

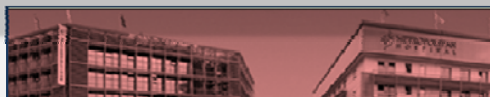


BrachyNext Symposium  
Miami Beach, USA, May 30 - 31, 2014

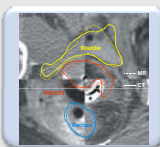


## Imaging Modalities: Current Challenges and Future Directions

Johannes C. Athanasios Dimopoulos



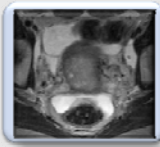
## Imaging Modalities: Current Challenges and Future Directions



WHICH MODALITIES ARE AVAILABLE?  
(CHALLENGES AND FUTURE PERSPECTIVES)



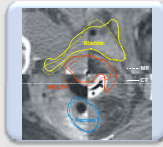
WHAT ARE THE STEPS WHICH CAN BE  
GUIDED BY IMAGES?



WHAT IS THE VALUE OF EACH MODALITY  
FOR EACH STEP?  
(CHALLENGES AND FUTURE PERSPECTIVES)



## Imaging Modalities: Current Challenges and Future Directions



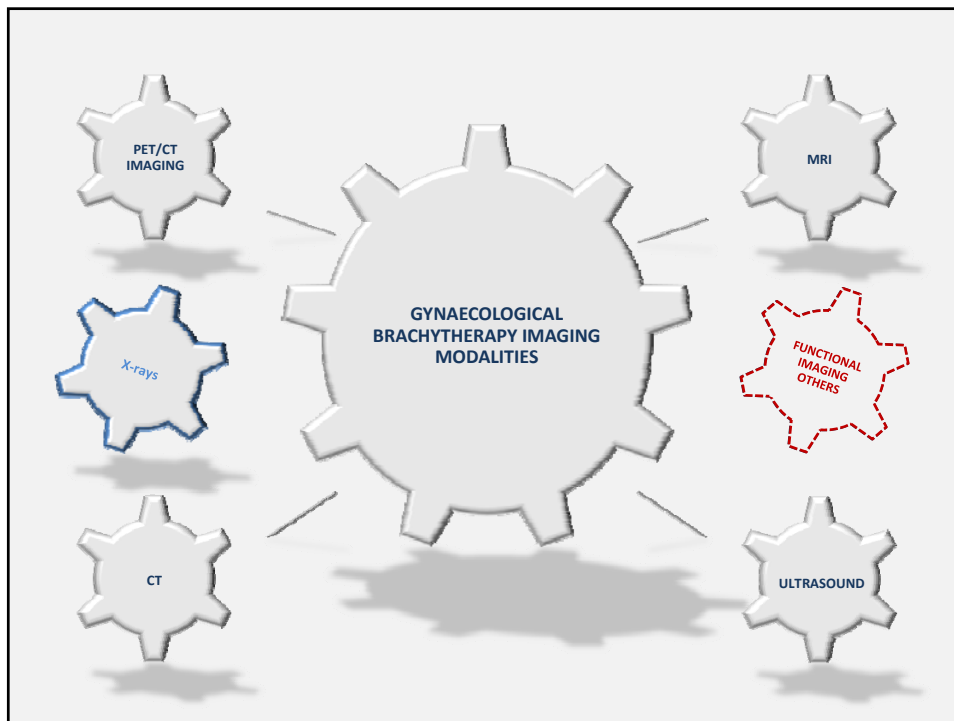
**WHICH MODALITIES ARE AVAILABLE?  
(CHALLENGES AND FUTURE PERSPECTIVES)**



**WHAT ARE THE STEPS WHICH CAN BE  
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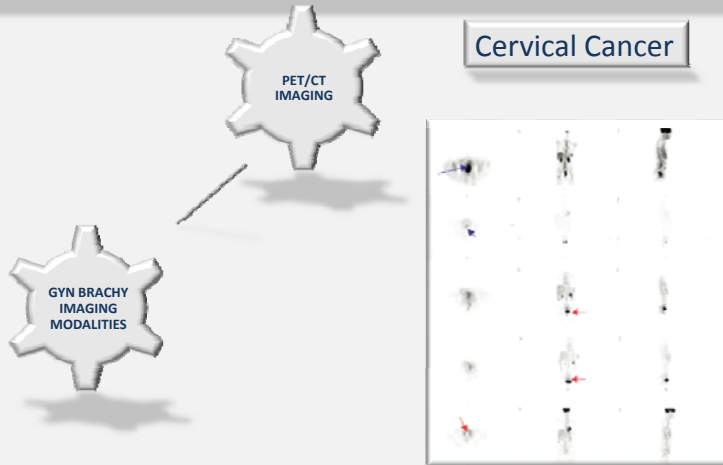


**WHAT IS THE VALUE OF EACH MODALITY  
FOR EACH STEP?  
(CHALLENGES AND FUTURE PERSPECTIVES)**





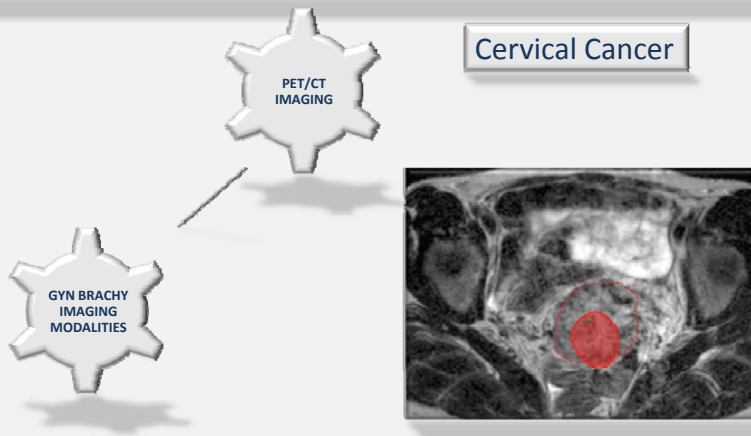
## ROLE OF IMAGING MODALITIES GYNAECOLOGICAL BRACHYTHERAPY – PET/CT



*PET-guided assessment of tumor regression*

Lin et al. *Int J Radiat Oncol Biol Phys* 2006; 65(1):177-81

## ROLE OF IMAGING MODALITIES GYNAECOLOGICAL BRACHYTHERAPY – PET/CT

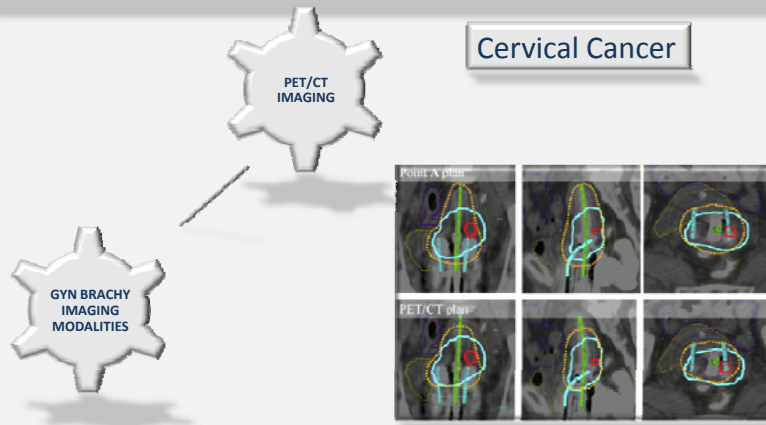


*PET-guided assessment of tumor regression  
Correlation with MRI  
PET/CT volumes of target < MRI volumes*

Ma D et al. *Radiother Oncol* 2011; 98(1):139-42



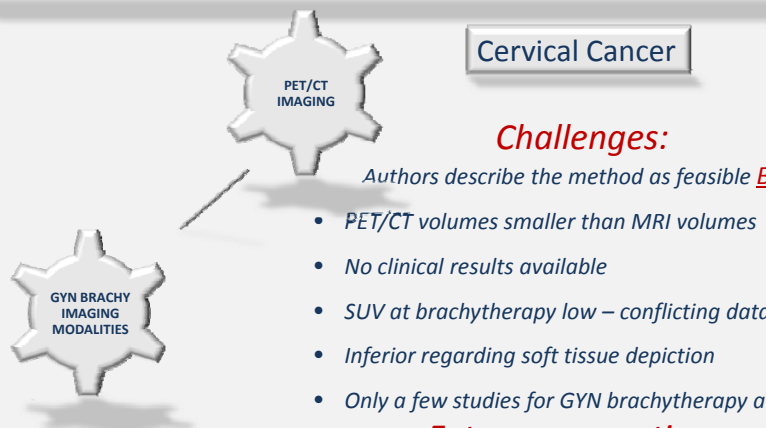
## ROLE OF IMAGING MODALITIES GYNAECOLOGICAL BRACHYTHERAPY – PET/CT



**PET/CT-guided cervix brachytherapy treatment planning**  
Only some studies available – patient numbers low

Malyapa et al. *IJROP* 2002; 54: 1140–1146  
Lin et al. *IJROBP* 2007; 65: 177–181  
Nam et al. *IJROBP* 2012;84(1):e29-34

## ROLE OF IMAGING MODALITIES GYNAECOLOGICAL BRACHYTHERAPY – PET/CT



### Challenges:

Authors describe the method as feasible **BUT**

- PET/CT volumes smaller than MRI volumes
- No clinical results available
- SUV at brachytherapy low – conflicting data
- Inferior regarding soft tissue depiction
- Only a few studies for GYN brachytherapy available

### Future perspectives:

- Validation of Method?
- PET/MRI – not likely to replace PET/CT

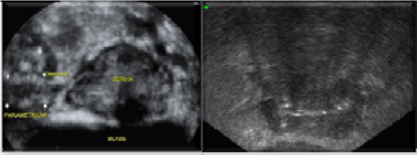


### ROLE OF IMAGING MODALITIES GYNAECOLOGICAL BRACHYTHERAPY – US

Cervical Cancer

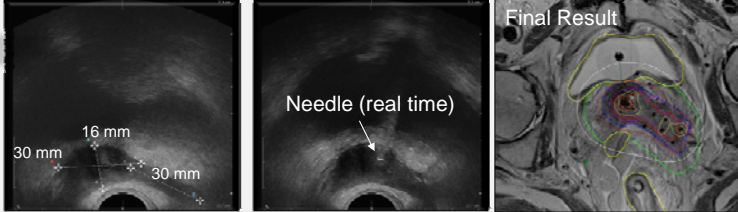
US

GYN BRACHY IMAGING MODALITIES



- Gynecology: important for initial tumor detection
- Major improvements in technology, real time guidance for BT

Final Result



Source: Institute of Oncology Lubiana

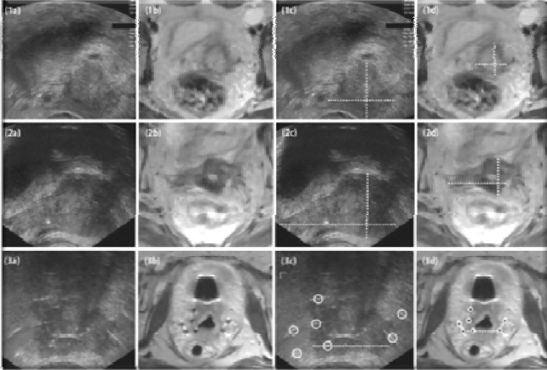
T2W FSE MRI (same patient)

### ROLE OF IMAGING MODALITIES GYNAECOLOGICAL BRACHYTHERAPY – US

Cervical Cancer

US

GYN BRACHY IMAGING MODALITIES

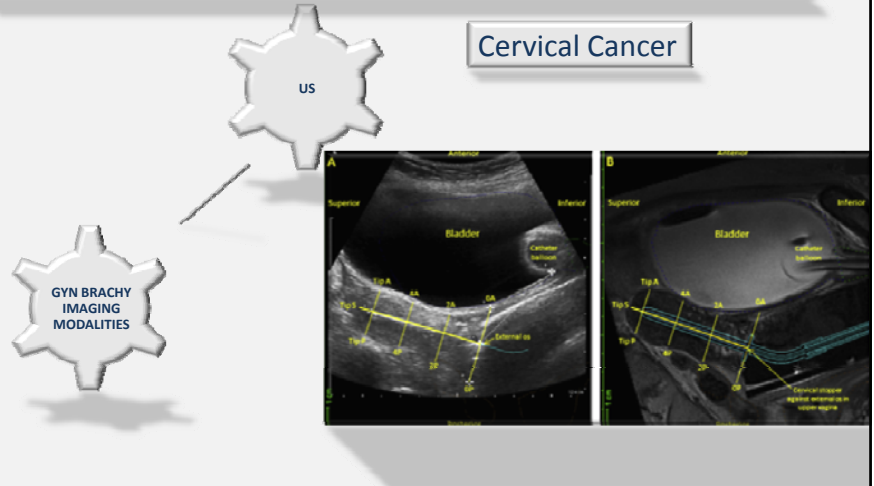


- Good correlation between US and MRI

Schmid et al. Strahlenther Onkol 2013



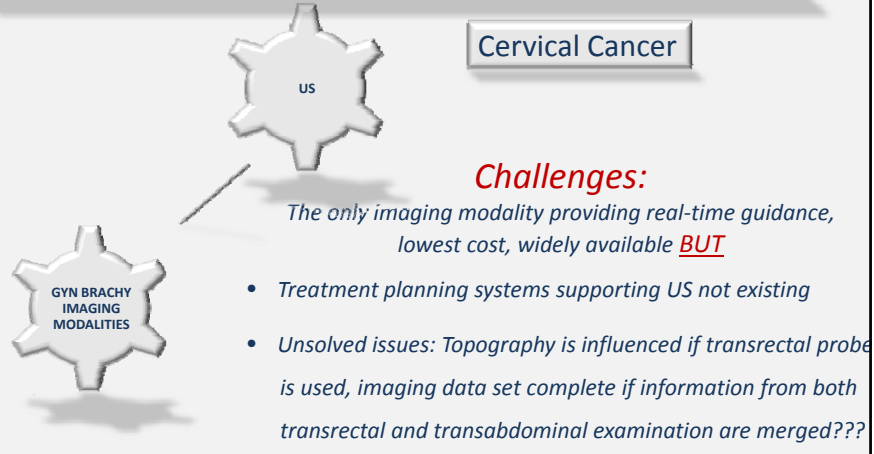
## ROLE OF IMAGING MODALITIES GYNAECOLOGICAL BRACHYTHERAPY – US



•Good correlation between US and MRI

van Dyk et al. IJROBP 2014; 88(4): 860-5.

## ROLE OF IMAGING MODALITIES GYNAECOLOGICAL BRACHYTHERAPY – US

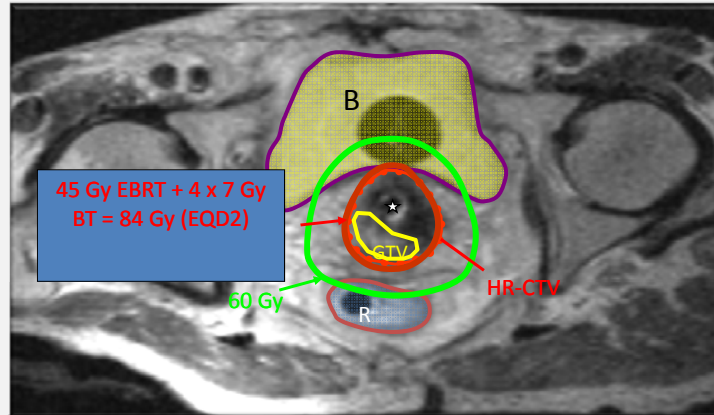


**Future perspectives:**  
Development of systematic method is ongoing!!!!



## ROLE OF IMAGING MODALITIES GYNAECOLOGICAL BRACHYTHERAPY – MRI

*Gold Standard for Image-Guidance  
of cervical cancer brachytherapy*



## ROLE OF IMAGING MODALITIES - MRI GEC ESTRO RECOMMENDATIONS!



Radiotherapy and Oncology 74 (2015) 235–245

RADIO THERAPY  
& ONCOLOGY  
www.elsevier.com/locate/radonc

Recommendations from Gynaecological (GYN) GEC-ESTRO Working Group<sup>3\*</sup> (I): concepts and terms in 3D image based 3D treatment planning in cervix cancer brachytherapy with emphasis on MRI assessment of GTV and CTV

Christine Haie-Meder<sup>a,d</sup>, Richard Pötter<sup>b</sup>, Erik Van Limbergen<sup>c</sup>, Edith Briot<sup>a</sup>, Marisol De Brabandere<sup>e</sup>, Johannes Dimopoulos<sup>b</sup>, Isabelle Dumas<sup>a</sup>, Taran Paulsen Hellebust<sup>d</sup>, Christian Kirisits<sup>b</sup>, Stefan Lang<sup>a</sup>, Sabine Muschitz<sup>b</sup>, Juliana Nevinson<sup>a</sup>, An Nulens<sup>c</sup>, Peter Petrow<sup>f</sup>, Natascha Wachter-Gerstner<sup>b</sup>

### ESTRO project

Recommendations from gynaecological (GYN) GEC ESTRO working group (II): Concepts and terms in 3D image-based treatment planning in cervix cancer brachytherapy—3D dose volume parameters and aspects of 3D image-based anatomy, radiation physics, radiobiology

Rikhard Pötter<sup>a,\*</sup>, Christine Haie-Meder<sup>b</sup>, Erik Van Limbergen<sup>c</sup>, Isabelle Barillot<sup>d</sup>, Marisol De Brabandere<sup>e</sup>, Johannes Dimopoulos<sup>b</sup>, Isabelle Dumas<sup>b</sup>, Beth Erickson<sup>a</sup>, Stefan Lang<sup>a</sup>, An Nulens<sup>c</sup>, Peter Petrow<sup>f</sup>, Jason Rownd<sup>f</sup>, Christian Kirisits<sup>a</sup>



## ROLE OF IMAGING MODALITIES GYNAECOLOGICAL BRACHYTHERAPY – MRI

Cervical Cancer

	Pre-B1 MRI examination	1 <sup>st</sup> week B1 MRI	B1 MRI examination
	a)	d)	g)
	b)	e)	h)
	c)	f)	i)

Recommendations from Gynaecological (GYN) GEC-ESTRO Working Group (IV):  
Basic principles and parameters for MR imaging within the frame of image based adaptive cervix cancer brachytherapy

Johannes C.A. Dimopoulos<sup>1</sup>, Peter Petrow<sup>2</sup>, Kari Tanderup<sup>3</sup>, Primoz Petric<sup>4</sup>, Daniel Berger<sup>5</sup>, Christian Kirisits<sup>6</sup>, Erik M. Pedersen<sup>7</sup>, Erik van Limbergen<sup>8</sup>, Christine Haie-Meder<sup>9</sup>, Richard Potter<sup>10</sup>

<sup>1</sup>Marousi Hospital, Athens, Greece; <sup>2</sup>Hatzidimitriou, Paris, France; <sup>3</sup>Aarhus University Hospital, Denmark; <sup>4</sup>Institute of Oncology Ljubljana, Slovenia; <sup>5</sup>Comprehensive Cancer Center Medical University of Vienna, Austria; <sup>6</sup>Universitätsklinikum Carl-Neuberg, Leipzig, Germany; <sup>7</sup>Institut Gustave Roussy, Villejuif, France

**DIMOPOULOS et al. Radiother Oncol 2012; 103(1):113-22**

## ROLE OF IMAGING MODALITIES GYN BRACHYTHERAPY – ADVANCED MRI

Cervical Cancer

ADVANCED MRI

Is there room for improvement?





**ROLE OF IMAGING MODALITIES  
GYN BRACHYTHERAPY – ADVANCED MRI**

**Cervical Cancer**

**3.0T versus 1.5T MRI**- image quality and contrast of zonal anatomy and cervical structure superior on 3.0T

*Kataoka et al. J MAGN RES IMAG 2007; 25: 527-534.*

**ROLE OF IMAGING MODALITIES  
GYN BRACHYTHERAPY – ADVANCED MRI**

**Cervical Cancer**

**3.0T MRI interobserver Study**  
2D versus 3D T2 weighted Imaging  
2D superior due to less motion artefacts  
Less scanning time

*Dempsey et al. J Contemp Brachytherapy 2014; 6(1): 3-9*



## ROLE OF IMAGING MODALITIES GYN BRACHYTHERAPY – ADVANCED MRI

MRI

Cervical Cancer

GYN BRACHY  
IMAGING  
MODALITIES

A Before EBRT    B After EBRT    C After HDR Fx #1  
D After HDR Fx #2    E After HDR Fx #3    F After HDR Fx #4

**3.0T MRI** Interobserver Study and assessment of tumor regression

*Sun et al. Pract Radiat Oncol 2012; 2: e101–e106*

## ROLE OF IMAGING MODALITIES GYN BRACHYTHERAPY – ADVANCED MRI

Diffusion

SD	1.27
Max	1.23
Min	1.17
SD	0.10

Diffusion

Perfusion DCE

Perfusion DCE

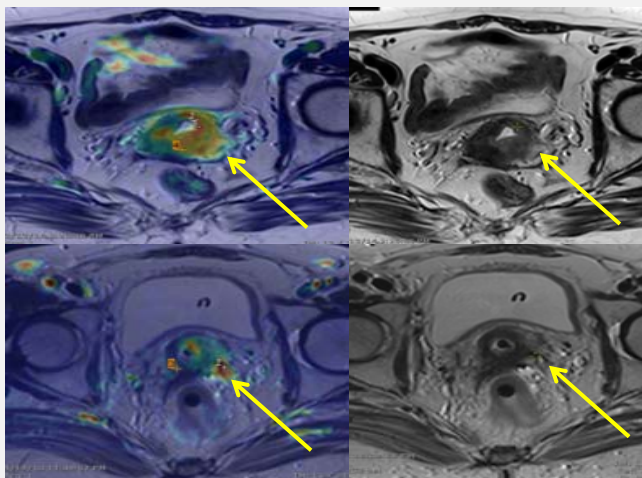
T2 weighted images

T2 weighted images

**Current investigation: Dimopoulos JCA, Varaki K et al.**



## ROLE OF IMAGING MODALITIES GYN BRACHYTHERAPY – ADVANCED MRI

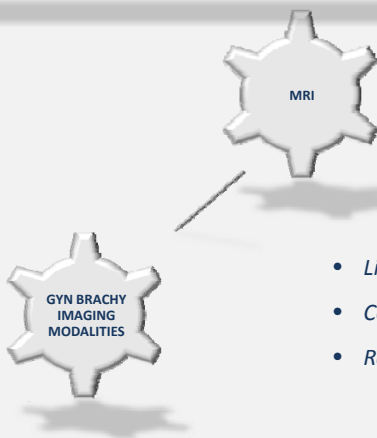


Perfusion DCE

T2 weighted images

Current investigation: Dimopoulos JCA, Varaki K et al.

## ROLE OF IMAGING MODALITIES GYNAECOLOGICAL BRACHYTHERAPY – MRI



Cervical Cancer

### Challenges:

Gold Standard **BUT**

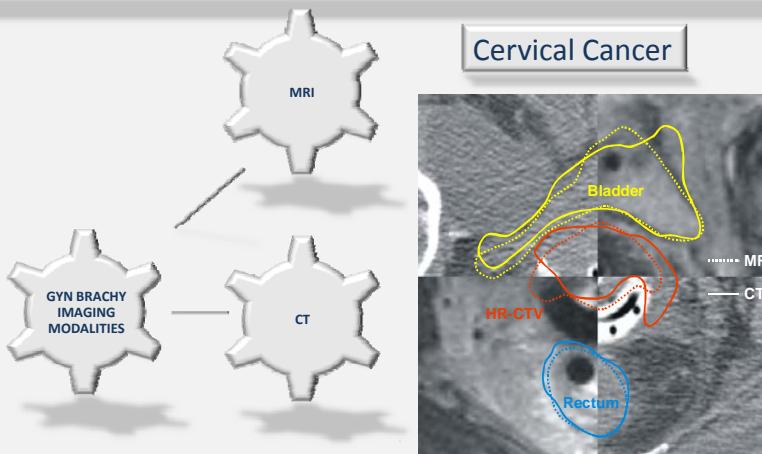
- Limited availability for brachytherapy
- Costs high
- Real time guidance of application not possible

### Future perspectives:

- 3.0T MRI for brachytherapy
- Multiparametric MRI (Diffusion, perfusion etc.)
- PET/MRI – not likely to replace PET/CT



## ROLE OF IMAGING MODALITIES GYNAECOLOGICAL BRACHYTHERAPY – MRI versus CT

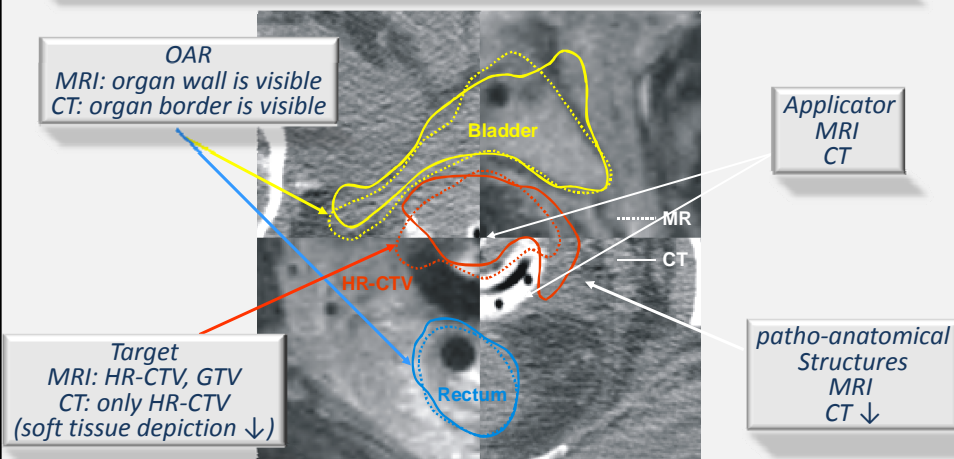


- CT inferior to MRI, but method of choice for many centers because of logistics and costs
- Data available

Viswanathan et al. Int J Rad Oncol Biol Phys 2007

## ROLE OF IMAGING MODALITIES GYNAECOLOGICAL BRACHYTHERAPY – MRI versus CT

Target, OARs, Applicator, Patho-anatomical structures



Viswanathan et al. Int J Rad Oncol Biol Phys 2007

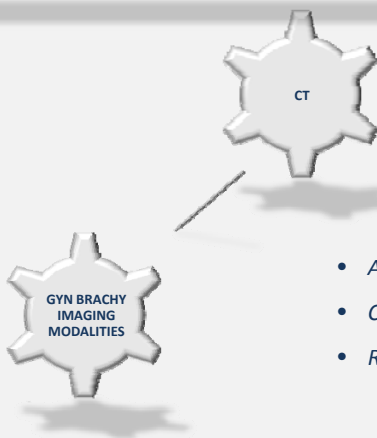


## ROLE OF IMAGING MODALITIES GYNAECOLOGICAL BRACHYTHERAPY – MRI versus CT

IGRT scans (in addition to information gained from diagnostic scans)						
Tumor regression			Organ changes			
MRI	Accurate quantitative estimation of tumor regression during the entire course of radiotherapy is possible. Distinction between macroscopic visible (residual) tumor mass(es), pathologic residual tissue including edema, inflammation, fibrosis and tumor cells ("gray zones"), and surrounding tissue possible			Reliable detection of changes in organ position and volume possible		
CT	Quantitative estimation of tumor regression not reliable. Distinction between macroscopic visible (residual) tumor mass(es), pathologic residual tissue ("gray zones"), and surrounding tissue not possible			Reliable detection of changes in organ position and size possible		
Brachytherapy scans						
Target definition	Parametrial invasion	Invasion of organs	Invasion of vagina	Applicator depiction		
MRI	Different parts of HR CTV [GTV = macroscopic tumor mass(es), ("gray zones") and cervix] are detectable	Detection of macroscopic tumor and residual pathologic tissue within the parametria possible	Detection of residual organ involvement possible	Detection of residual vaginal involvement possible	Inferior quality on T2-weighted sequences	
CT	Different parts of HR CTV are not detectable	Reliable detection of macroscopic tumor and residual pathologic tissue within the parametria not possible	Detection of residual organ involvement not always possible	Detection of residual organ involvement not always possible	Superior quality – Different parts of the applicator (e.g., source channel, wholes) are visible	

*Dimopoulos J, Fidarova E: Springer 2010  
The use of sectional imaging for image-guided radiotherapy*

## ROLE OF IMAGING MODALITIES GYNAECOLOGICAL BRACHYTHERAPY – CT



Cervical Cancer

### Challenges:

*Inferior to MRI BUT*


- Availability for brachytherapy not limited
- Costs less than for MRI
- Real time guidance of application not possible


### Future perspectives:


- Due to minor progress during last years???



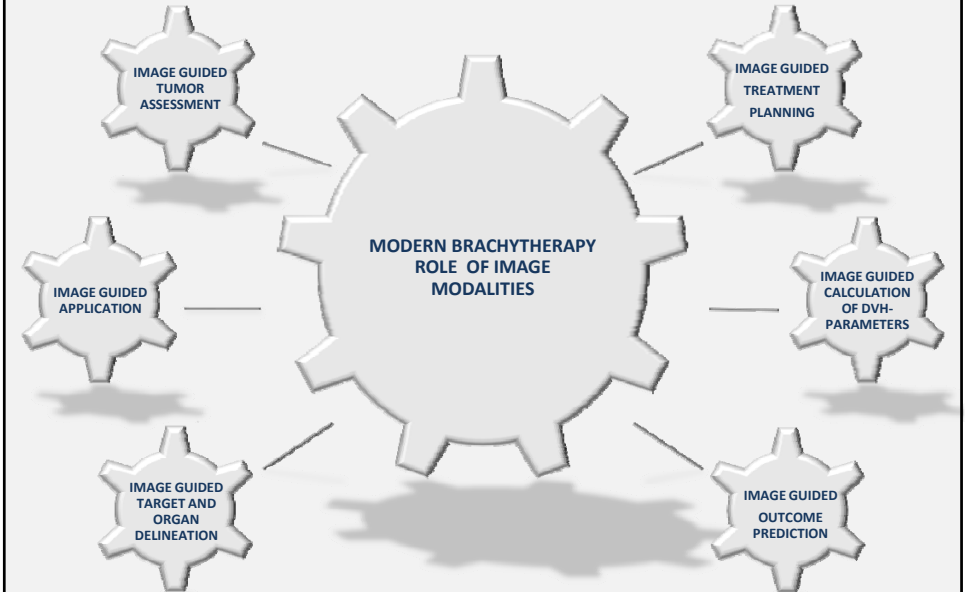
## Imaging Modalities: Current Challenges and Future Directions

 WHICH MODALITIES ARE AVAILABLE?  
(CHALLENGES AND FUTURE PERSPECTIVES)

 WHAT ARE THE STEPS WHICH CAN BE  
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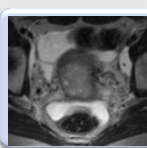
 WHAT IS THE VALUE OF EACH MODALITY  
FOR EACH STEP?  
(CHALLENGES AND FUTURE PERSPECTIVES)

## IMAGING IN GYNAECOLOGICAL BRACHYTHERAPY PROCEDURE „STEP BY STEP“

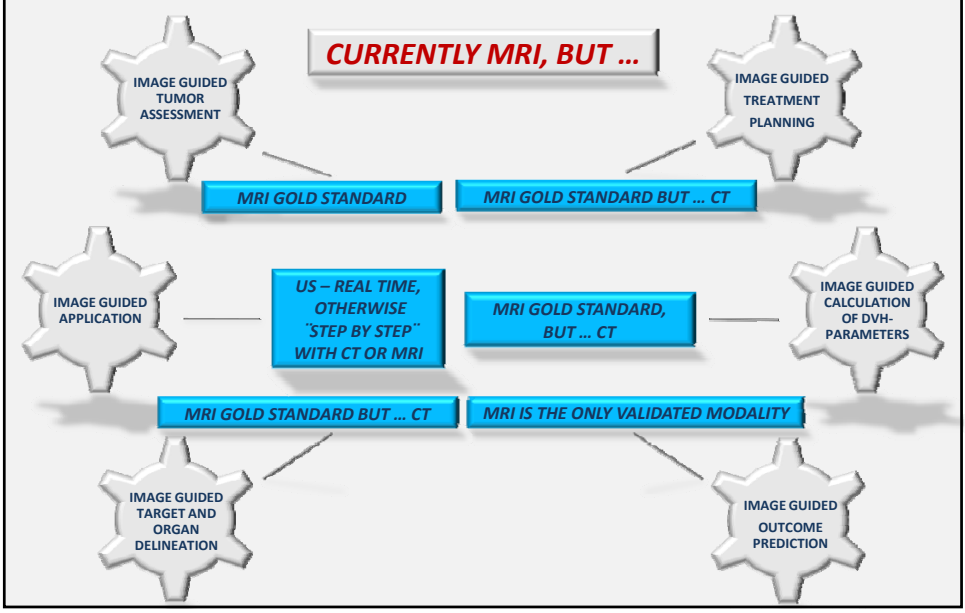


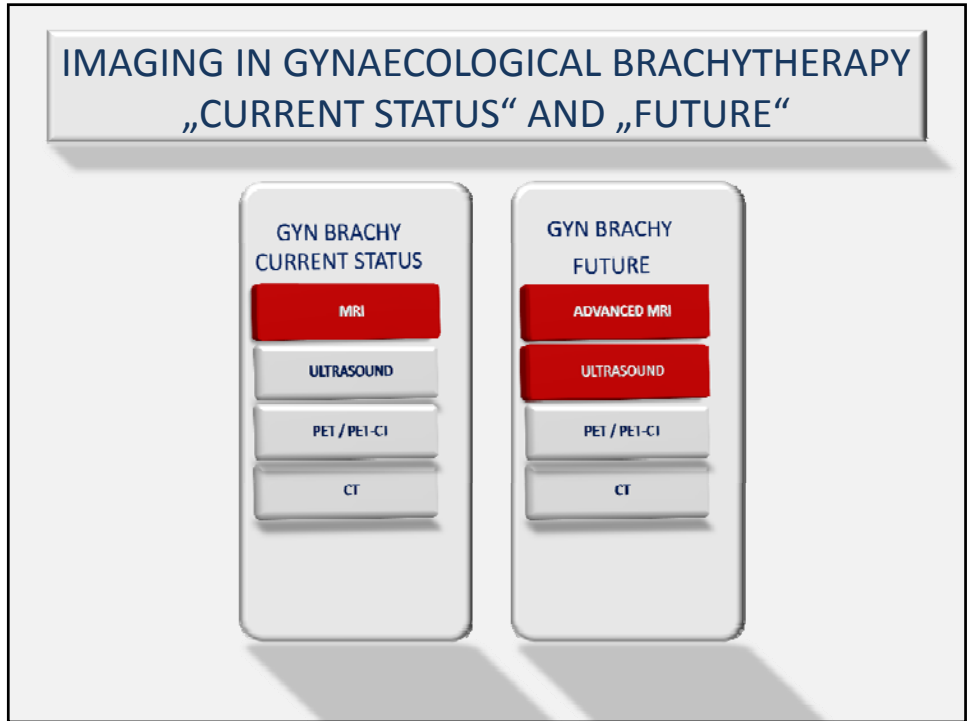
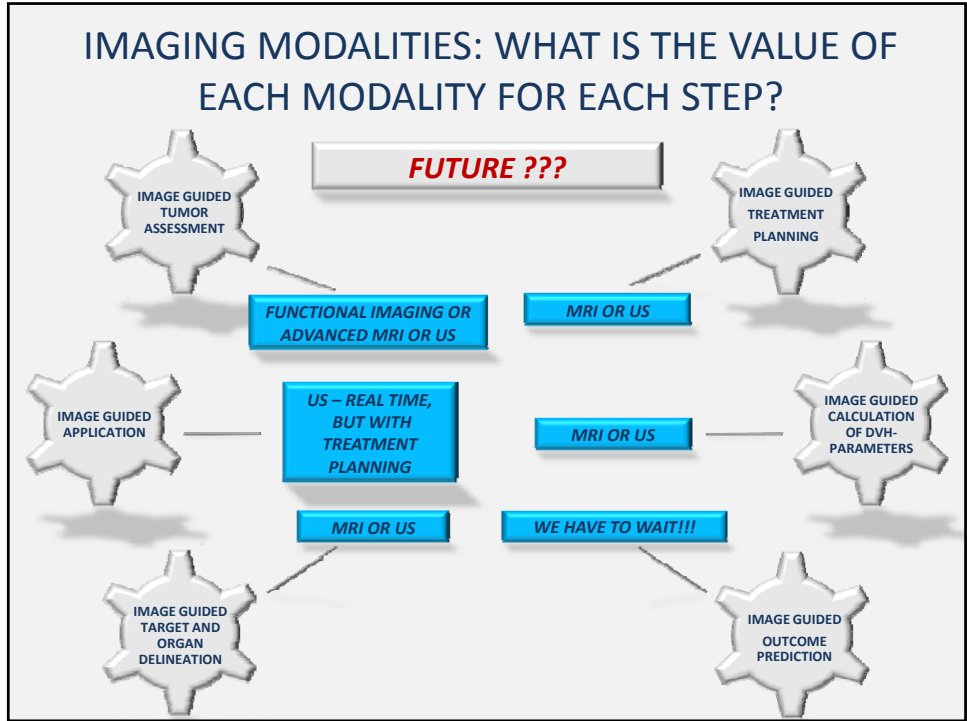


## Imaging Modalities: Current Challenges and Future Directions

-  WHICH MODALITIES ARE AVAILABLE?  
(CHALLENGES AND FUTURE PERSPECTIVES)
-  WHAT ARE THE STEPS WHICH CAN BE  
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(CHALLENGES AND FUTURE PERSPECTIVES)
-  WHAT IS THE VALUE OF EACH MODALITY  
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## IMAGING MODALITIES: WHAT IS THE VALUE OF EACH MODALITY FOR EACH STEP?



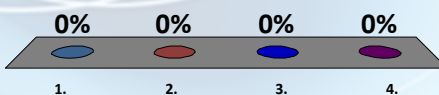






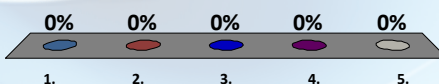
## Which answers are correct?

1. MRI provides improved target visualization compared to CT
2. MRI provides superior applicator depiction compared to CTV
3. CT provides detailed information about the target
4. CT provides information about organ walls



## Which answers are correct?

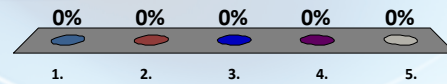
1. MRI and CT provide real time guidance during applicator insertion
2. US provides real time information during applicator insertion
3. US based treatment planning for GYN brachytherapy is enabled
4. Multi-parametric MRI (Diffusion – Perfusion) offers promising options
5. PET-CT volumes are larger than MRI volumes





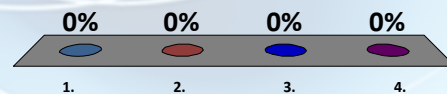
### What would be your approach for further treatment?

1. No further radiation
2. External Radiation Boost Only
3. Brachytherapy Boost
4. External Radiation Boost followed by Brachytherapy
5. Palliative treatment only



### What would be your approach to achieve the Brachytherapy Planning Objectives?

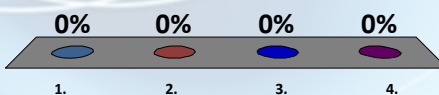
1. Intracavitary alone
2. Intracavitary + Interstitial
3. MUPIT Template Based
4. All of the Above





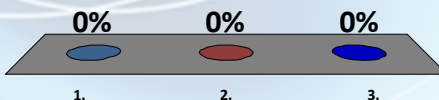
## Which Imaging Modality would you use for BT planning?

1. Orthogonal X-rays
2. CT
3. MRI
4. Ultrasound (Trans-abdominal / Trans-rectal)



## For this Locally Advanced Cervical Cancer Case, what would be your ideal choice now?

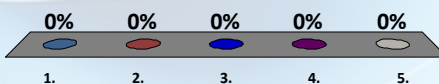
1. Orthogonal X-ray Based ICA Only
2. CT-Based MUPIT
3. MR Image Based





## What is your guess on the patient outcome at 2 years?

1. Progressive local disease / Local recurrence
2. Loco-regional Recurrence
3. Distant metastasis
4. Loco-regionally Controlled
5. Died of Other Causes



## What is your guess on the patient outcome at 2 years?

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