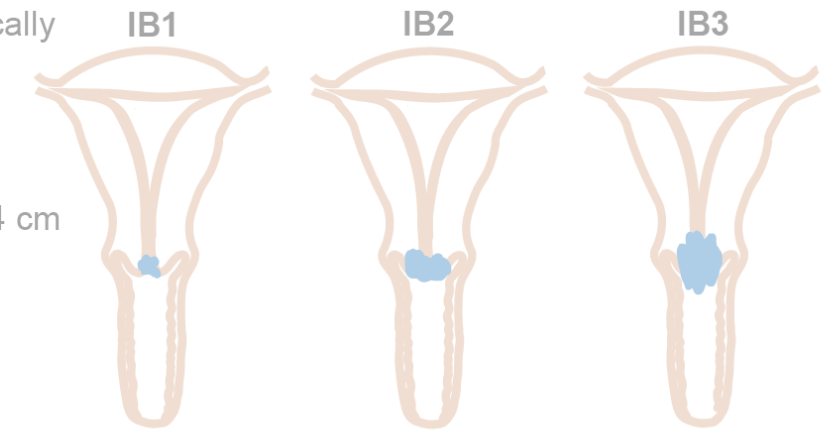


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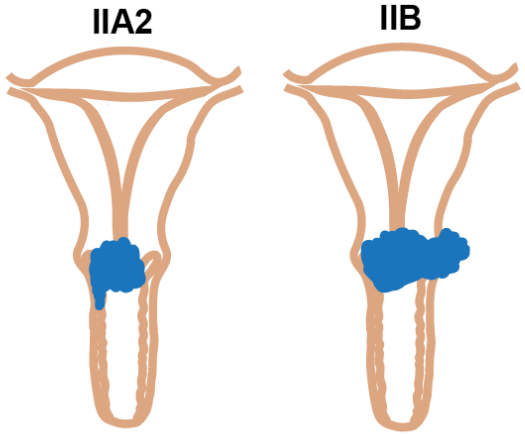


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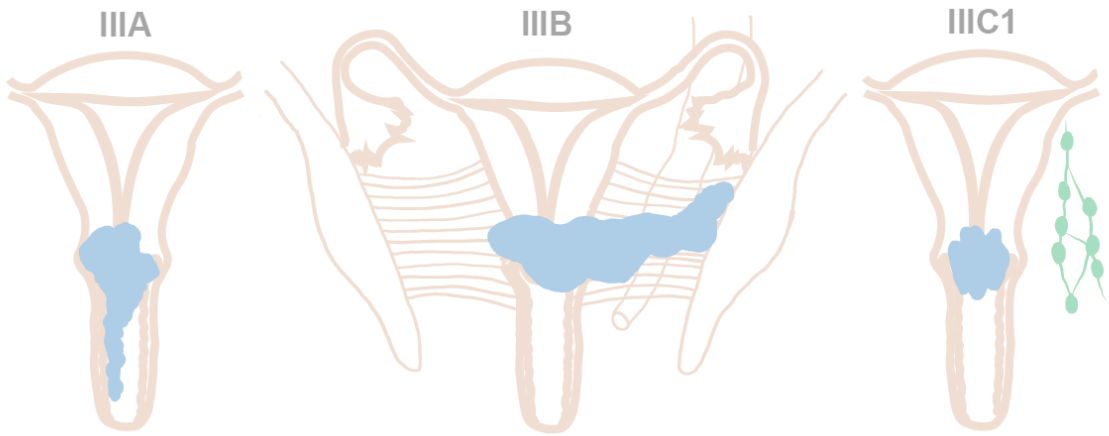


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**IVA**: bladder/ rectum involvement

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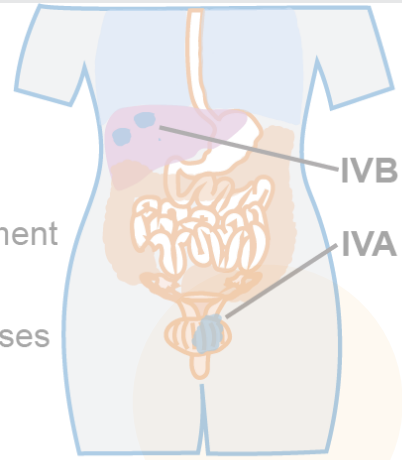

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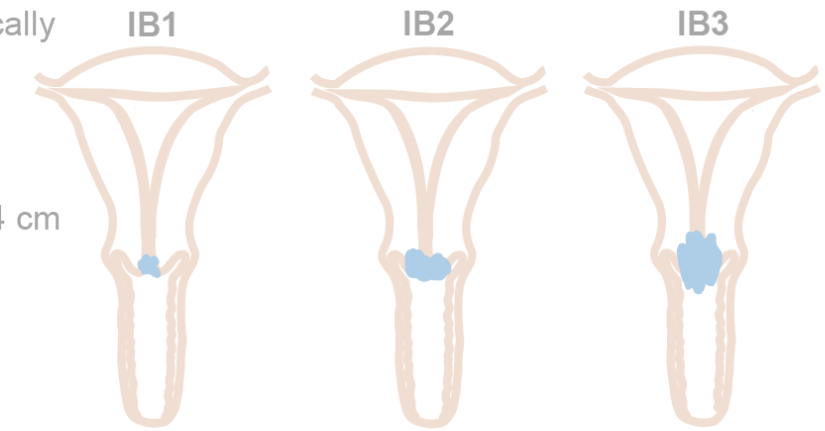


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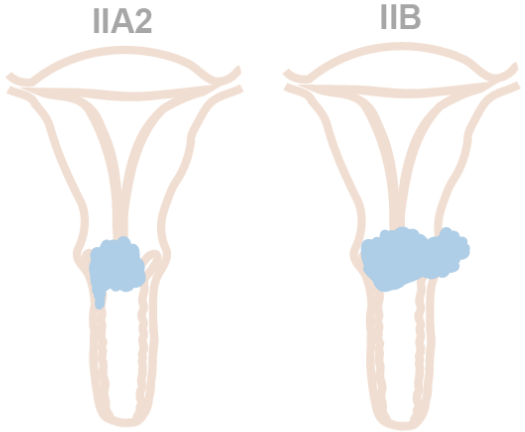


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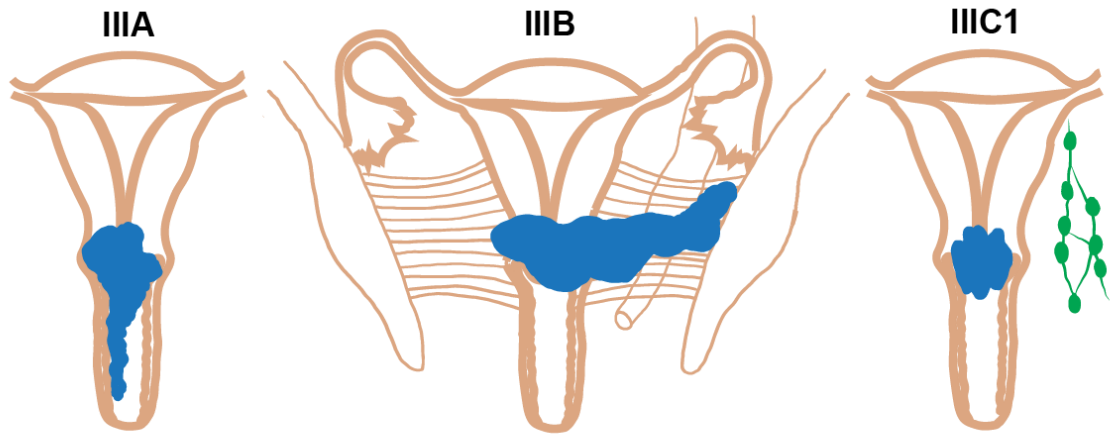


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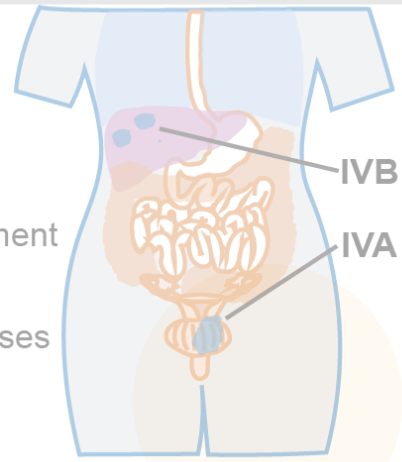

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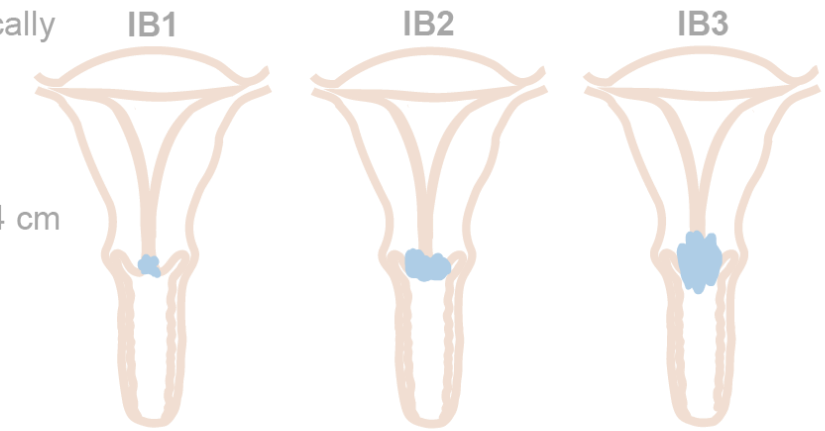


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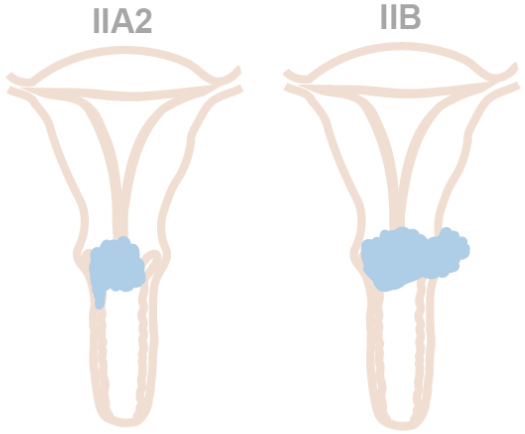
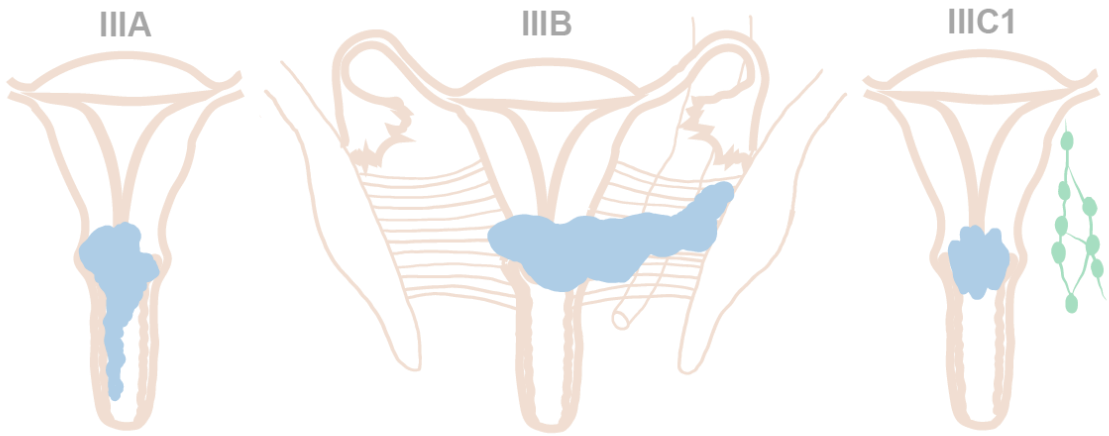



## STAGE III

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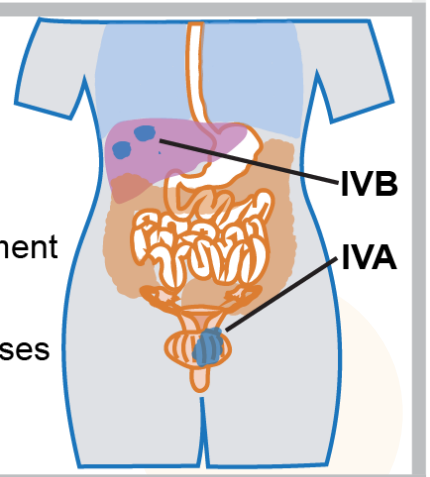
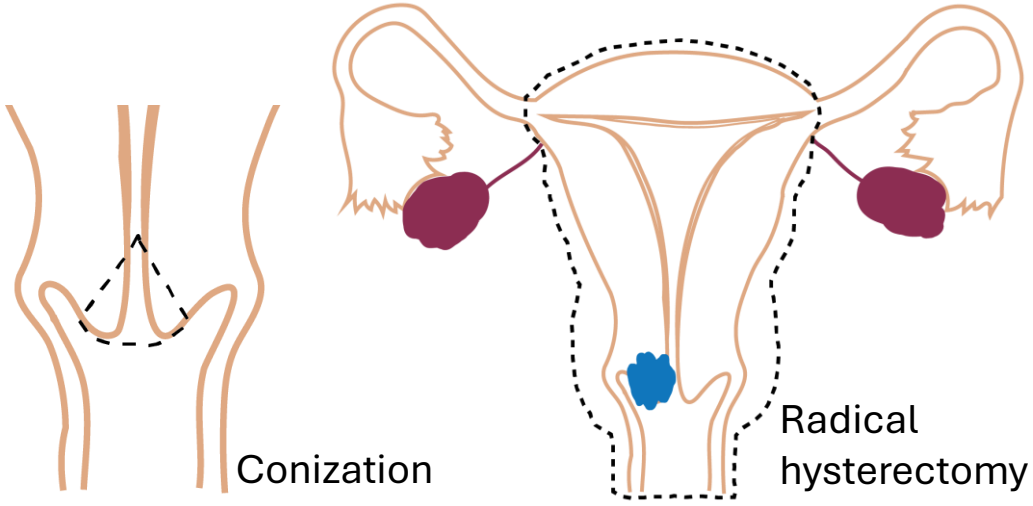


# Primary Treatment

## Early-stage disease (FIGO IA1–IB2, IIA1)

Surgery: conization or (radical) hysterectomy with pelvic lymphadenectomy




## Locally-advanced disease (FIGO IB3–IVA, except IIA1)

Concurrent chemoradiotherapy (CCRT)

## Metastatic disease

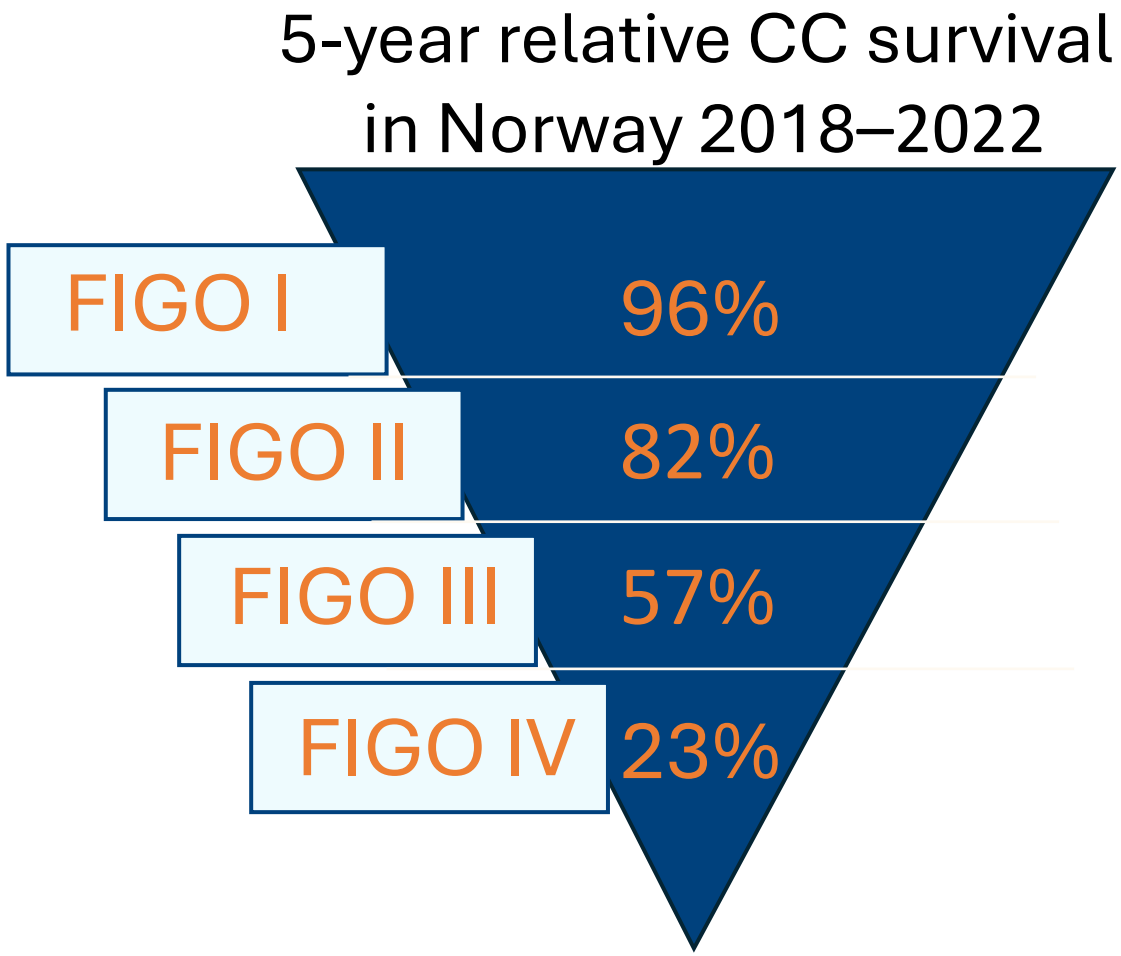
Individualized treatment

The Norwegian Directorate of Health, Gynekologisk kreft — Handlingsprogram 2023

# Increasingly poor prognosis with advancing FIGO stage

Imaging findings relevant for prognosis:

- Tumor size
- Vaginal extension
- Parametrial extension
- Lymph node metastases
- Spread to adjacent pelvic organs
- Distant spread




Cibula et al. Radiother Oncol 2023

Cancer Registry of Norway 2022

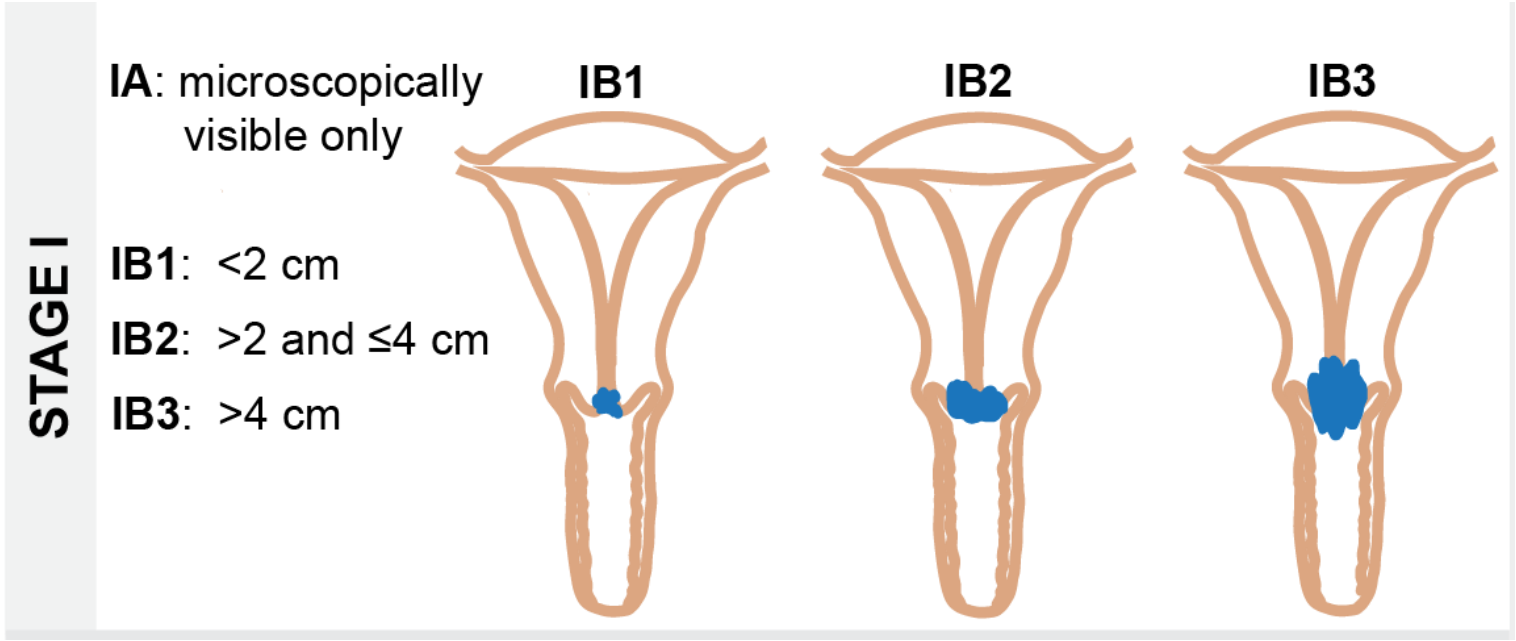
# Role of MRI and PET/CT for locoregional staging in cervical cancer

- In the revised 2018 FIGO* classification imaging- and pathology findings are formally incorporated in FIGO classification
- NCCN Guidelines**:
  - Consider pelvic MRI (or vaginal US) in all; CT/PET-CT if FIGO stage ≥IB1
- ESUR guidelines***:
  - Pelvic MRI is the preferred imaging modality to evaluate locoregional tumor extent
  - Whole-body FDG-PET/CT is recommended for evaluation of LN metastases and distant spread

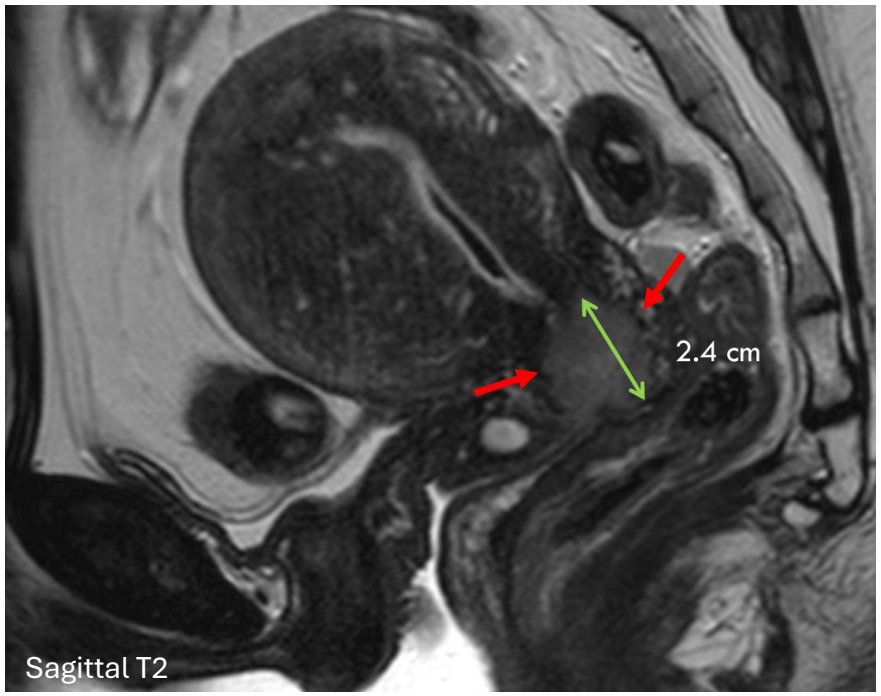
*Bhatla et al. Int J Gynecol Obstet 2019; FIGO =The International Federation of Gynecology and Obstetrics
**www.nccn.org/guidelines
***Manganaro et al., ESUR guideline, Eur Radiol 2021

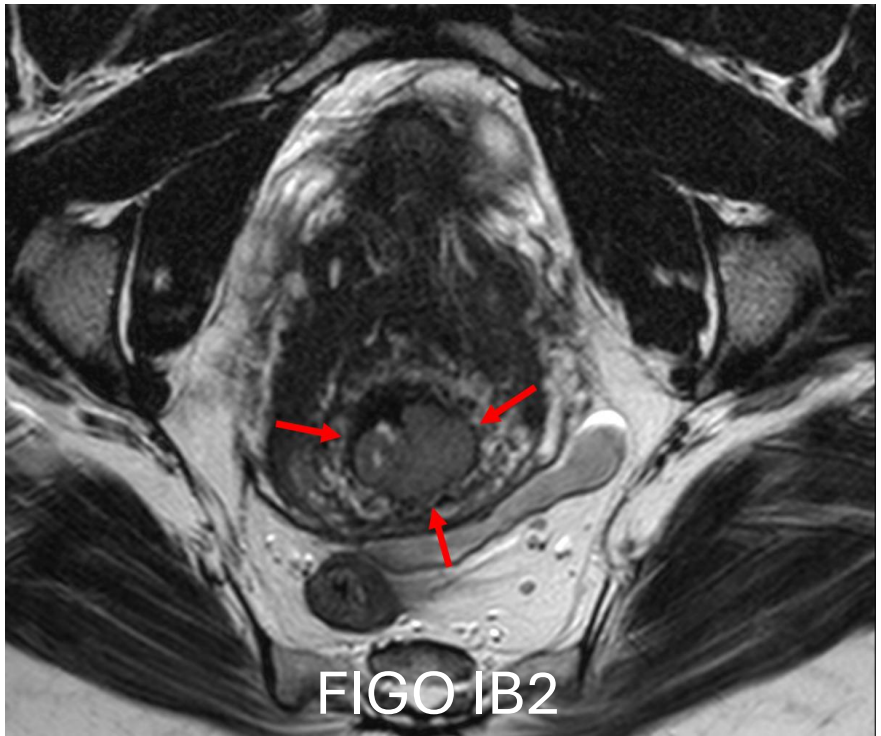
# FIGO I staging parameters assessable by MRI

Confined to the cervix

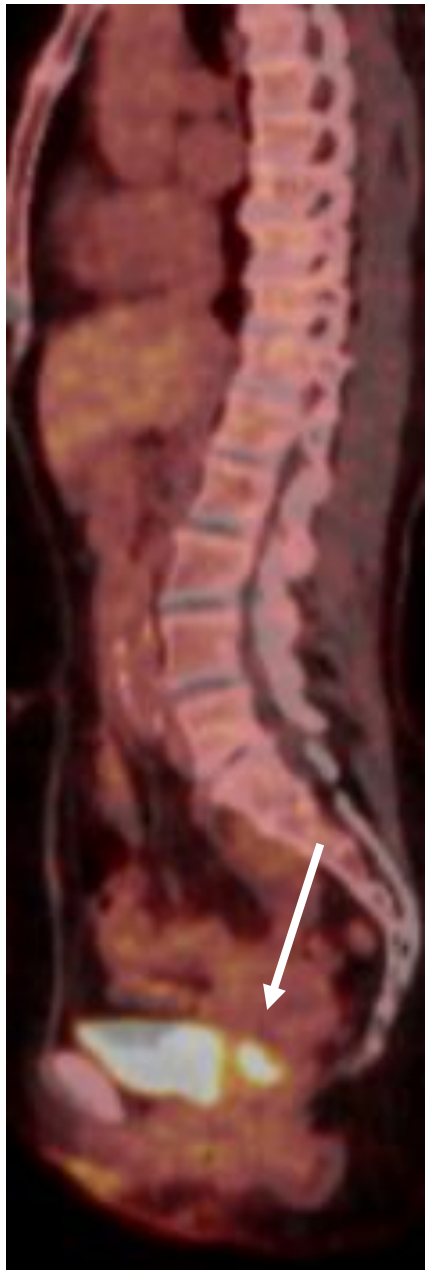


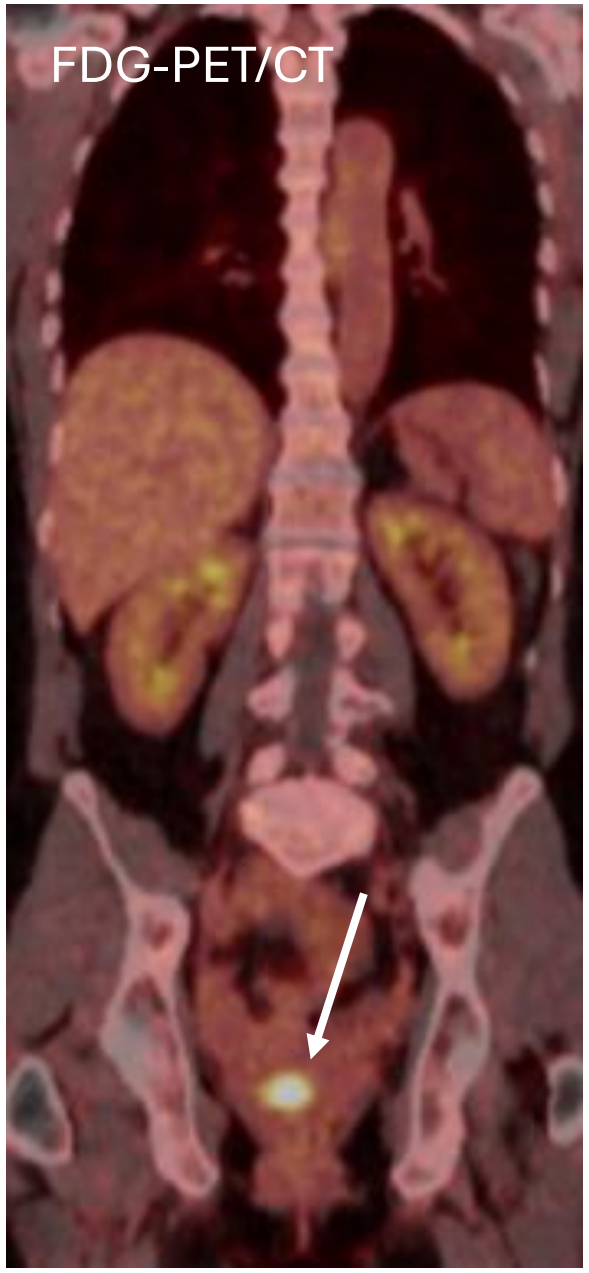

Largest primary tumor diameter defines substages IB1-3

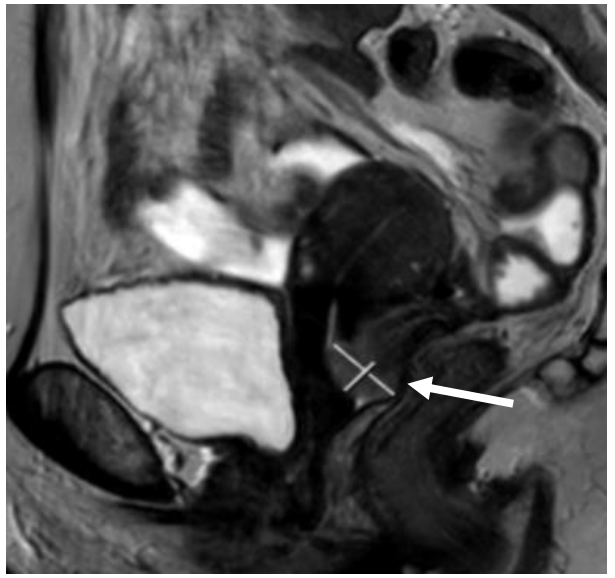


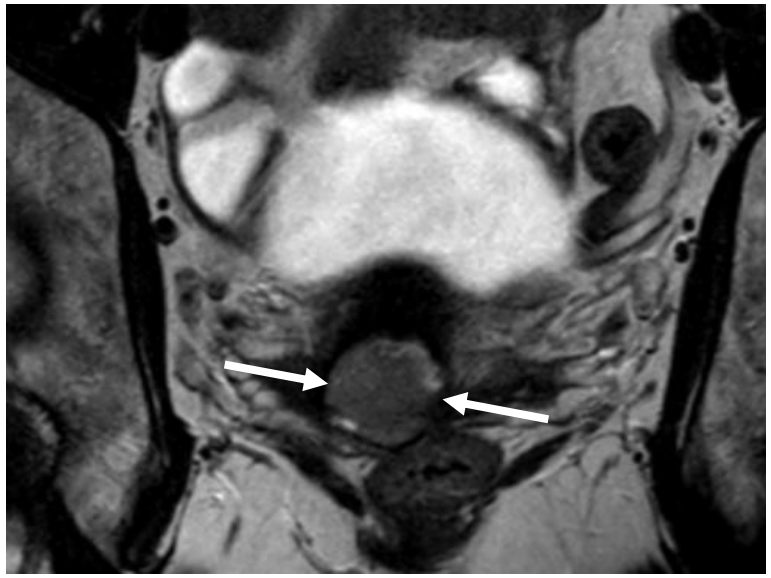



FIGO 1B2: localized FDG-avid lesion in the cervix,  no LNM or distant spread;  BSO (Meigs), no recurrence (7 yrs)

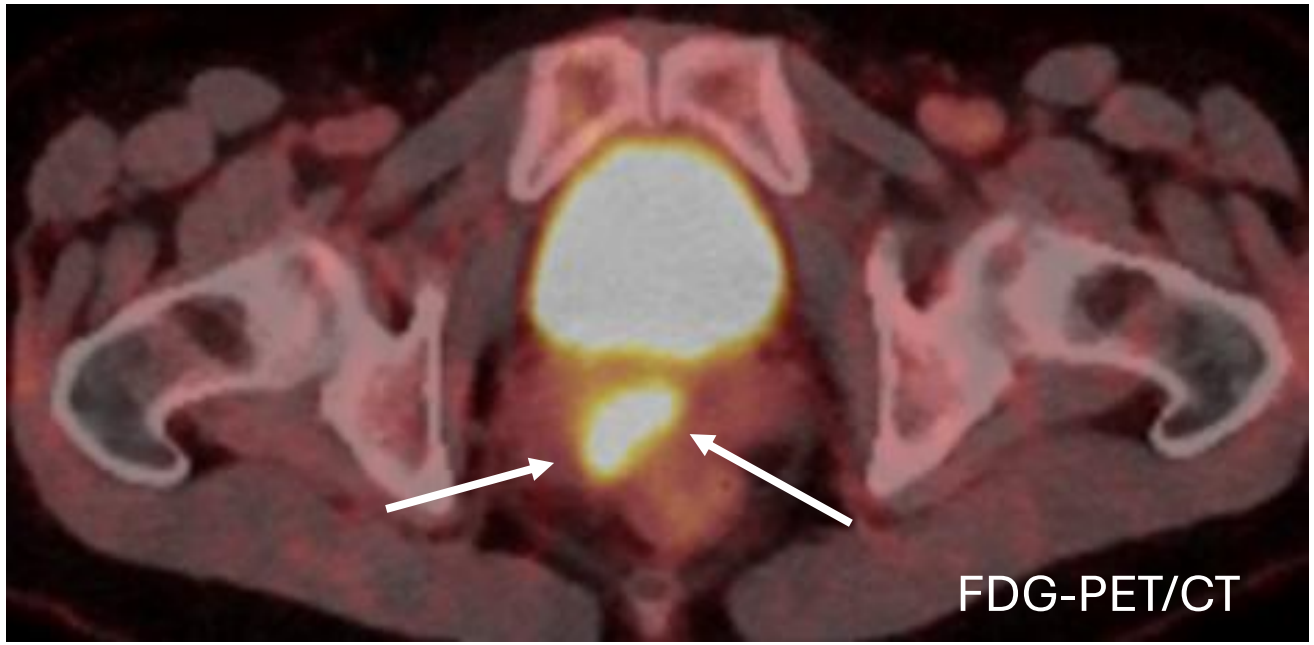




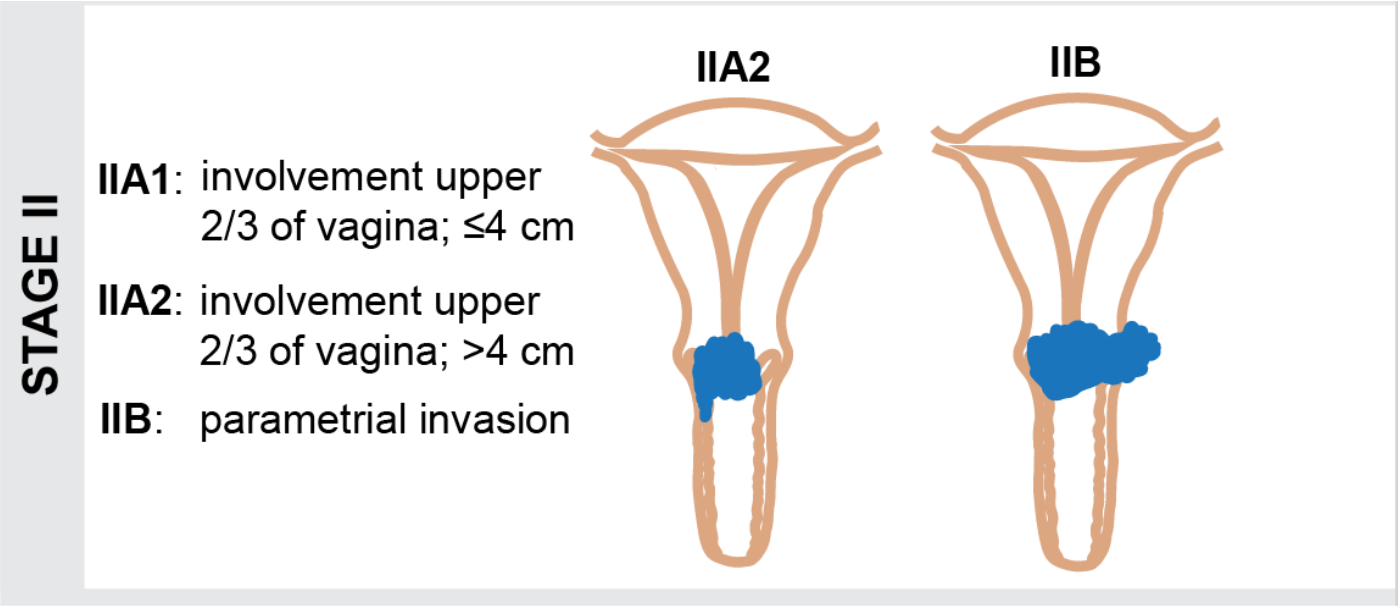


Pelvic T2-weighted MRI



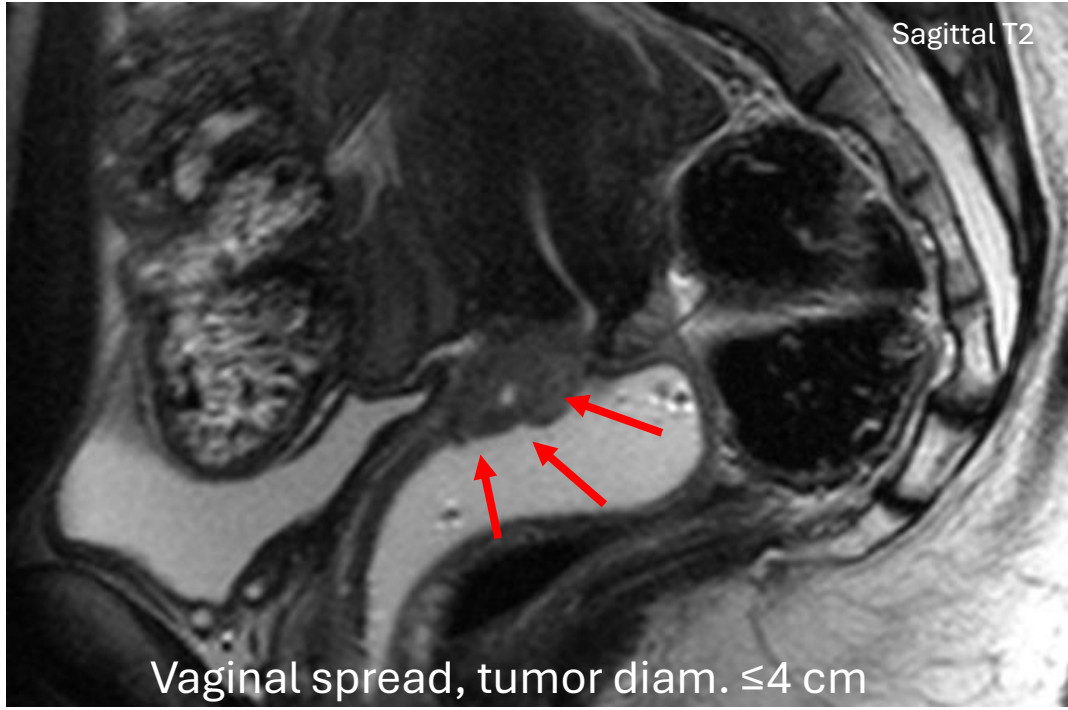
# FIGO II staging parameters assessable by MRI

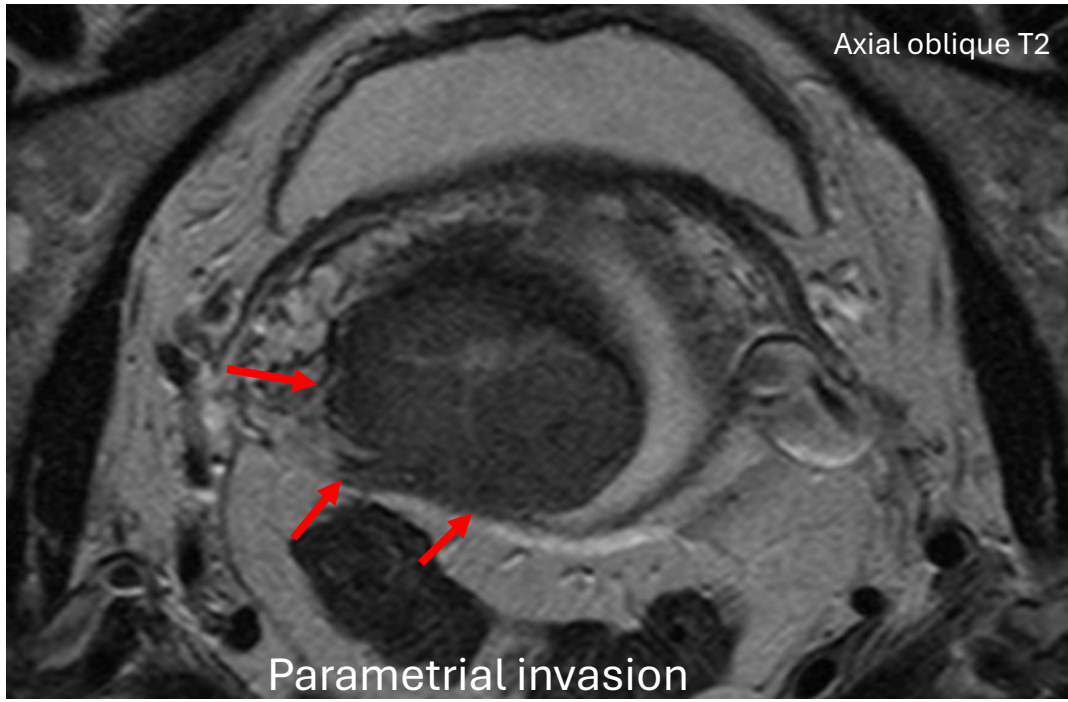
Invasion to upper 2/3 of the vagina or parametrium




Vaginal spread and tumor size (>/≤4 cm) define stage IIA1-2

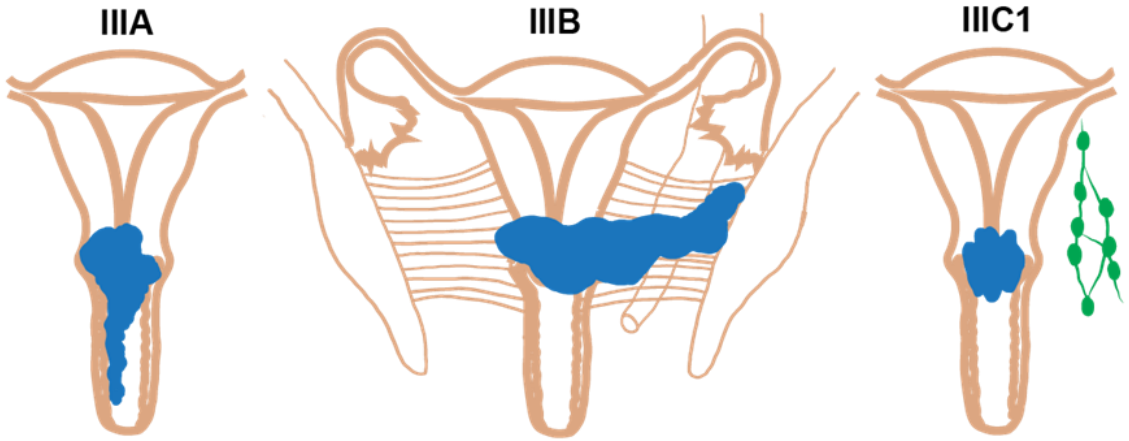
Parametrial invasion defines stage IIB



# FIGO III staging parameters assessable by MRI

Invasion of the lower 1/3 of the vagina/pelvic sidewall/pelvic and/or paraaortic LNM




**IIIA**: involvement lower 1/3 of vagina

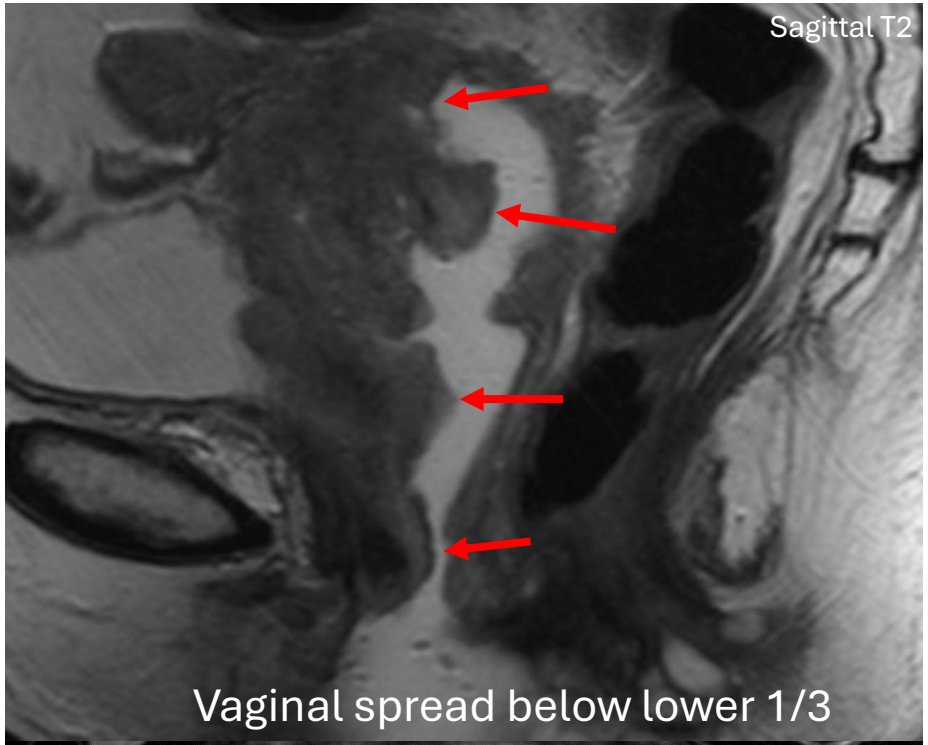
**IIIB**: extension pelvic wall/ hydronephrosis/ non-functioning kidney

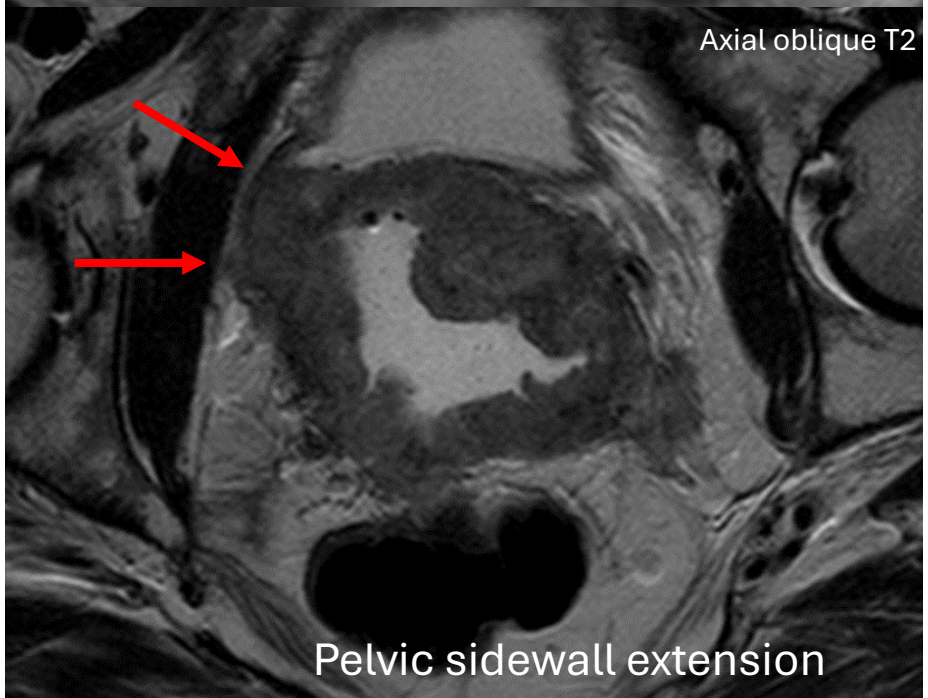
**IIIC1**: pelvic lymph node involvement

**IIIC2**: paraaotic lymph node involvement

Vaginal spread below lower 1/3 defines stage IIIA

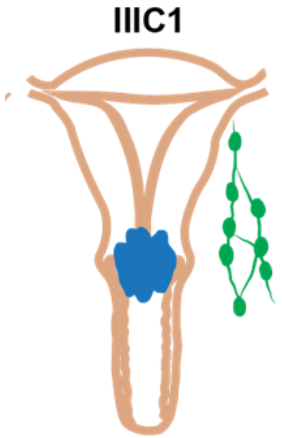
Pelvic side wall extension defines stage IIIB



# FIGO IIIC staging parameters assessable by MRI and PET

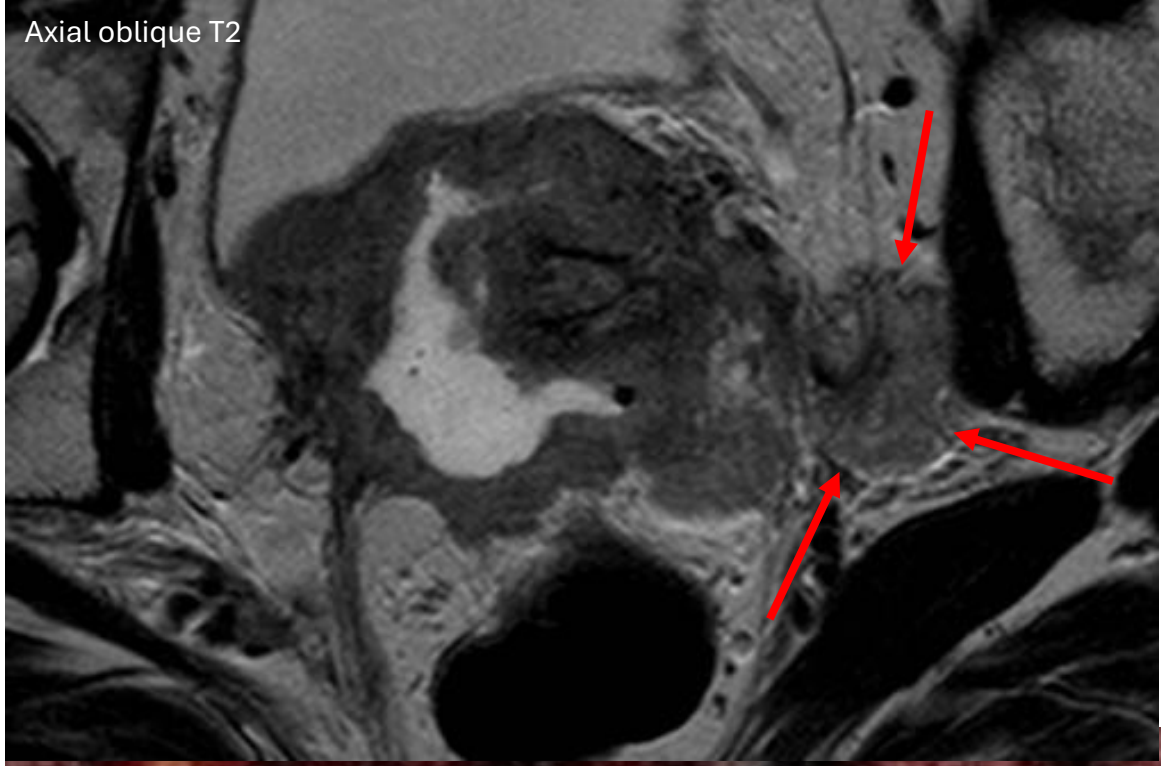
## Pelvic and or paraaortic LNM

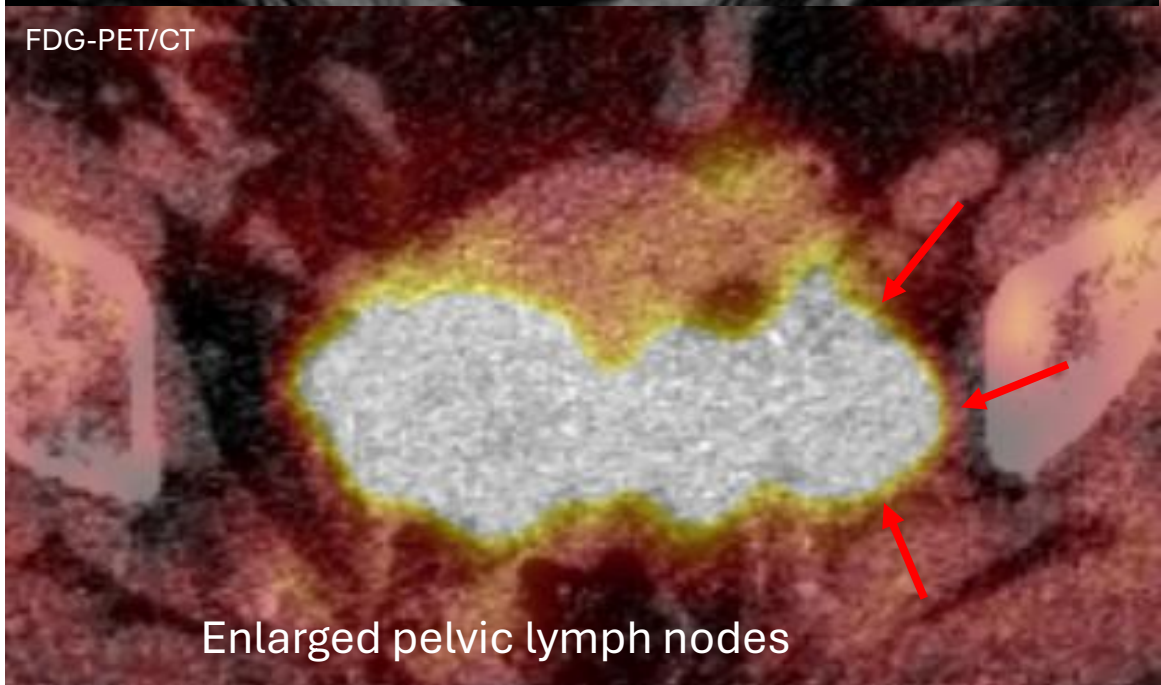


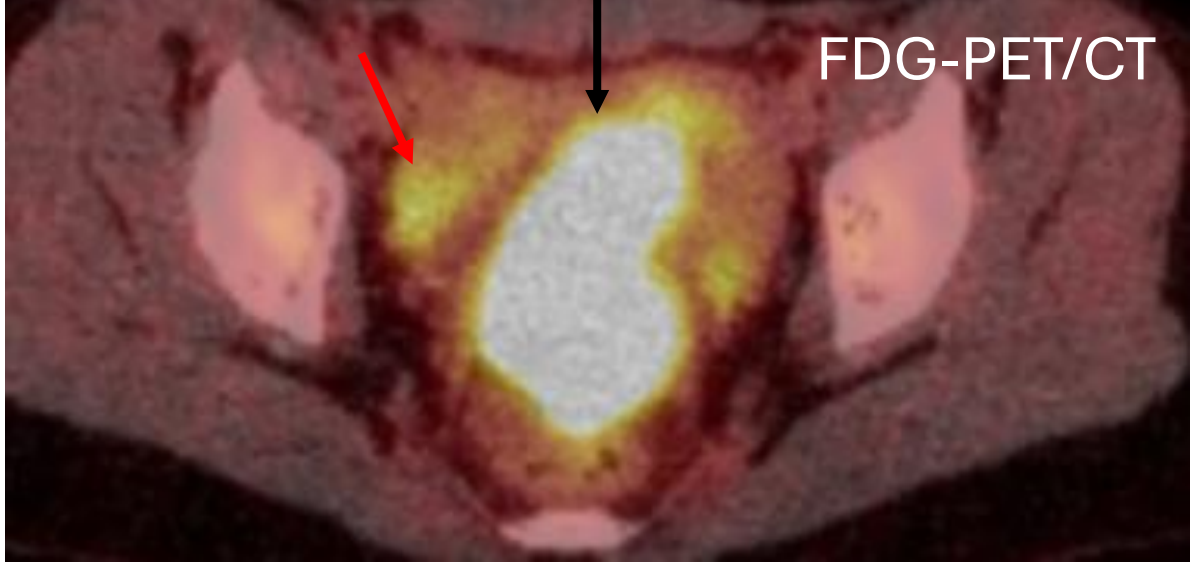

**IIIC1**: pelvic lymph node involvement

**IIIC2**: paraaotic lymph node involvement

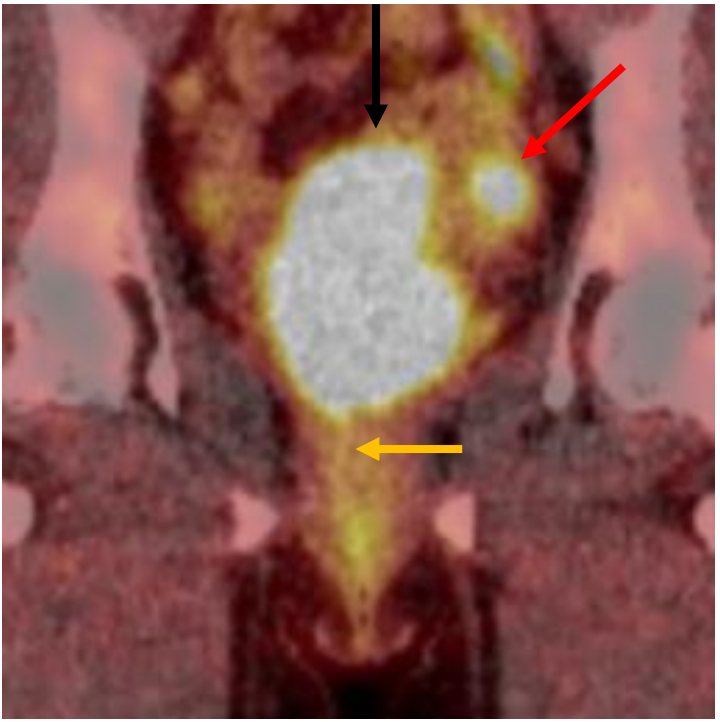
Pelvic/paraaortic LN enlargement defines stage IIIC1-2

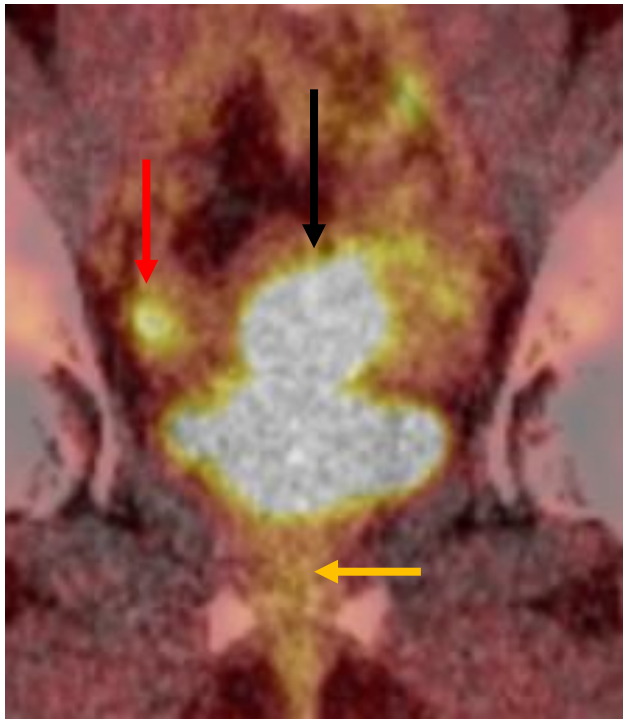


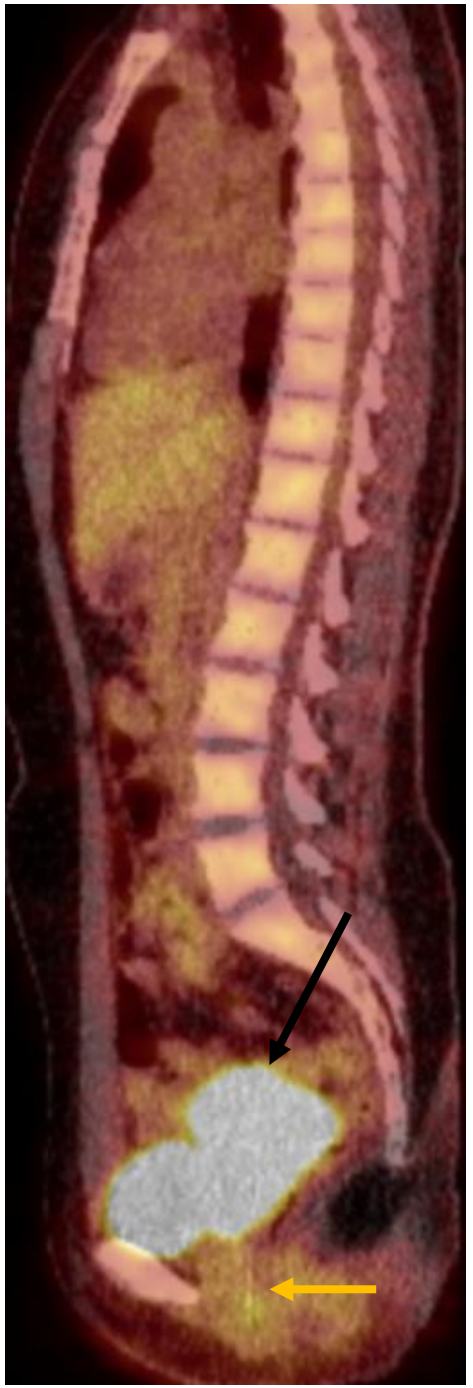



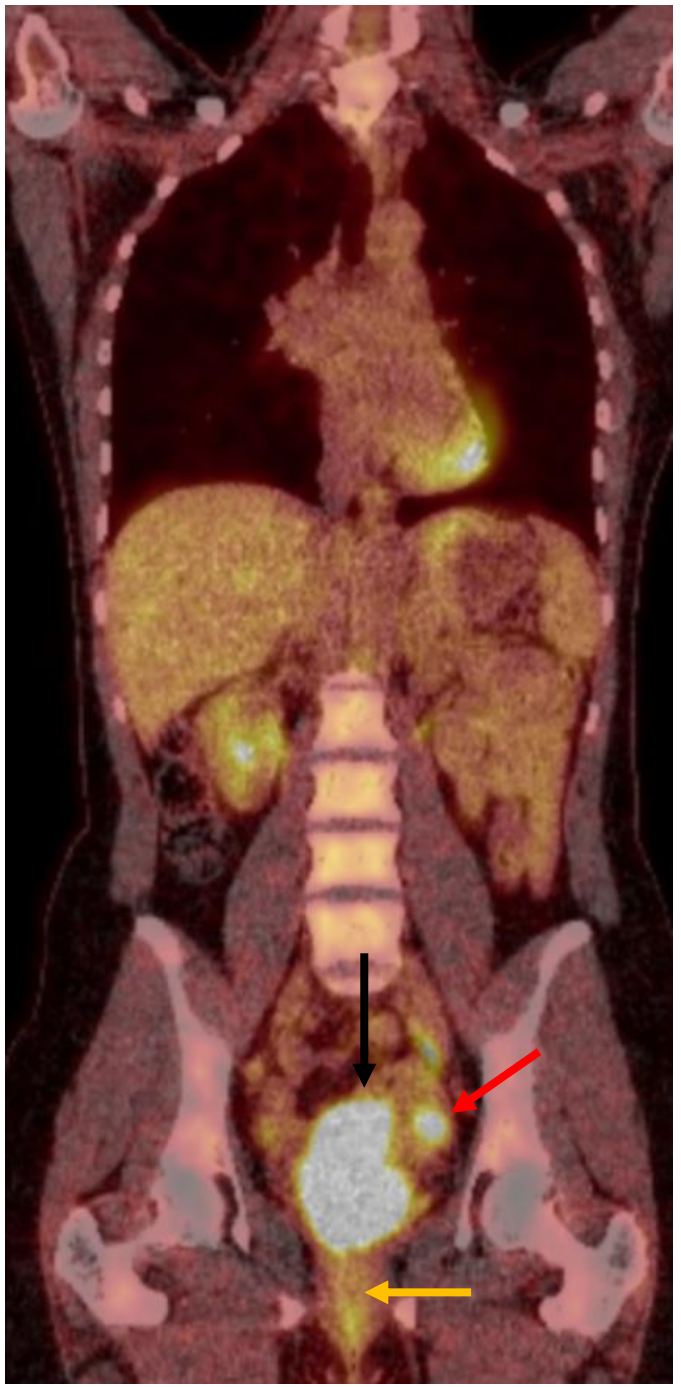



FIGO 3C1: large FDG-avid lesion invading the parametrium, parailiac LNM and vaginal tumor extension



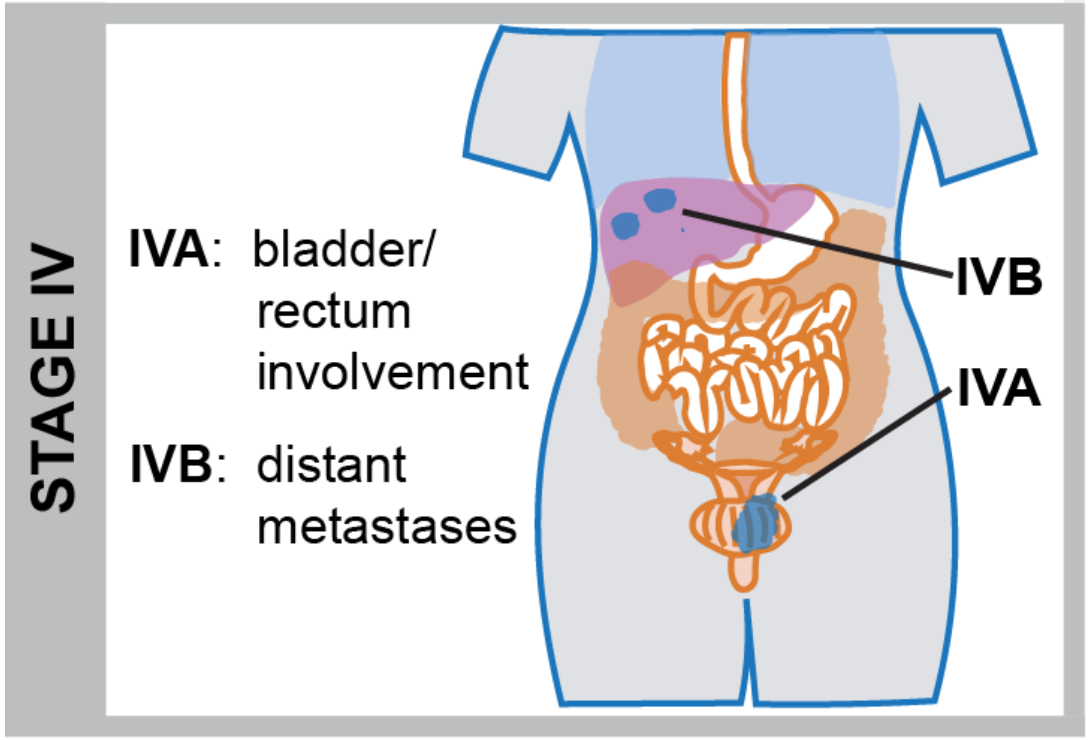




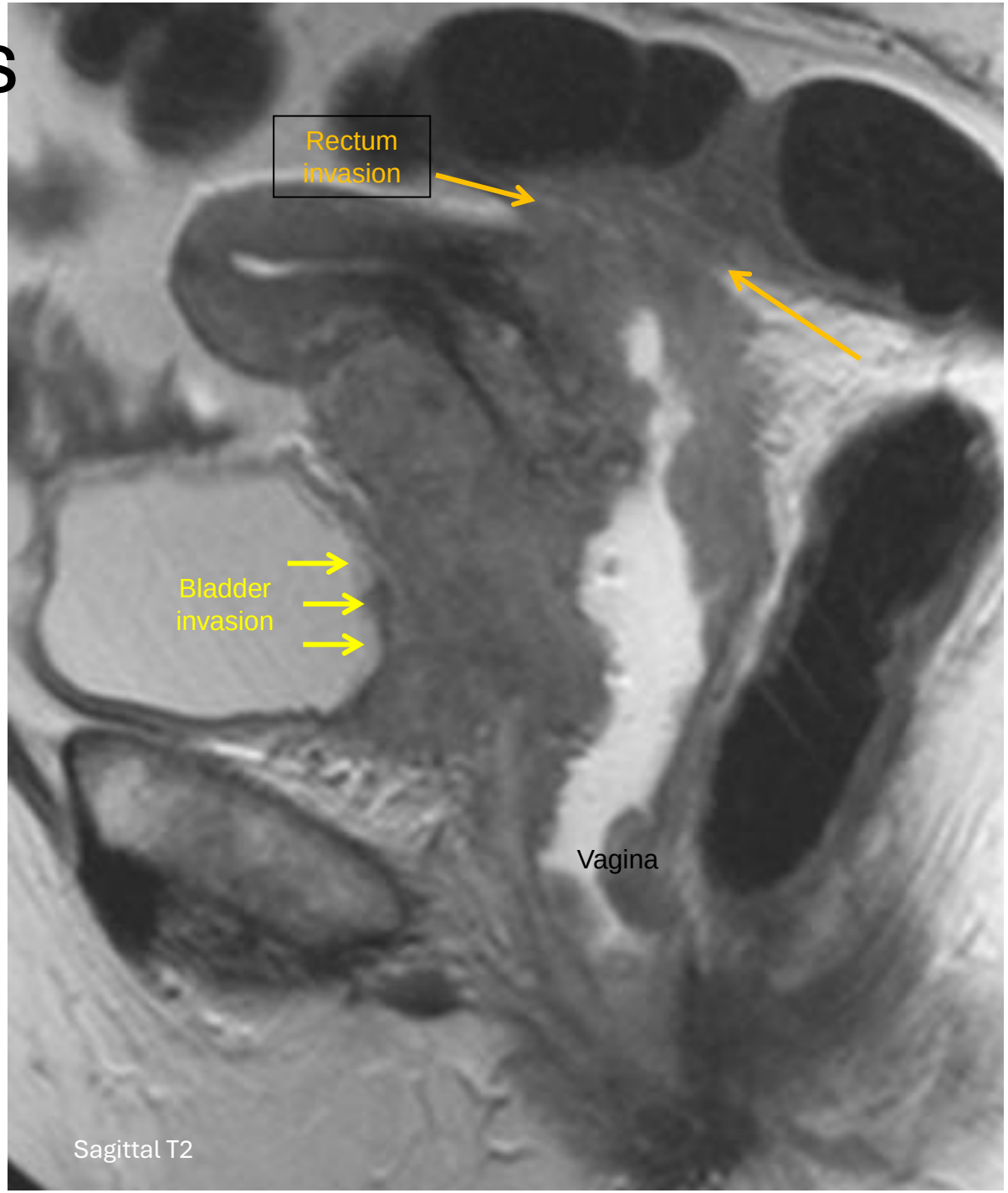


# FIGO IVA staging parameters assessable by MRI

Extension to bladder/rectum

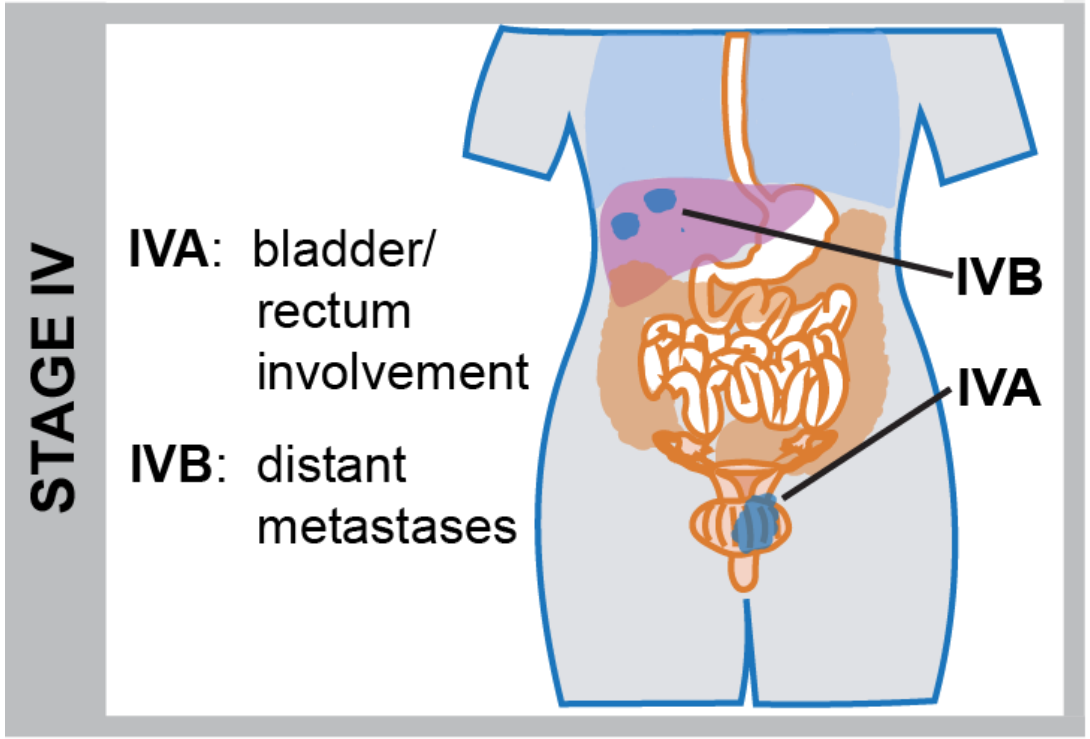



Extension to bladder or rectum defines stage IVA

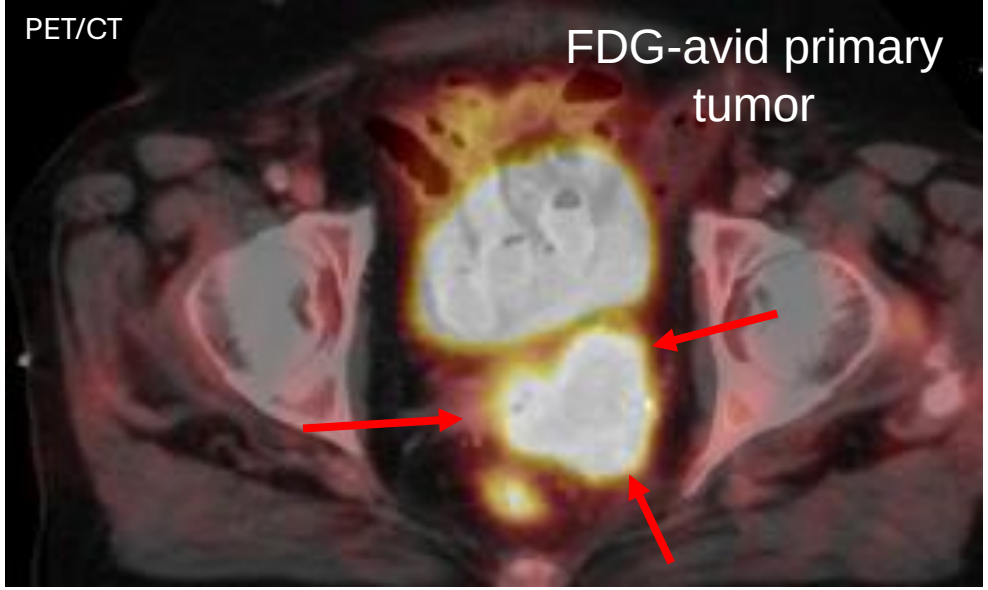


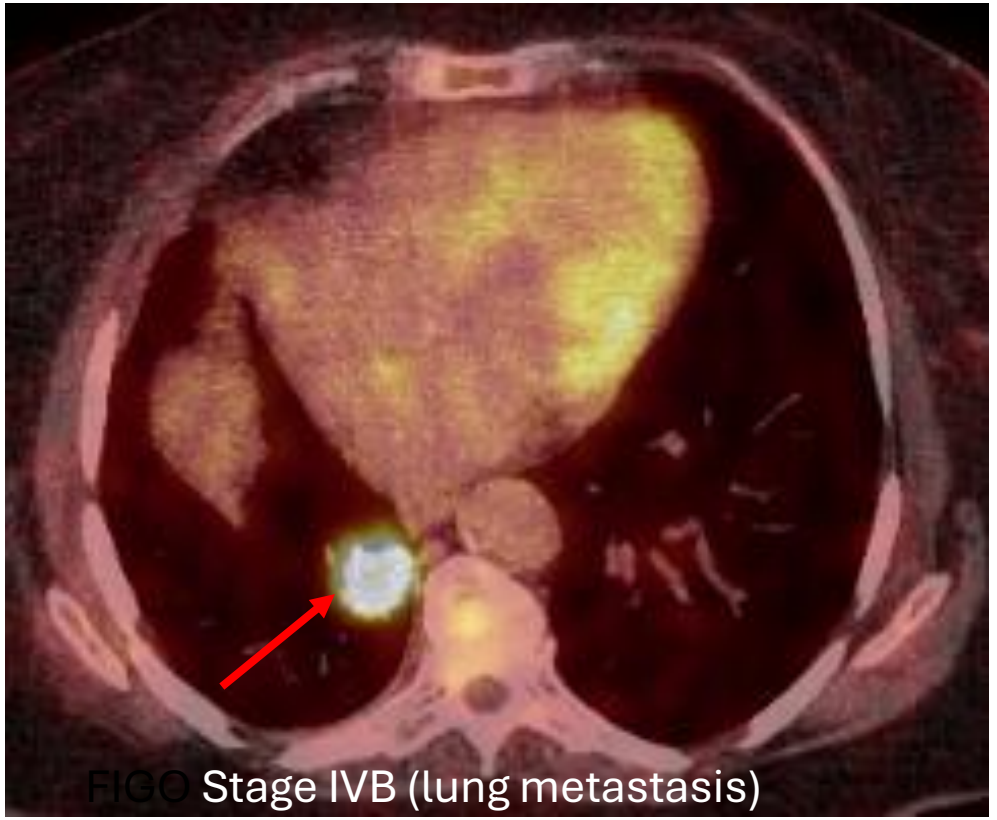
# FIGO IVB staging parameters assessable by CT or PET-CT

Distant spread

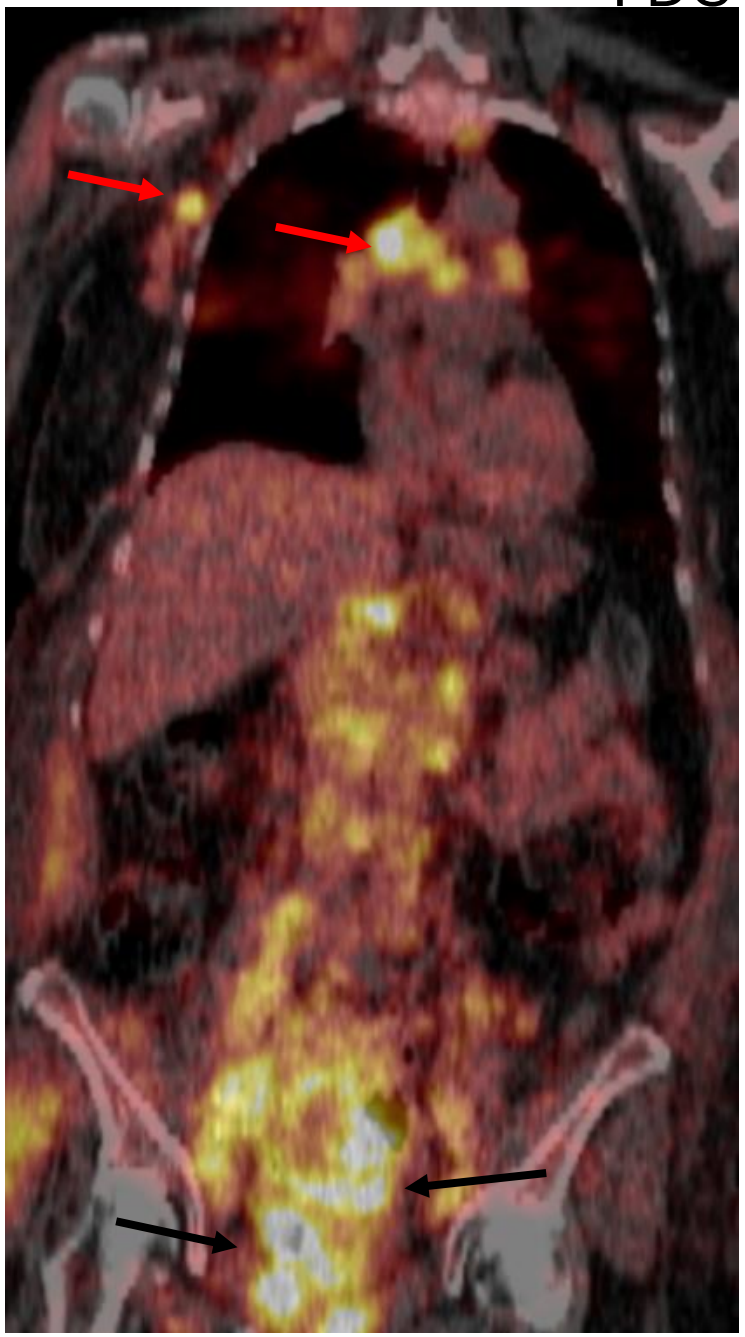


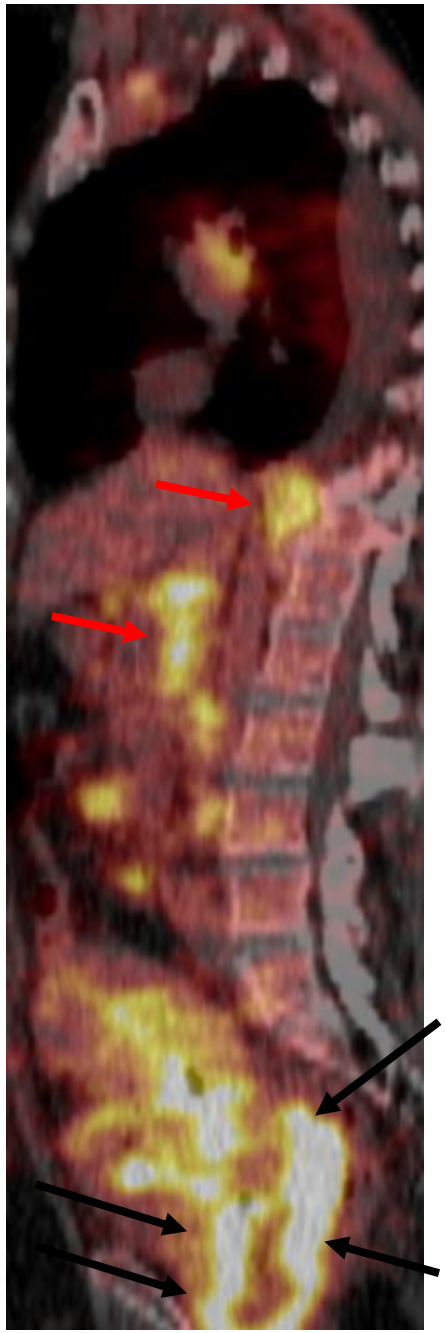

Distant spread defines stage IVB



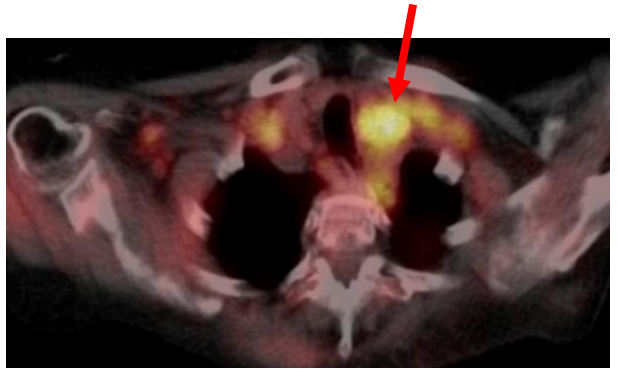



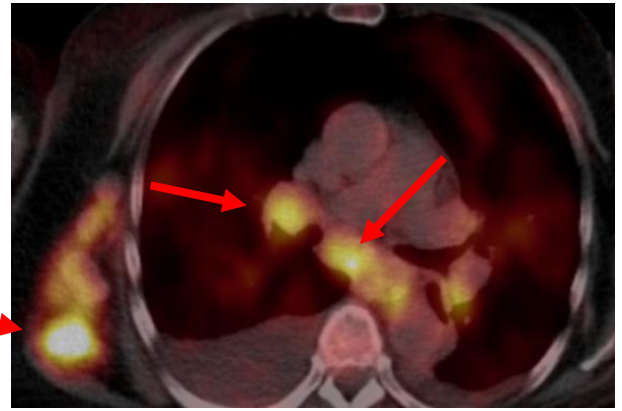
FDG-PET/CT

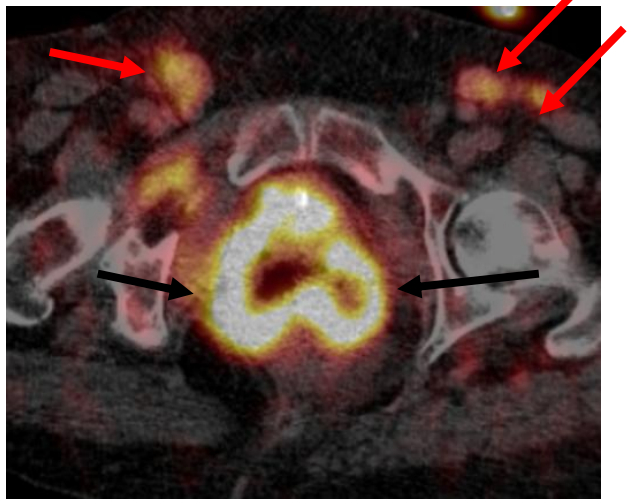




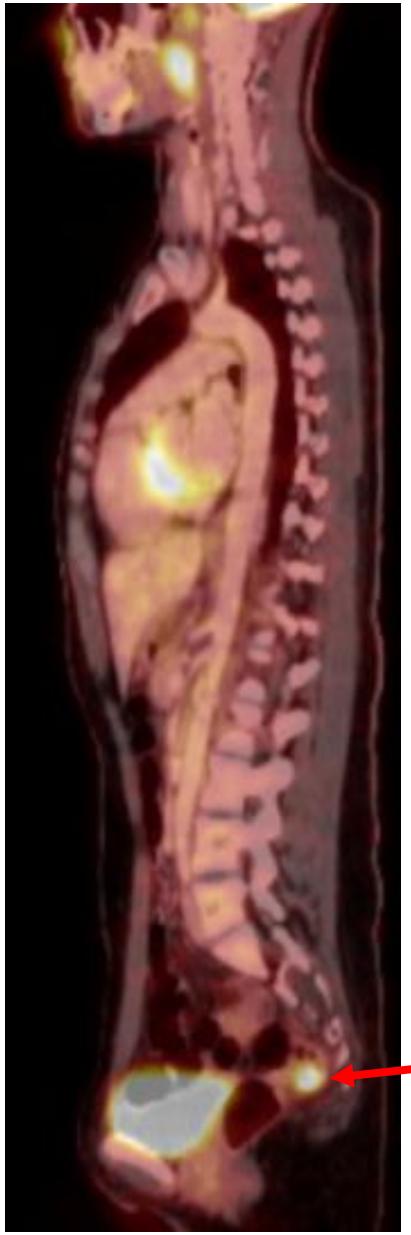
FIGO 4B: large FDG-avid lesion in the cervix/vagina/ parametrium, widespread LNM in the abdomen mediastinum, axillary and iliac; palliative treatment, died from CC (2 months)

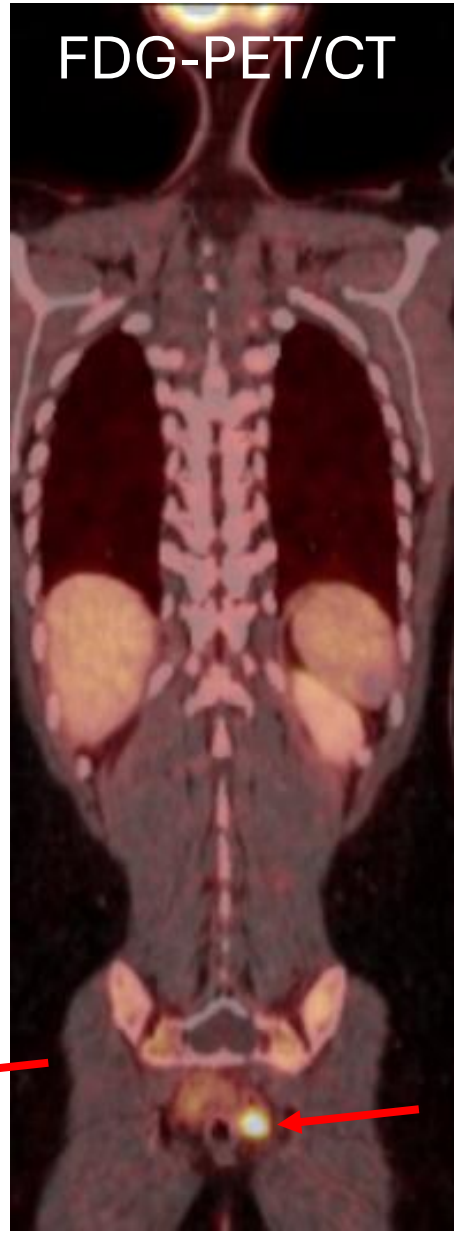




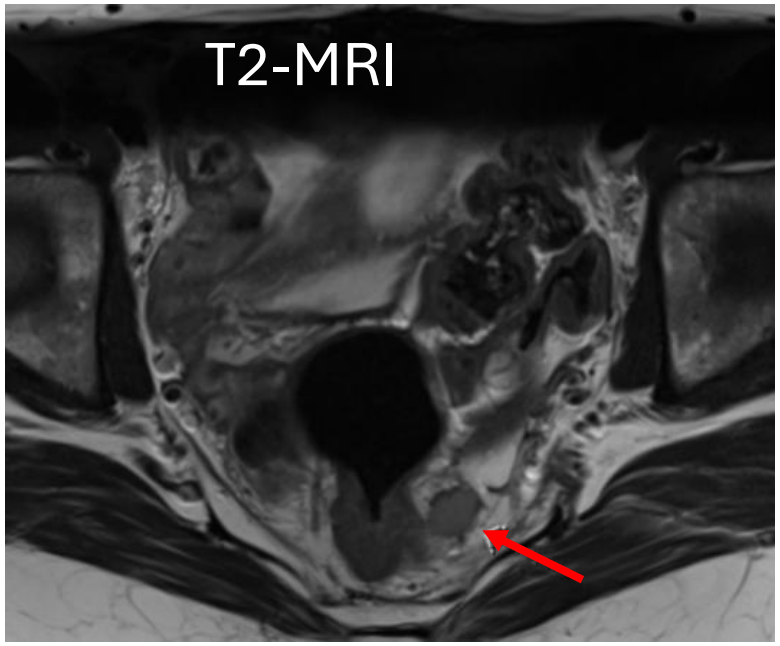


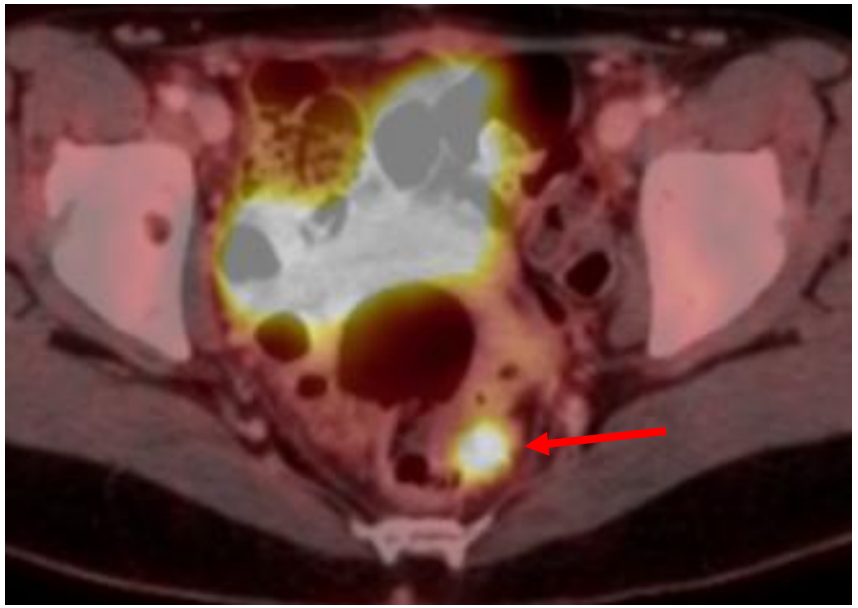
# MRI and PET-CT at time of local recurrence in CC

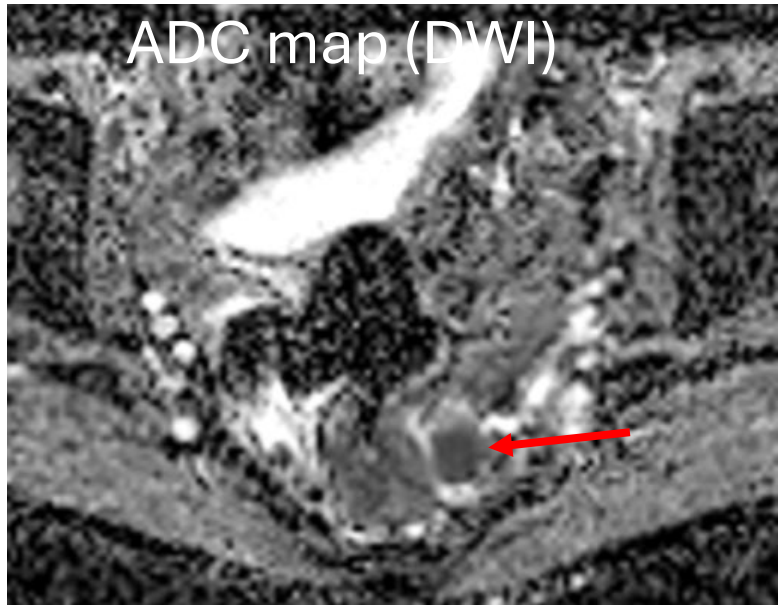





FIGO 1B1 treated with
Meigs without BSO,
1 year after treatment:
FDG-avid lesion in the
vaginal vault

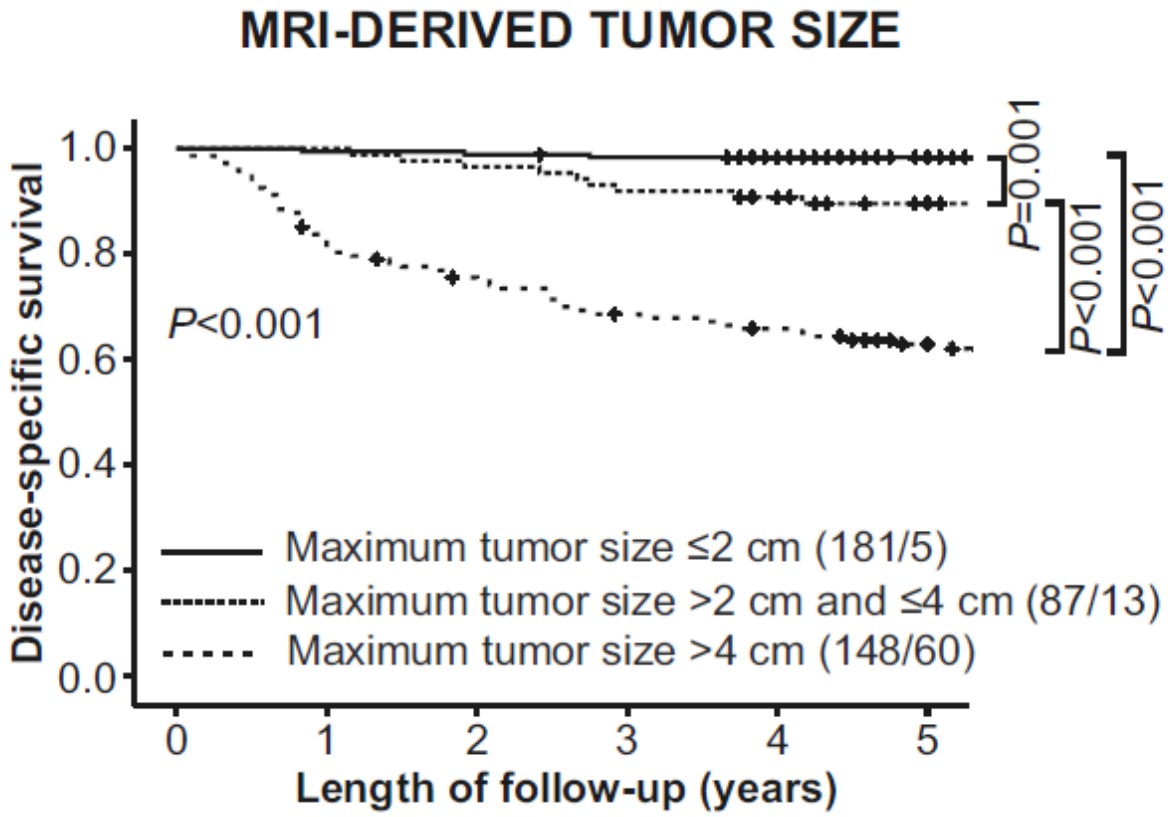




# How is the interobserver agreement for central MRI staging parameters in FIGO 2018?

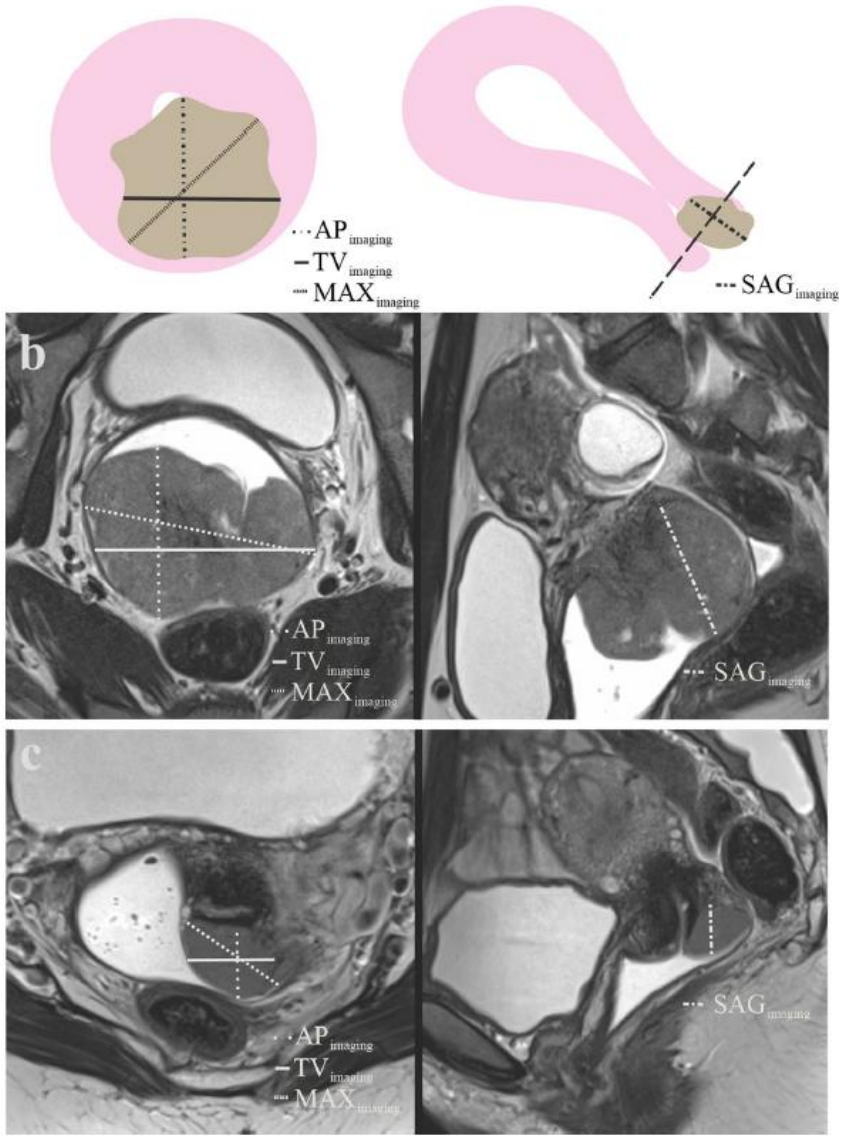
| | Overall $\kappa$ (95% CI) |
|---|---|
| Tumor size > 2 cm | 0.80 (0.74–0.85) |
| Tumor size > 4 cm | 0.76 (0.70–0.81) |
| Tumor size, three categories | 0.78 (0.74–0.81)[a] |
| ≤ 2 cm | |
| > 2 and ≤ 4 cm | |
| > 4 cm | |
| Parametrial invasion | 0.63 (0.58–0.69) |
| Vaginal invasion | 0.61 (0.56–0.67) |




Substantial agreement (kappa values of 0.61-0.80, 3 readers, n=416)

Wagner-Larsen et al, Eur Radiol, 2022

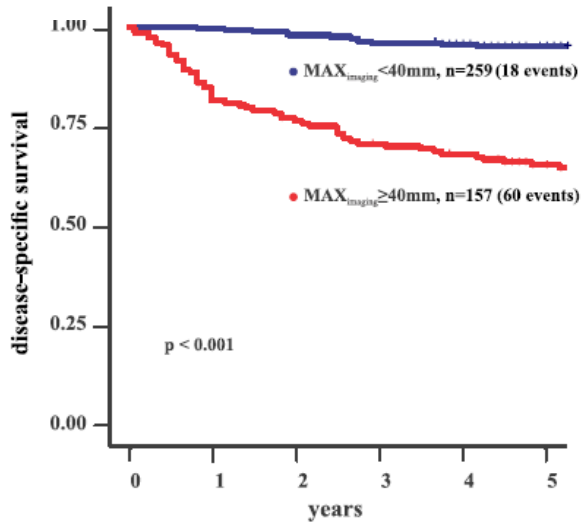
# What tumor size measurement is most prognostic?

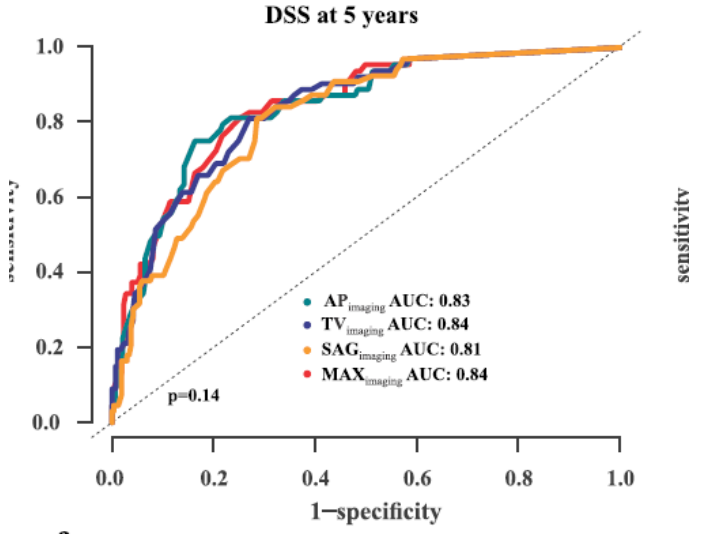



Lura et al, Insights into Imaging, 2022

**Table 4** Uni- and multivariable hazard ratios for MRI-derived tumor size variables for predicting disease-specific survival in 416 patients with uterine cervical cancer (78 patients died from disease)

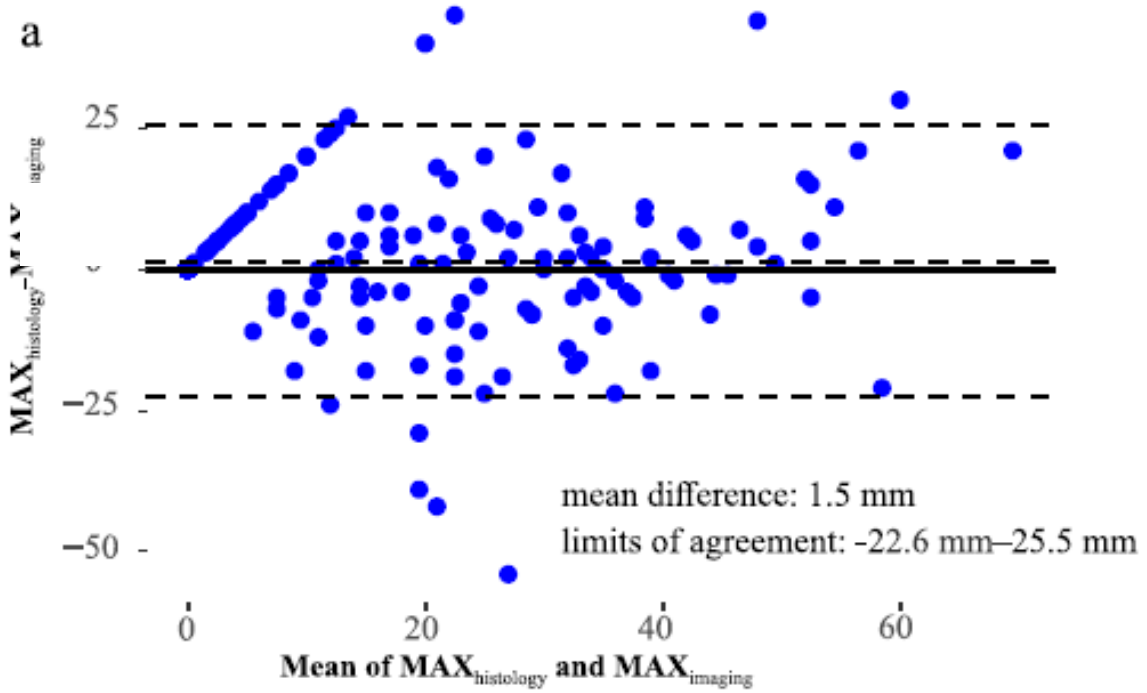
| Variables | Univariable HR (95% CI) | p* | Multivariable HR (95% CI)[a] | p* |
|---|---|---|---|---|
| $AP_{imaging}$ (cm) | 1.76 (1.58–1.97) | **< 0.001** | 1.11 (0.78–1.58) | 0.77 |
| $TV_{imaging}$ (cm) | 1.69 (1.53–1.87) | **< 0.001** | 1.14 (0.85–1.54) | 0.77 |
| $SAG_{imaging}$ (cm) | 1.42 (1.33–1.51) | **< 0.001** | 0.82 (0.65–1.04) | 0.28 |
| $MAX_{imaging}$ (cm) | 1.44 (1.35–1.53) | **< 0.001** | 1.51 (1.11–2.04) | **0.03** |




Maximum tumor diameter (irrespective of plane)

# Maximum tumor size measured on MRI vs. from histological specimen – same thing?



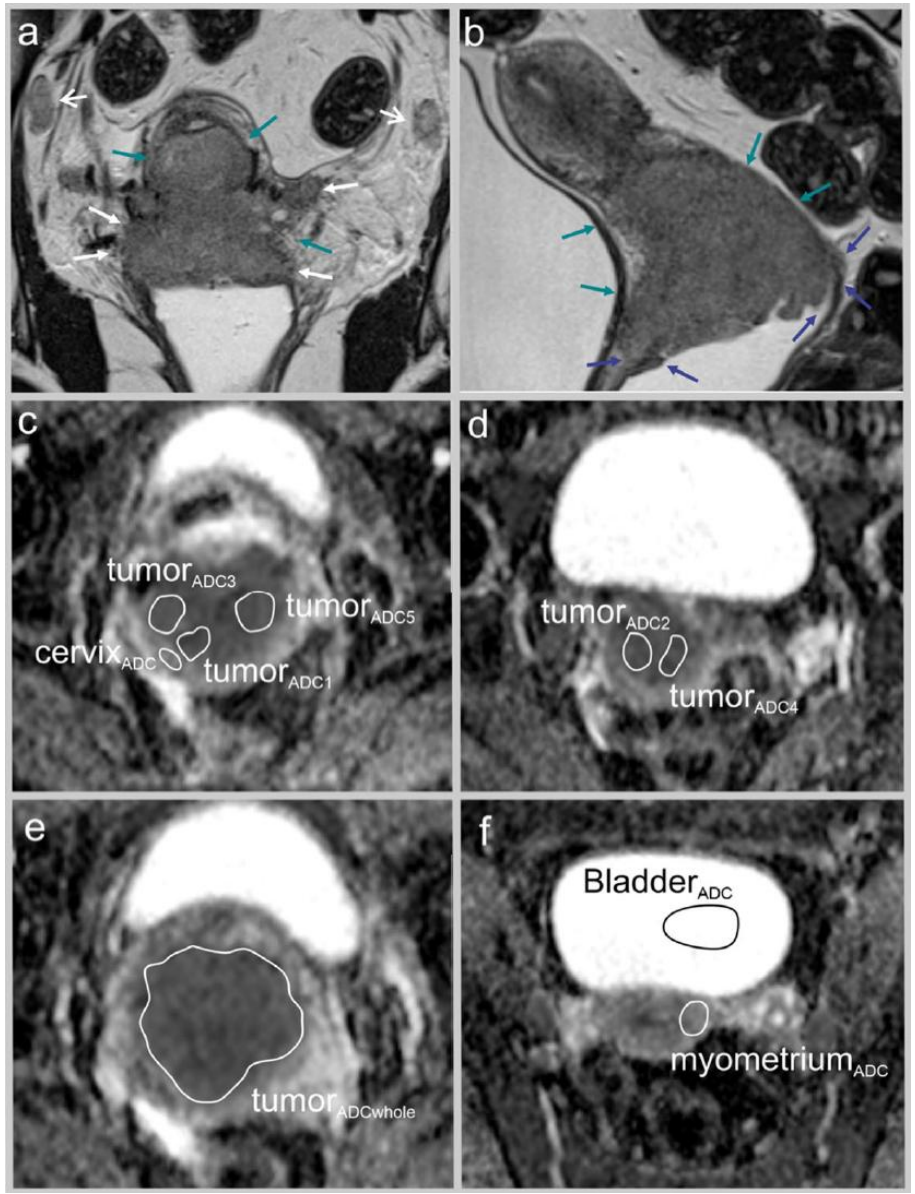

| | Mean (cm) | | | Mean difference (IQR) (cm) | | | ICC (95% CI) |
|---|---|---|---|---|---|---|---|
| | reader 1 | reader 2 | reader 3 | reader 1/2 | reader 1/3 | reader 2/3 | |
| | All patients (n=416) | | | | | | |
| $MAX_{imaging}$ | 2.9 | 2.9 | 3.0 | 0 (1.2) | 0 (1.8) | 0 (1.7) | 0.85 (0.83-0.87) |

Excellent agreement for maximum tumor size measurements at MRI (3 readers, ICC of 0.85, n=416)

Mean histological tumor size is **1.5 mm larger** than mean MRI measured max tumor size (n=212)

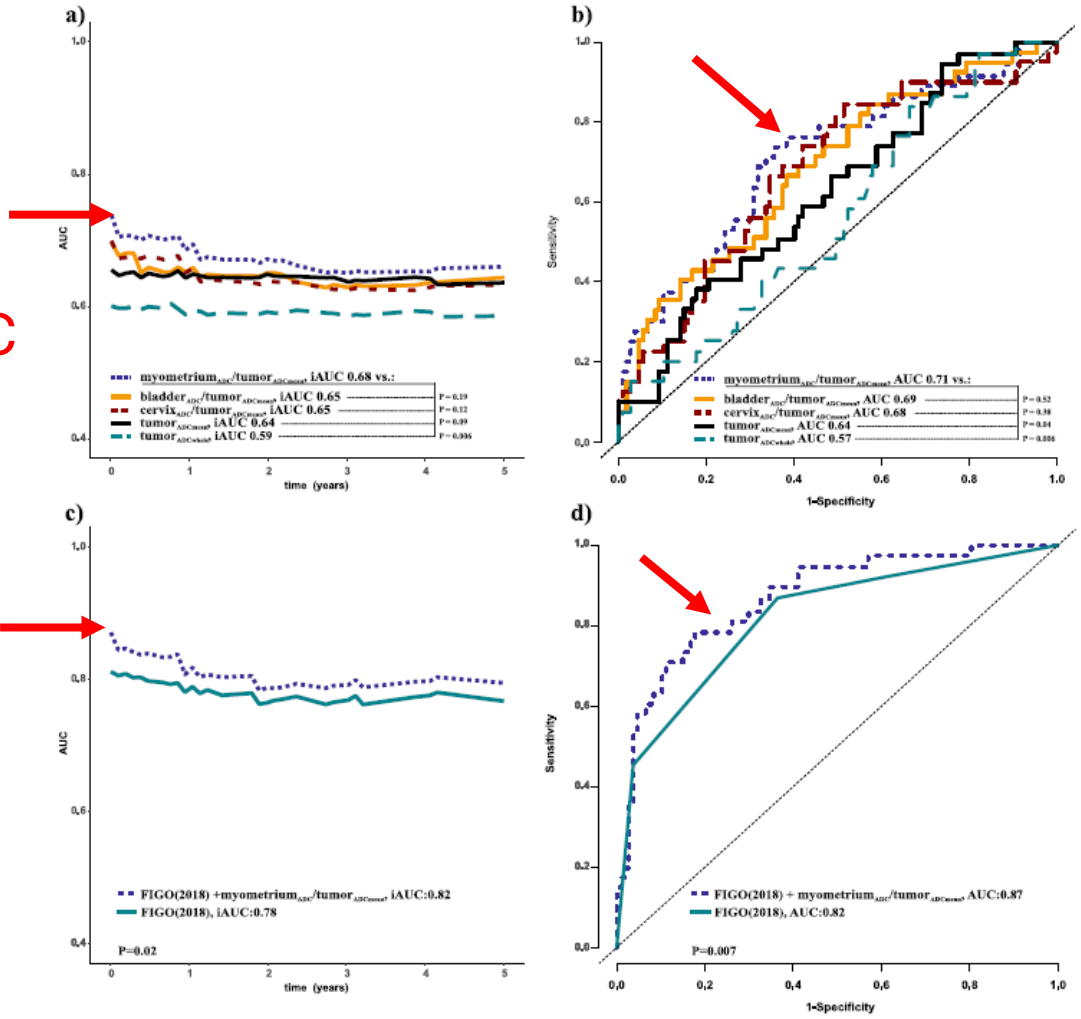
Lura et al, Insights into Imaging, 2022

# DWI and tumor ADC for better prognostication in CC?



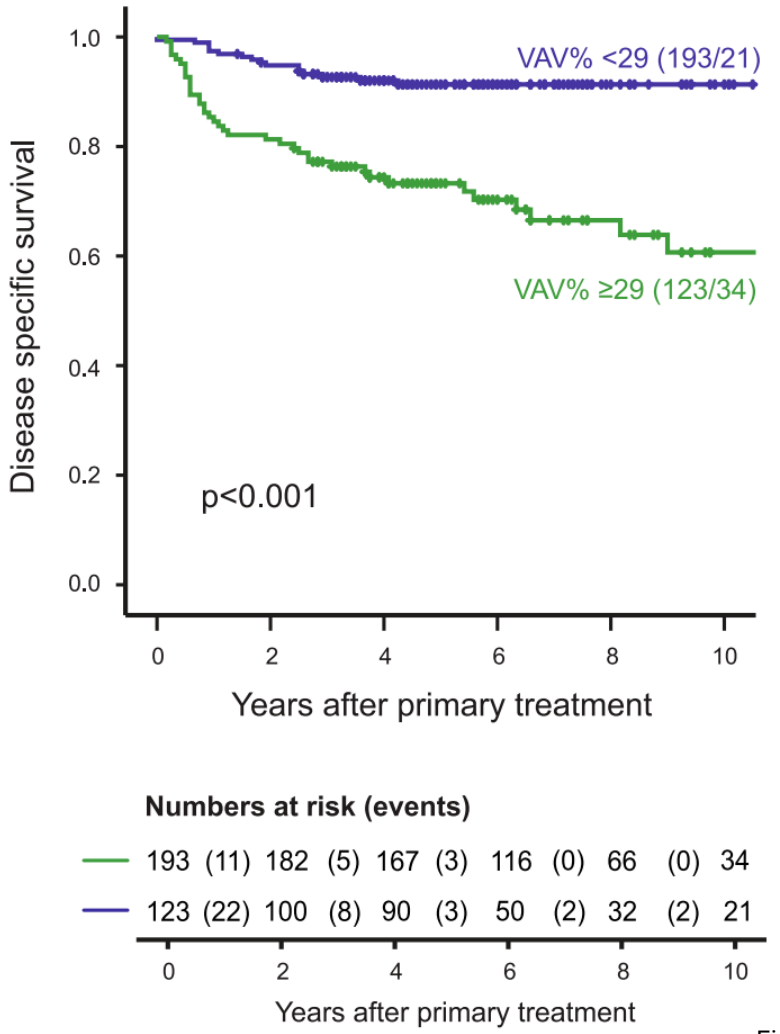

Low tumor ADC predicts reduced DSS

High ratio myometriumADC / tumorADC was most predictive of poor survival



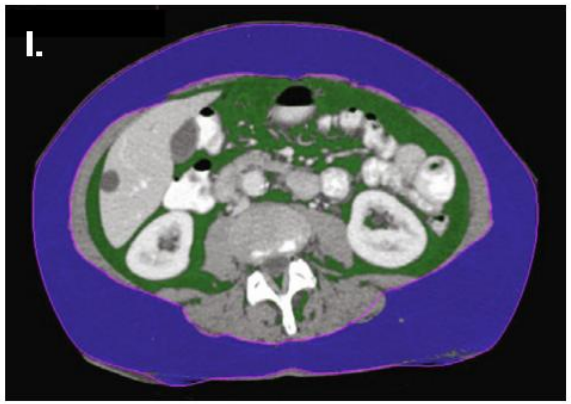

Lura et al, Cancer Imaging, 2025

# High visceral fat percentage predicts poor outcome in CC



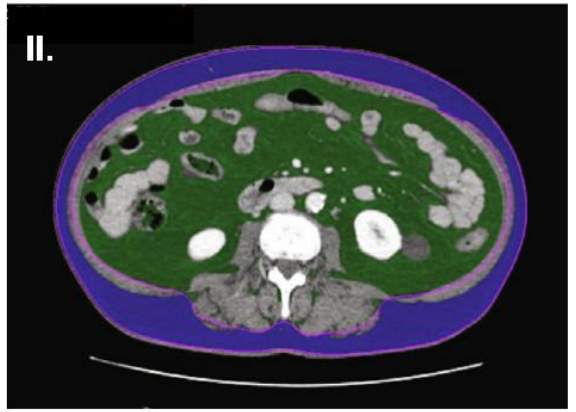

Eide et al,
Gynecologic Oncology, 2023

Low-risk body composition




BMI: 29.7 WC: 96.7 cm
VAV: 1570 $cm^3$ SAV: 5204 $cm^3$
TAV: 6774 $cm^3$ VAV%: 23

High-risk body composition

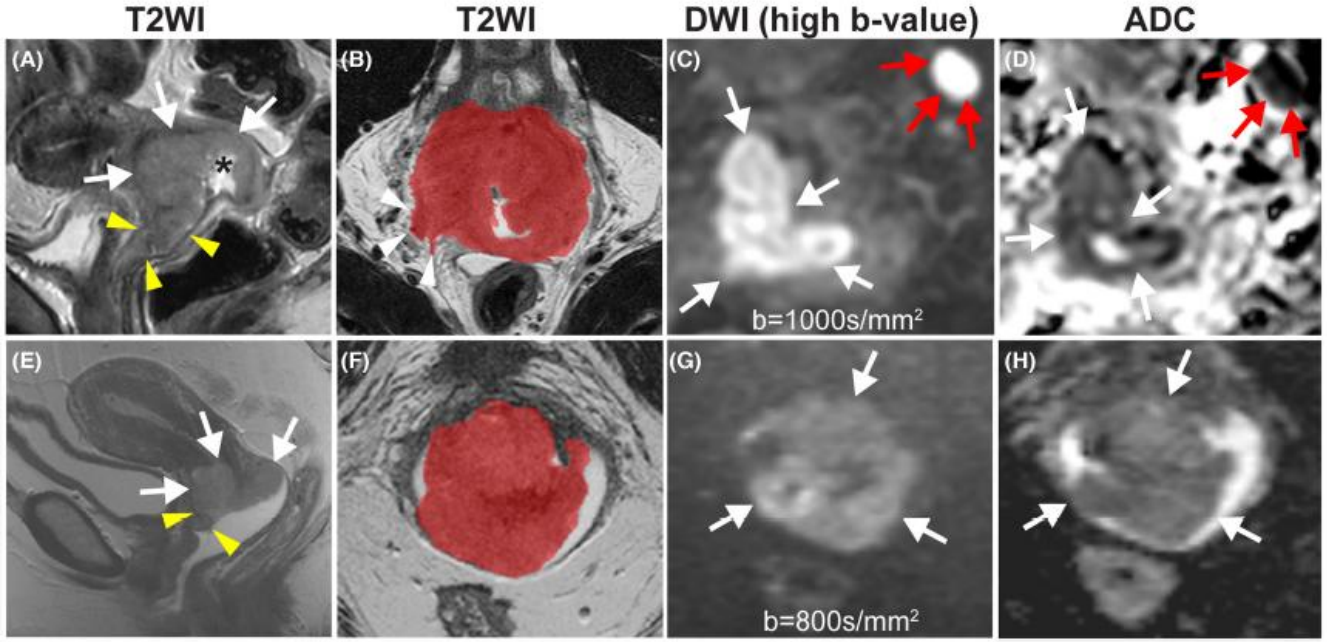


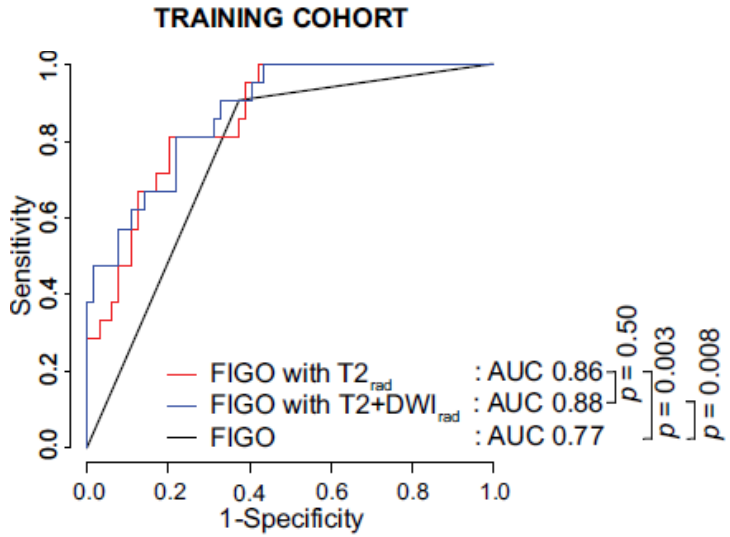

BMI: 28.7 WC: 106 cm
VAV: 3804 $cm^3$ SAV: 4956 $cm^3$
TAV: 8760 $cm^3$ VAV%: 43

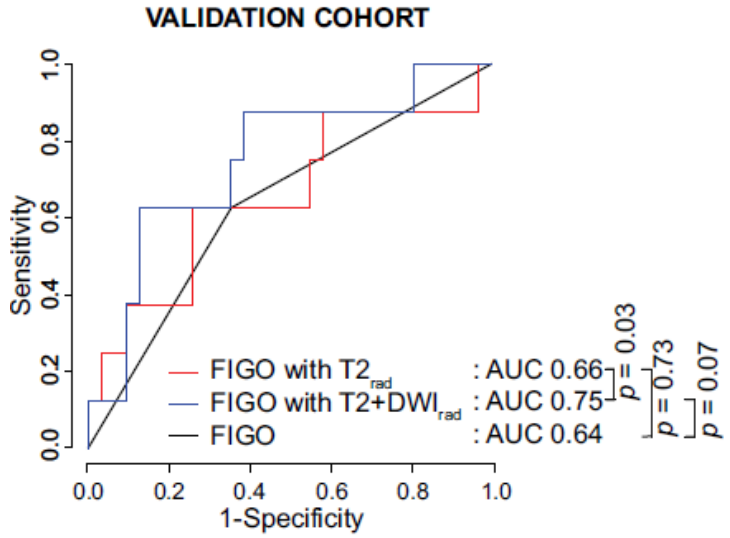
# MRI based radiomic signatures for pretreatment prognostication in CC (n=133)

48 yrs,
MRI diam 5.9 cm
↓radiomic scores,
alive 5.5 yrs

47 yrs,
MRI diam 4.8 cm
↑radiomic scores,
dead 3.5 yrs



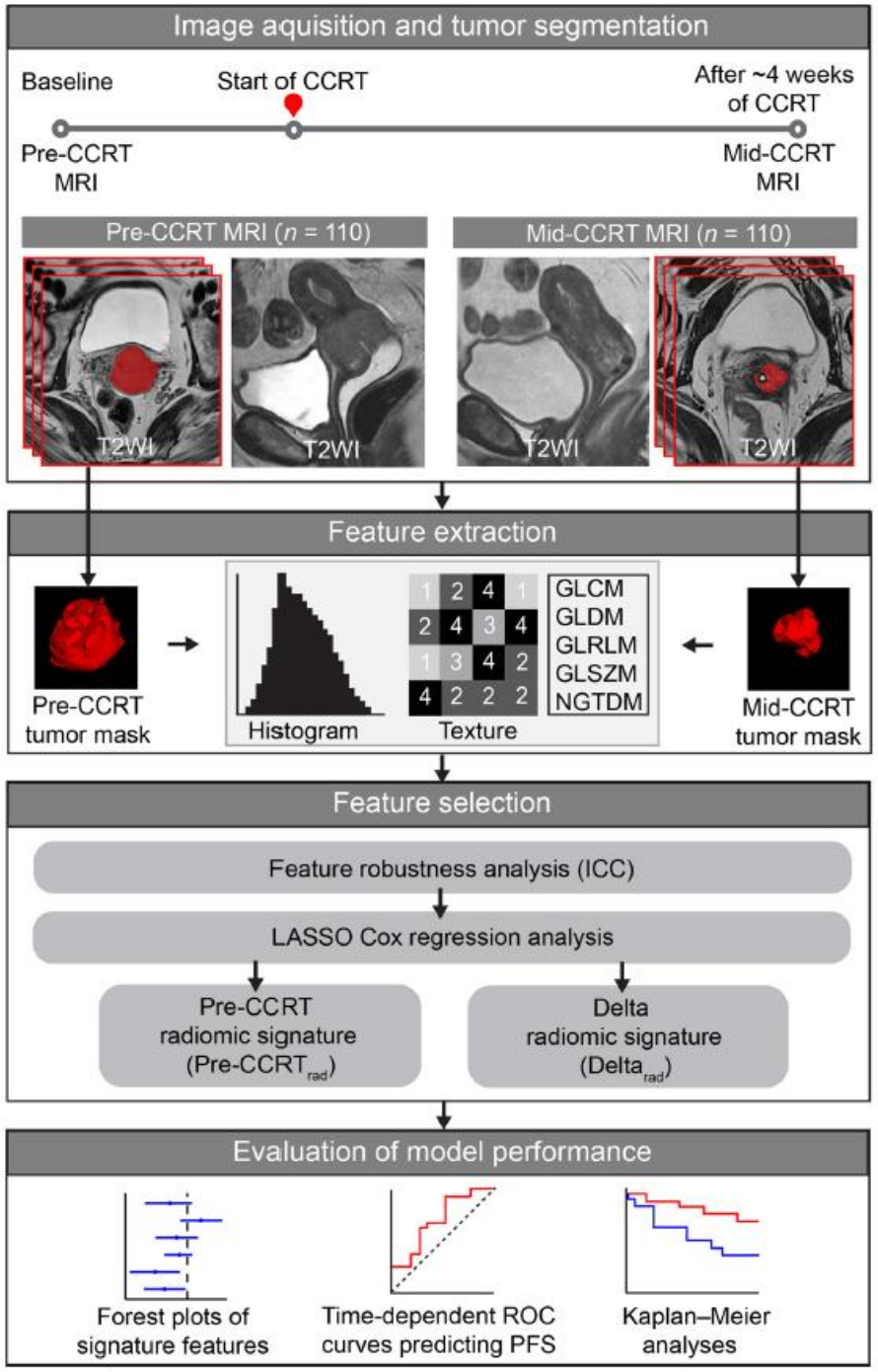



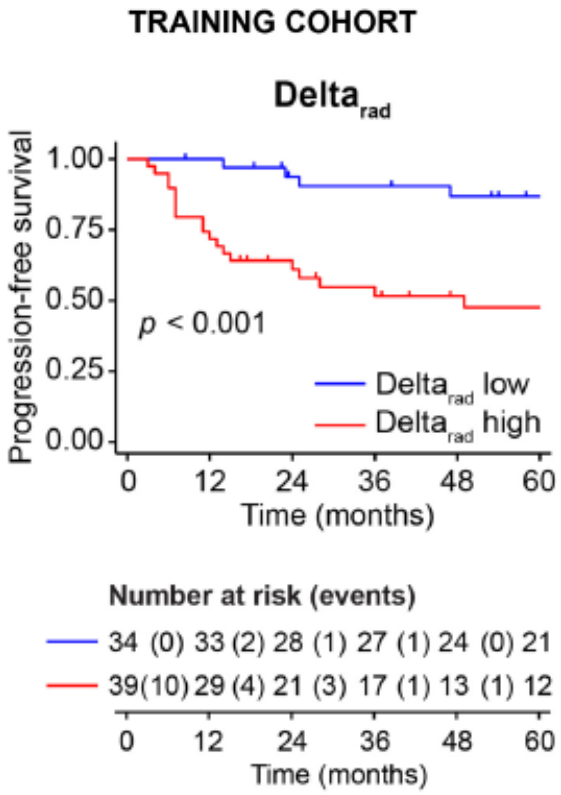



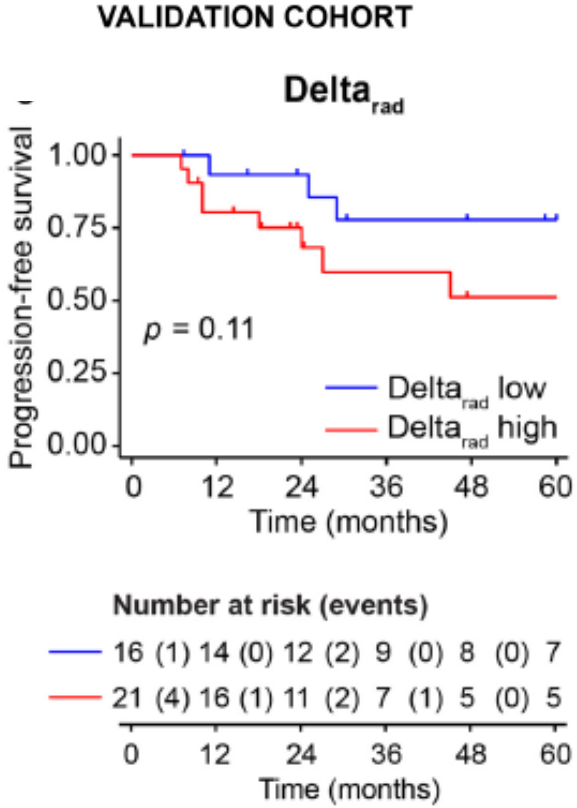

The radiomic signatures T2rad and T2 + DWIrad yielded AUCT/AUCV of 0.80/0.62 and 0.81/0.75, respectively, for predicting 5-year DSS.

Wagner-Larsen et al, Cancer Medicine, 2023

# MRI delta radiomics during chemoradiotherapy for prognostication



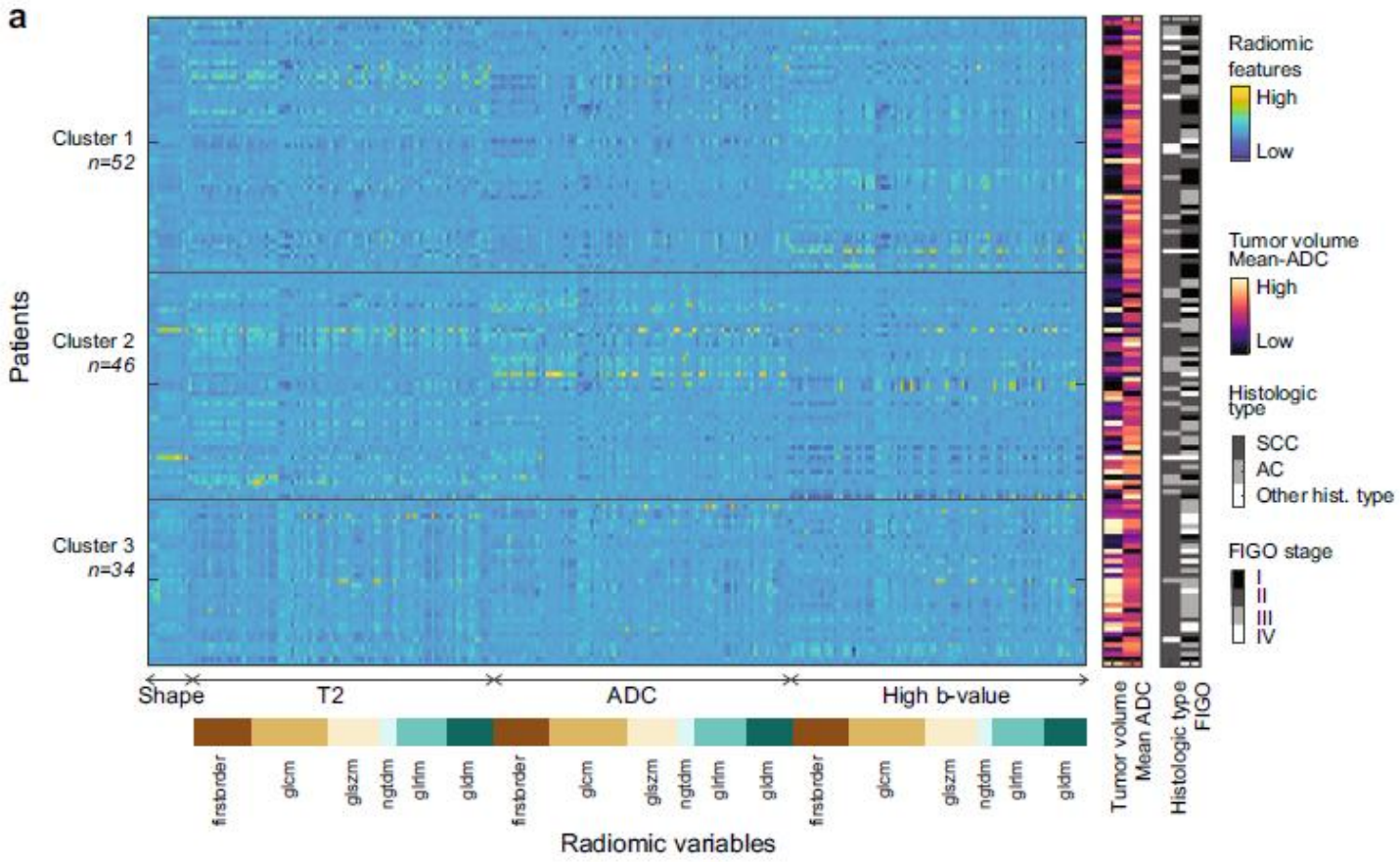



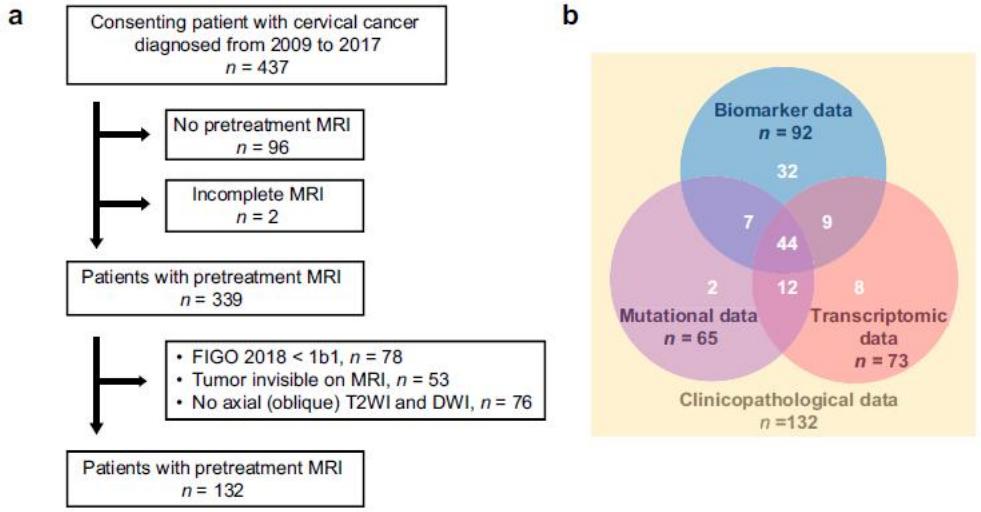



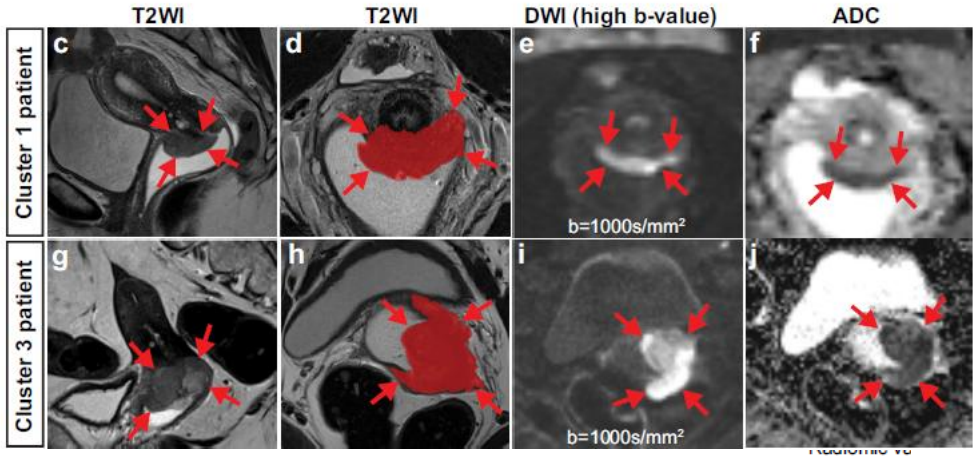

Delta- and pretreatment radiomic signatures equally allow early prognostication in LACC, outperforming FIGO stage and MRI-assessed maximum tumor diameter

Wagner-Larsen et al, BMC Cancer, 2025

# MRI radiomic profiles reveal targets for therapy in CC

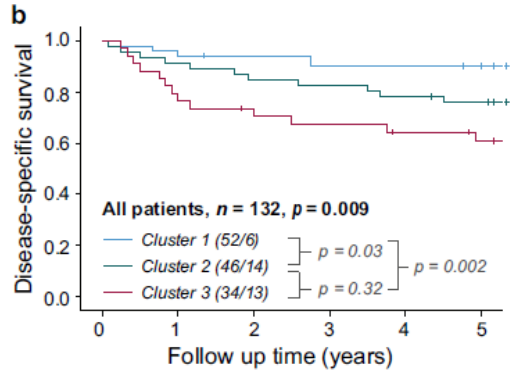



**Putative treatment targets (e.g. immunotherapy, CDK4/6 and YAP-TEAD inhibitors and p53 pathway) for different patient clusters**

Radiomic clusters predict DSS



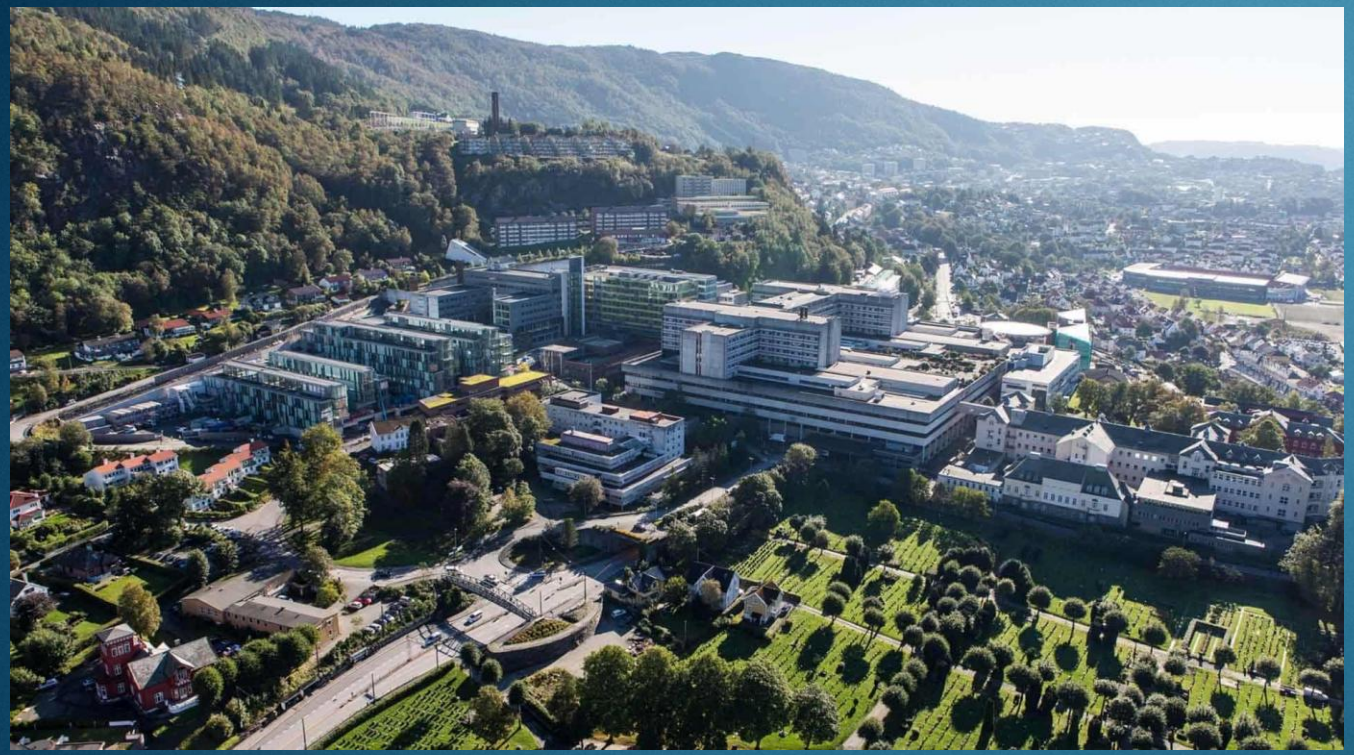

Halle et al, Scientific Reports, 2024

# Cervical Cancer Summary

- Pretreatment imaging is recommended, and imaging findings are incorporated into FIGO (2018) stage assignment:
  - MRI (or ultrasound) for local staging
  - CT or PET/CT for detecting lymph node metastases or distant spread
- Characteristic imaging findings yield high accuracy for central staging parameters, predict outcome and detect recurrence
- Novel imaging techniques e.g. radiomics and radiogenomics may improve staging accuracies, prognostication and reveal targets for treatment
- Radiomics and radiogenomics: although promising – role not yet defined

Funded by:
Trond Mohn Foundation
Haukeland University Hospital
University of Bergen
Western Norway Regional Health Authority
The Research Council of Norway

Bergen Cancer Imaging Research Group and Bergen Gynecologic Cancer Research Group



Haukeland University Hospital, Bergen, Norway

**Ingfrid H. S. Haldorsen**
Professor in Radiology at the University of Bergen, Norway
Director at Dep. of Radiology at Haukeland University Hospital, Bergen, Norway
ingfrid.haldorsen@helse-bergen.no

# Progress in Radiology 2018 – sweet memories from Bergen – nice to meet again. ☺

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