10. Konference radiologické fyziky, Přerov, 22. dubna 2022

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FAKULTA JADERNÁ A FYZIKÁLNĚ INŽENÝRSKÁ ČVUT V PRAZE

DOSIMETRIC COMPARISON OF VMAT, IMRT AND 3DCRT PLANS FOR LEFT-SIDED BREAST PATIENTS TREATED IN DIBH

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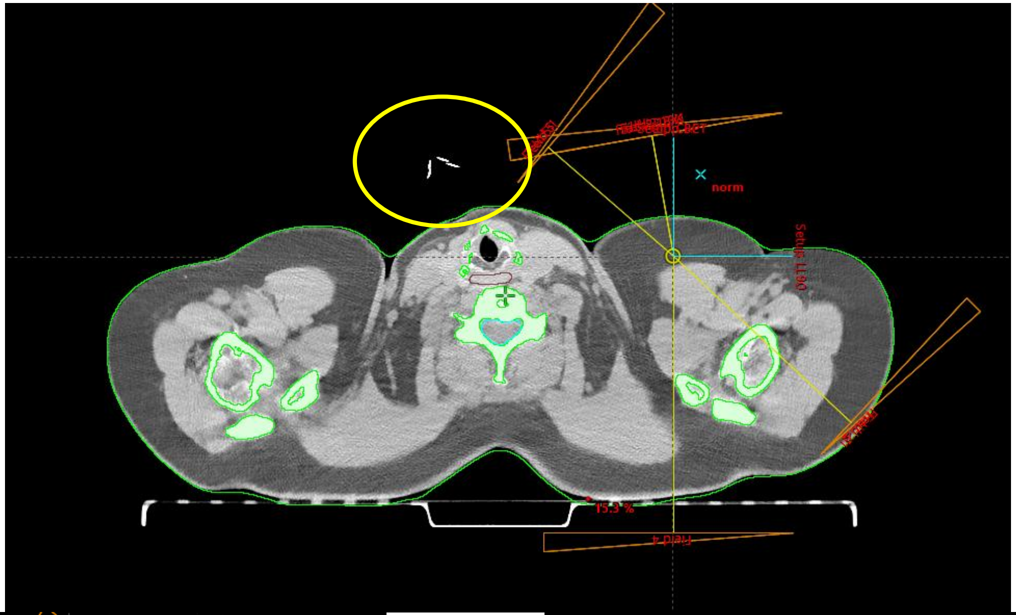
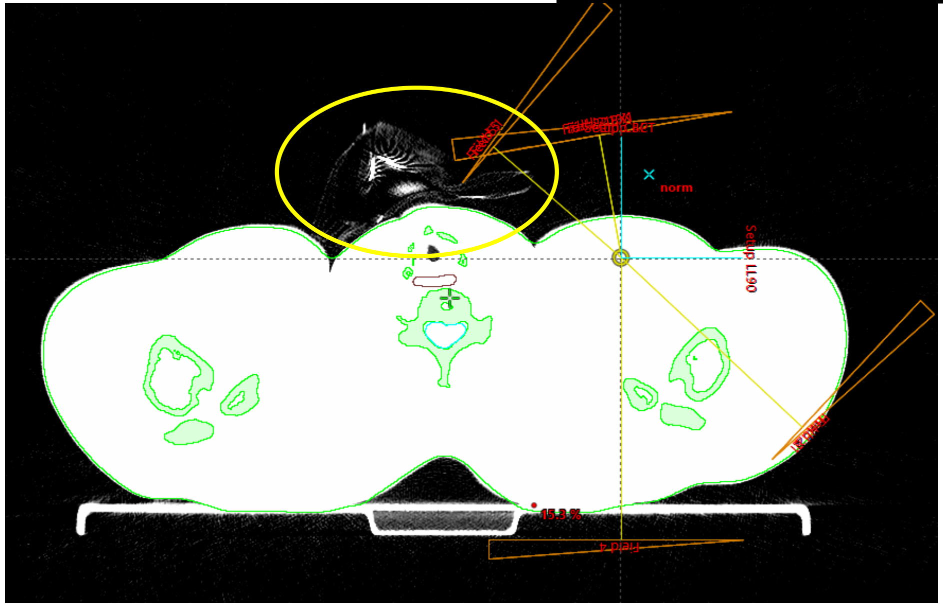
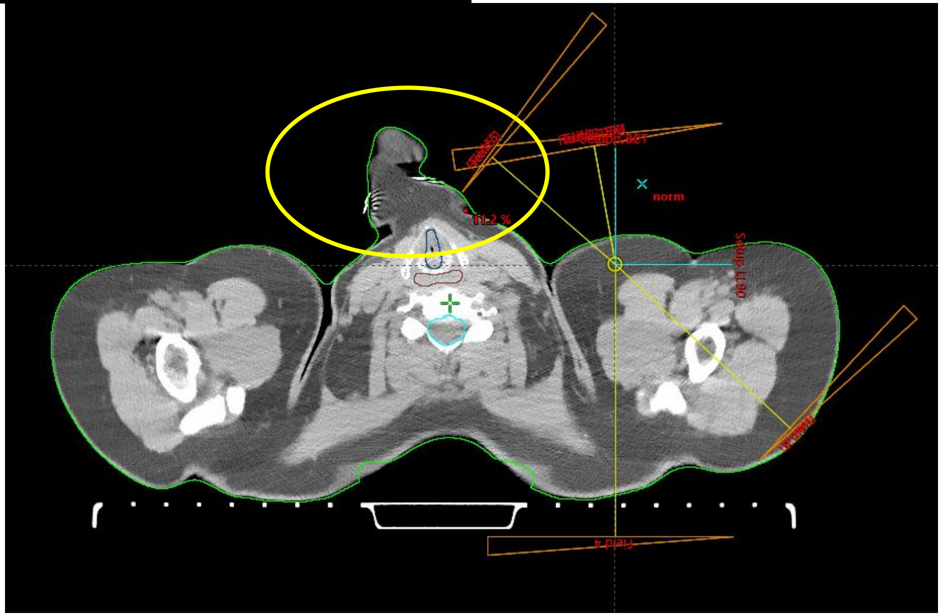
Hádanka







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Introduction

Studies have shown:

VMAT and IMRT	3DCRT
Lower dose to ipsilateral lung and heart *	Lower dose to heart (Jensen, Emel)
Better target homogeneity	Better sparing of contralateral tissues
	Lower integral dose

Depends on:

- Treatment technique
- Treatment position and fixation devices
- Gating method (*Jensen*)
- Treatment goals

Question: *What is the best technique for left-sided breast patients treated in DIBH at our hospital?*

- VMAT and gating are being established for the first time

*high dose tail, not EUD or mean dose

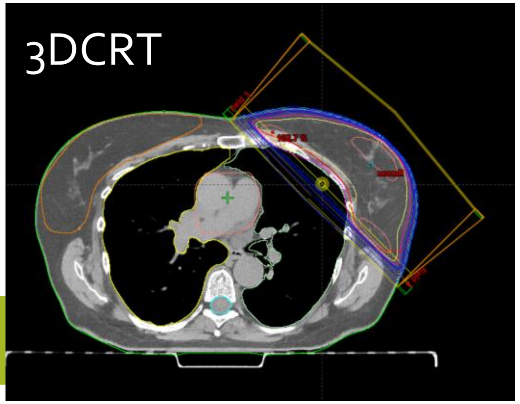
Methods

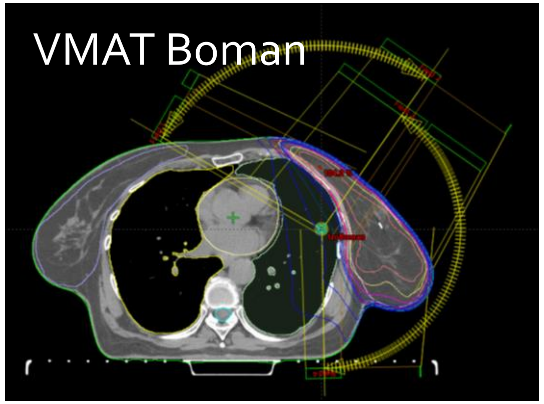
VMAT and IMRT planning techniques:

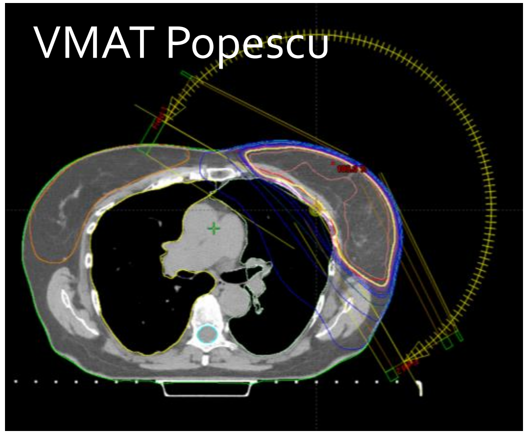
- **Boman et al.** (VMAT)
  - split dual arc 300° to 35° and 35° to 179°, coll 350° and 10°, isocenter in lung 2 cm from chest wall, 6 MV
- **Popescu et al.** (VMAT)
  - dual arc 300° to approx. 150°, coll 350° and 10°, isocenter on boundary chest wall/lung, 6 MV
- **Karpf et al.** (IMRT)
  - 6 fields (appr. 310° to 179° equidistant), coll 0°, isocenter on boundary chest wall/lung, 6 MV

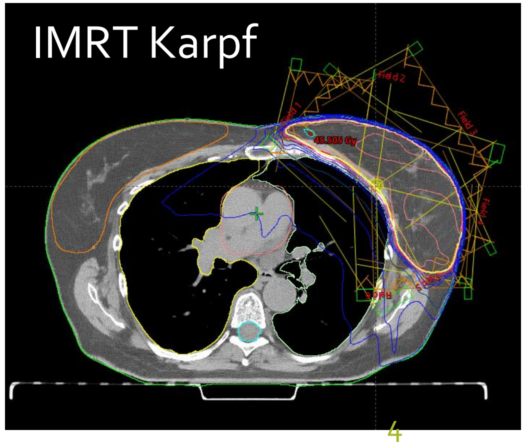
3DCRT planning technique:

- 2 tangential fields – field-in-field technique, combination of 6 MV and 18 MV, dynamic wedges
- Collimator angle adjusted to anatomy (around 90°)
- Isocenter in left lung, approx. 2 cm from chest wall









Methods

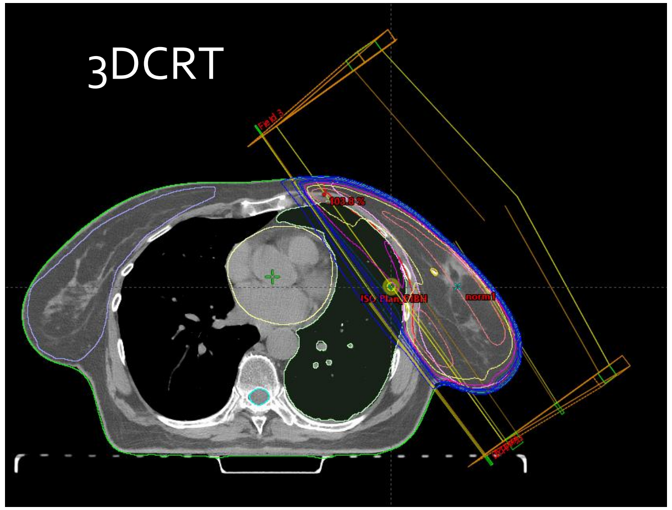
- **Patients in case study:**
  - 2 left-sided breast patients, without lymph nodes, DIBH
- **Dose prescription:**
  - 43.2 Gy in 16 fractions
- **Dose objectives** *(not the same as optimization contraints):*

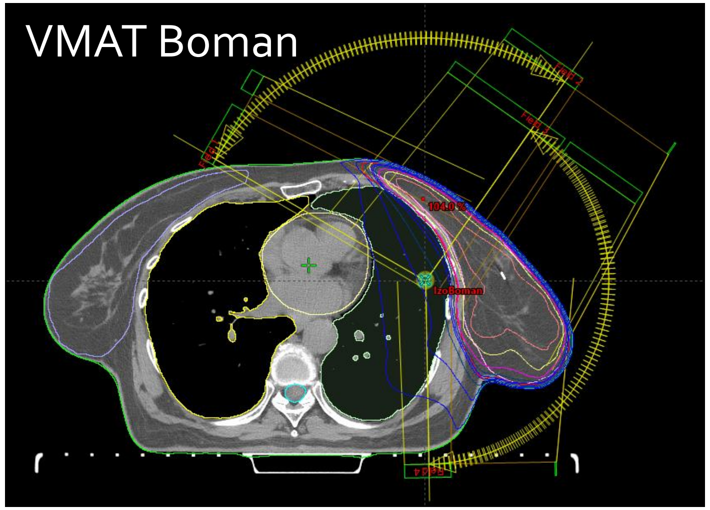
Spinal cord	Dmax < 39.52 Gy
Heart	Dmean < 4.8 Gy
Ipsilateral lung	V23.2Gy ≤ 15 %
	Dmean < 9.6 Gy
Contralateral breast	Dmean < 3 Gy
PTV coverage	V95% ≥ 98%

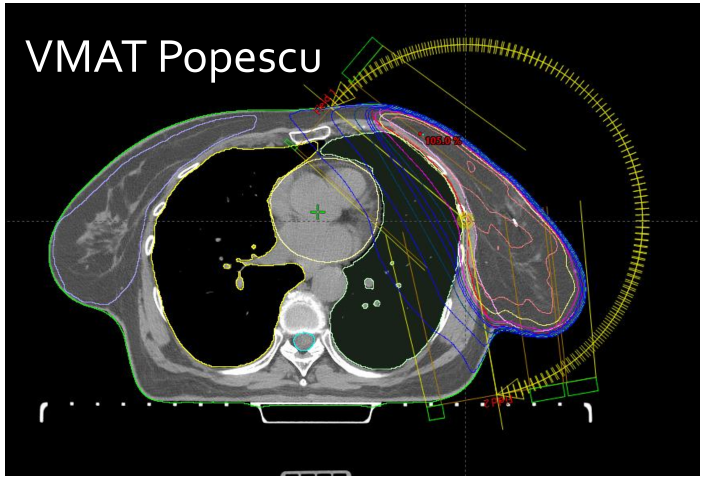
- Other evaluated parameters:
- *Gradient Measure* (the difference between the equivalent sphere radius of the prescription isodose and the equivalent sphere radius of half the prescription isodose. It is given in centimeters)
- *Conformity Index* (volume of the prescription isodose divided by the volume of PTV)
- **V5Gy**
- **Number of MU**

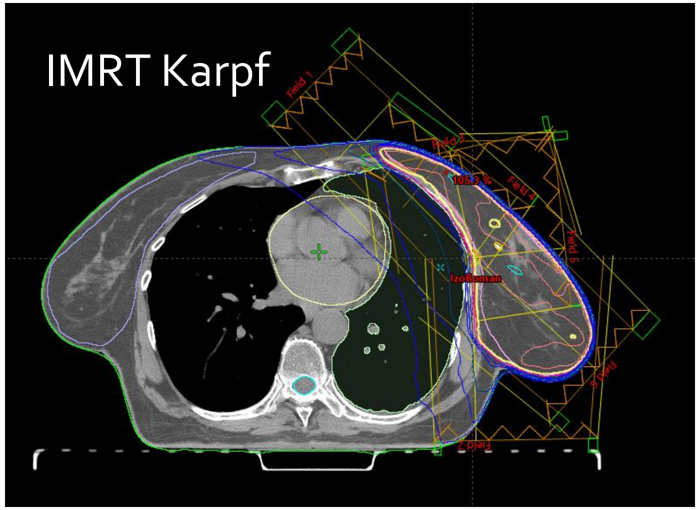
Results

- Dose coverage





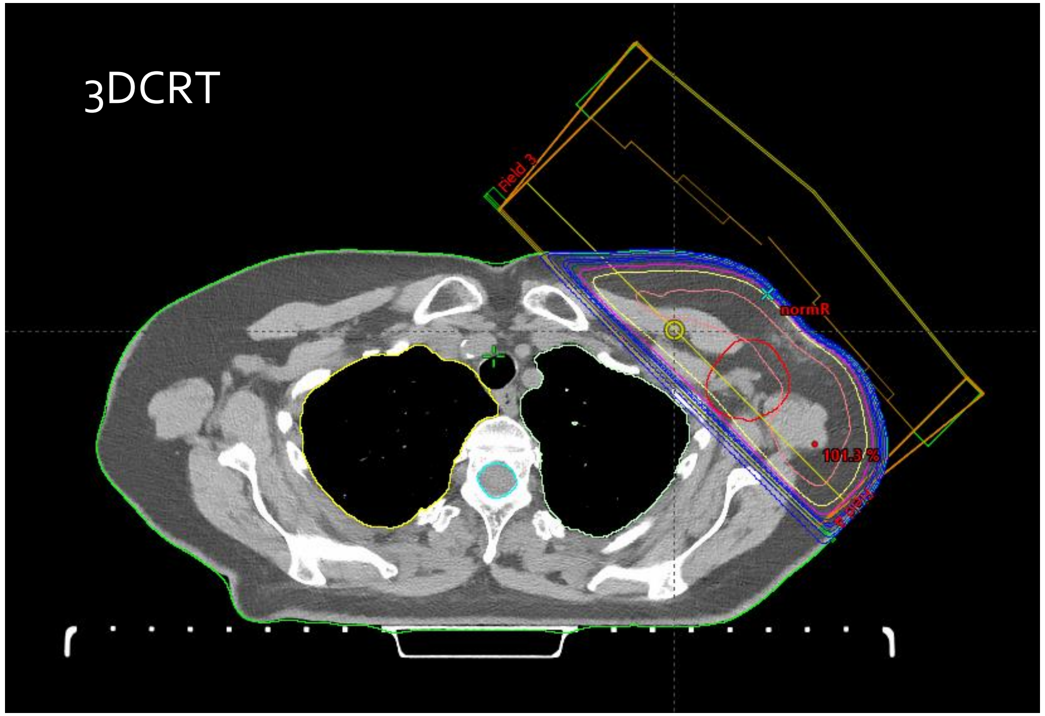


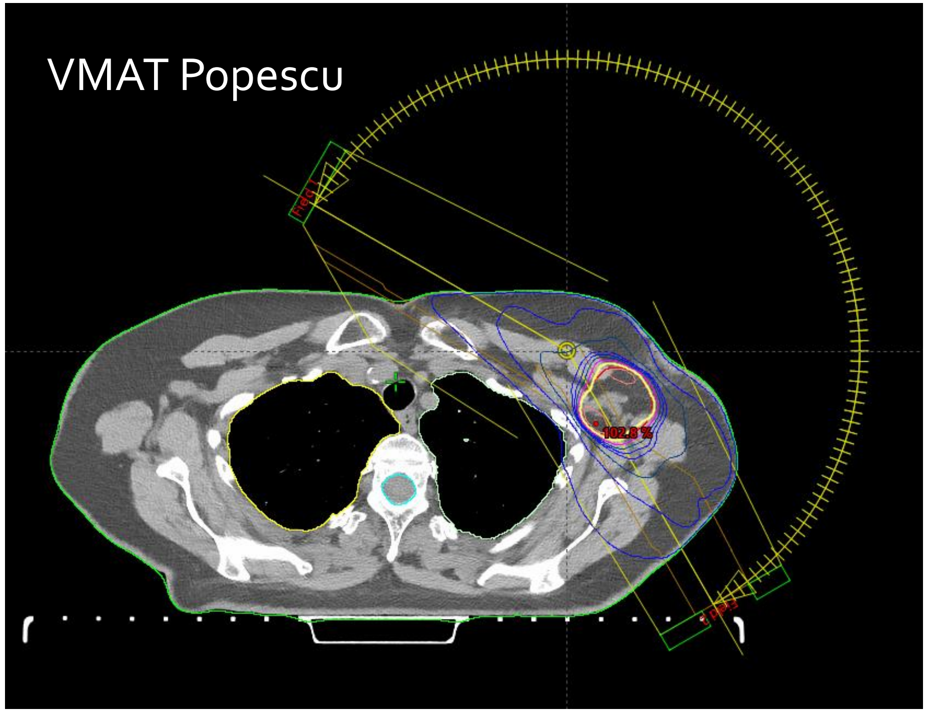


Results

- Dose coverage

High tangent dose distribution:





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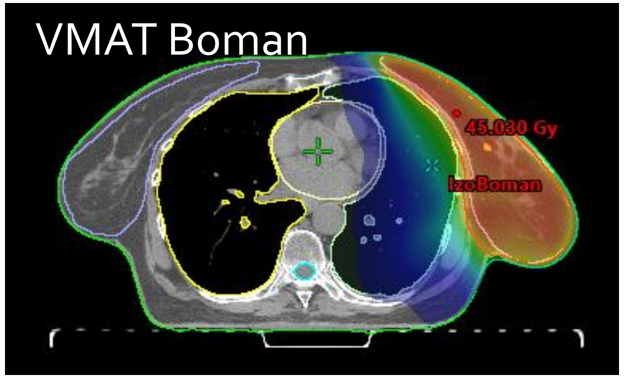
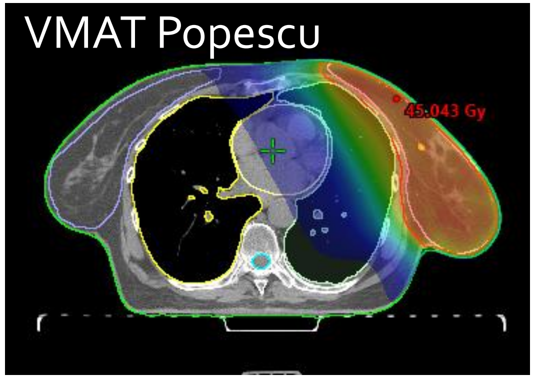
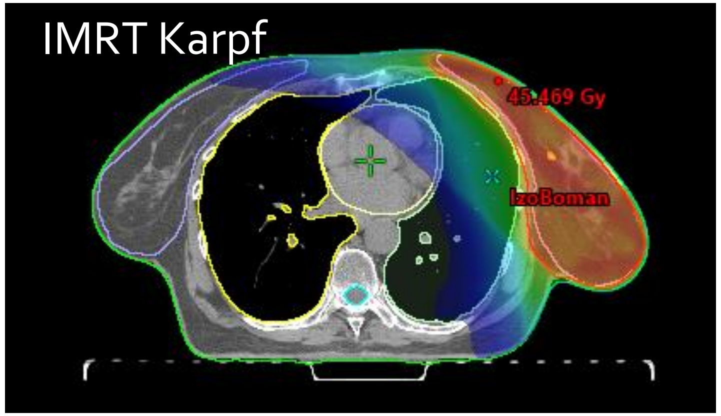
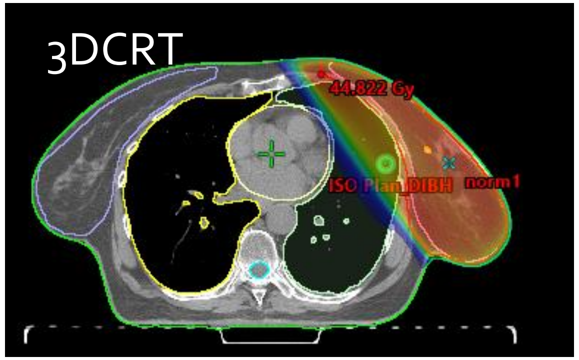




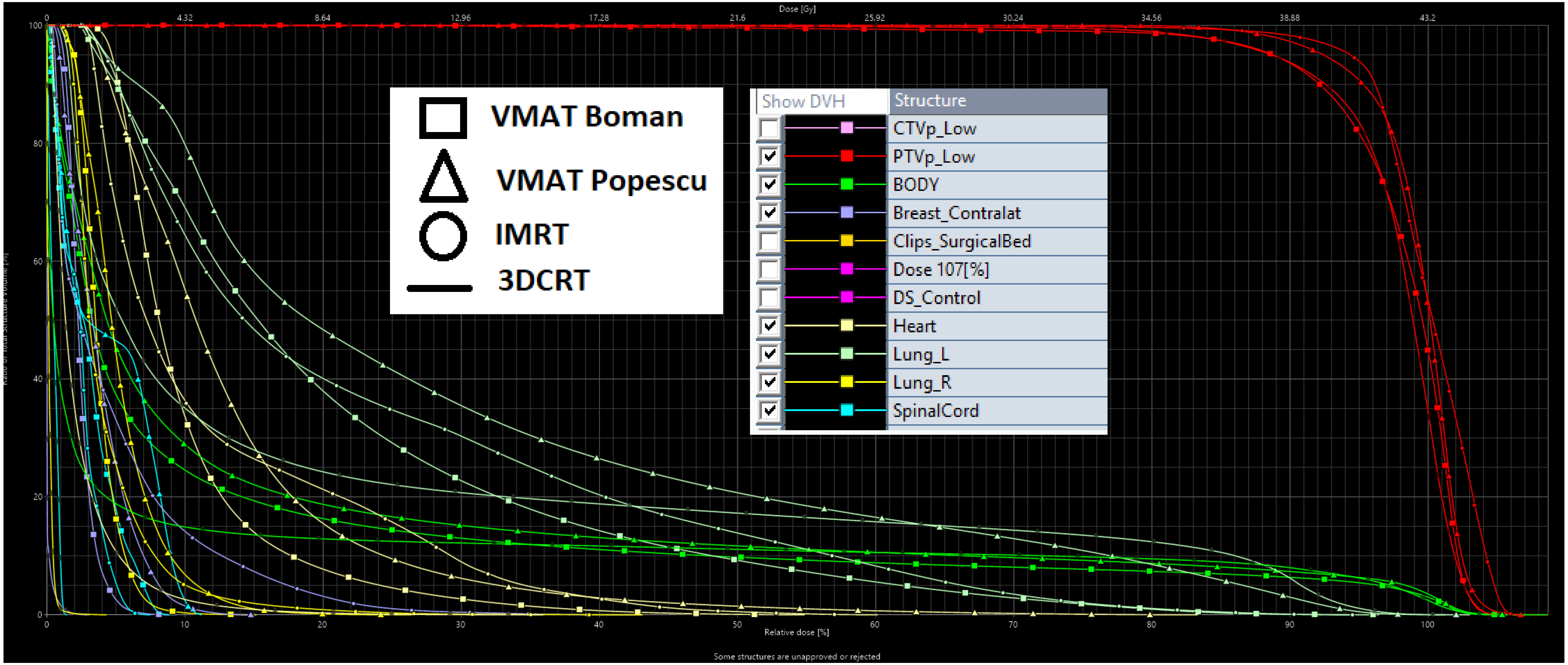




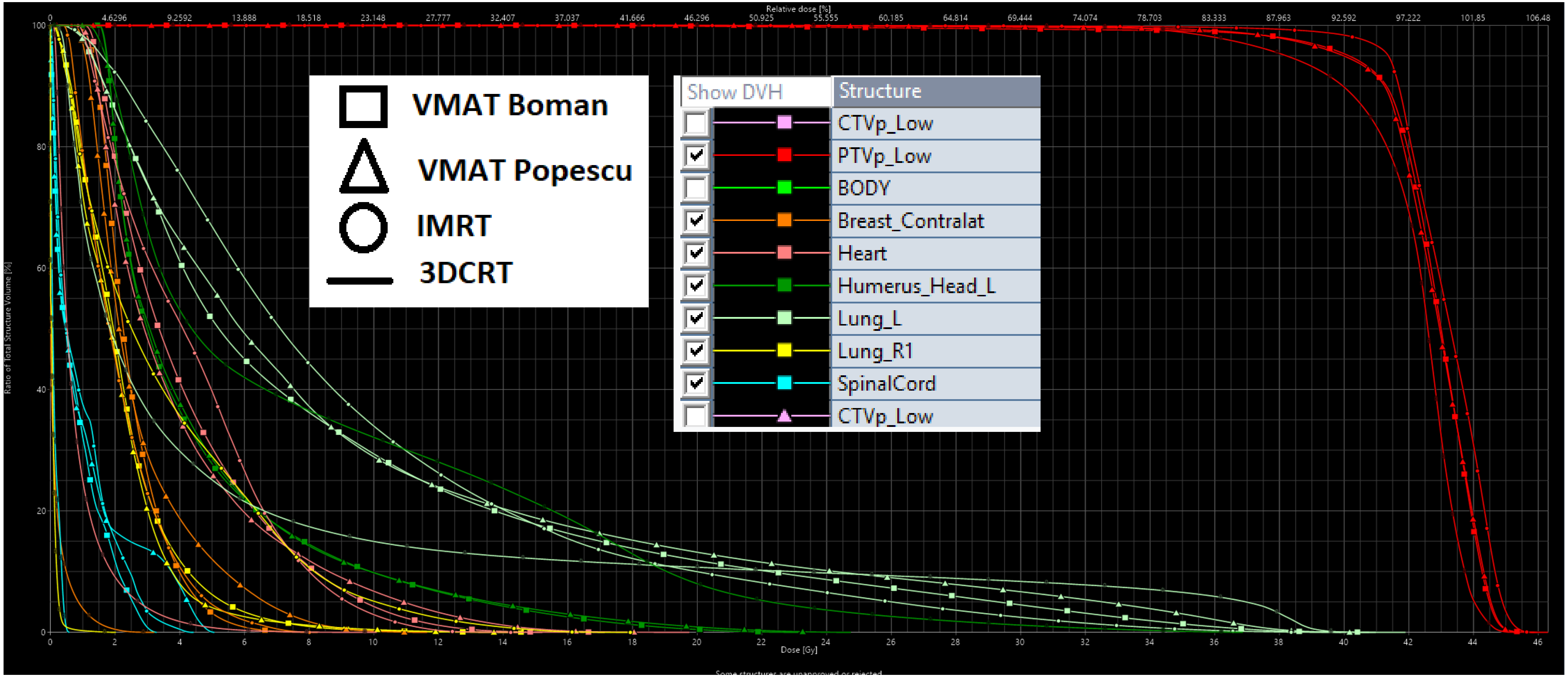
RESULTS

Dose coverage – 5Gy isodose

Results DVH – Patient 1



Results DVH – Patient 2



Results

Patient 1

	Best OARs*, MU, low dose	Best coverage		
	Least conformal	Worst MU	Worst OARs, low dose	Compromise ?
	3DCRT	**IMRT**	**VMAT Popescu**	**VMAT Boman**
Spinal cord – Dmax [Gy]	0.631	3.244	4.856	3.845
Heart - Dmean [Gy]	0.095	5.22	5.743	4.406
Ipsilateral lung - Dmean [Gy]	8.84	10.088	12.952	9.202
Contralateral lung - Dmean [Gy]	0.08	1.848	2.278	1.642
Contralateral breast - Dmean [Gy]	0.03	2.075	1.589	1.037
PTV coverage V95% ≥ 98%	no	yes	no	no
D98%	36.0 Gy	39.1 Gy	38.4 Gy	36.8 Gy
V95%	83.6 %	93.8 %	90.7 %	81.4 %
D2%	44.6 Gy	45.4 Gy	44.8 Gy	44.6 Gy
V105%	0 %	2.8 %	0.5 %	0 %
Gradient index [cm]	3.33	2.69	2.82	2.62
Conformity index	0.37	0.54	0.53	0.45
Number of MU	293.0	1361.1	587.3	488.9
Volume of 5Gy isodose [cm^3]	3264	5812	5846	5042

*except for high dose in left lung

Results

Patient 2

Best OARs*, MU, low dose | Worst coverage, least conformal | Best coverage | Worst MU, low dose | Bad OARs | Compromise

	3DCRT	IMRT	VMAT Popescu	VMAT Boman
Spinal cord – Dmax [Gy]	0.603	4.441	5.075	3.303
Heart - Dmean [Gy]	0.845	4.412	4.049	4.208
Ipsilateral lung - Dmean [Gy]	6.169	9.345	9.284	8.738
Contralateral lung - Dmean [Gy]	0.076	3.634	2.096	2.242
Contralateral breast - Dmean [Gy]	0.158	2.173	2.751	2.524
PTV coverage V95% ≥ 98%	no	yes	no	no
D98%	36.0 Gy	40.3 Gy	37.9 Gy	38.1 Gy
V95%	83.0 %	96.7 %	91.3 %	91.6 %
D2%	44.4 Gy	45.1 Gy	44.7 Gy	44.7 Gy
V105%	0 %	0.66 %	0 %	0 %
Gradient index [cm]	3.43	2.63	3.01	3.08
Conformity index	0.35	0.54	0.43	0.44
Number of MU	294.2	1354.9	578.6	521.2
Volume of 5Gy isodose [cm^3]	2880	6536	4998	4921

*except for high dose in left lung and humerus head

Discussion

- Hybrid techniques not considered
- 3DCRT uses 6MV and 18 MV, IMRT and VMAT only 6 MV
- VMAT is not commissioned yet
  - Complexity, deliverability and time on the machine might have impact on decision making in the future
  - Placement of isocenter x gantry rotation around the patient?; different fixation strategy?
- Acuros is not commissioned yet
  - Different outcomes than AAA

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Conclusions

- Trade-off between PTV coverage and OARs sparing:
  - PTV coverage best for IMRT
  - Conformity best for IMRT and VMAT
  - OARs best for 3DCRT (*except for high dose in left lung and humerus head*)
  - Volume of 5Gy isodose best for 3DCRT
  - OARs worst for IMRT and VMAT Popescu
  - Volume of 5Gy isodose worst for IMRT and VMAT Popescu
  - MU highest for IMRT
- VMAT technique according to Boman et al. might be a good compromise, depending on physician‘s criteria
- Hybrid technique combining IMRT (VMAT) and 3DCRT might be a solution (not objective of this study)

Literature

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