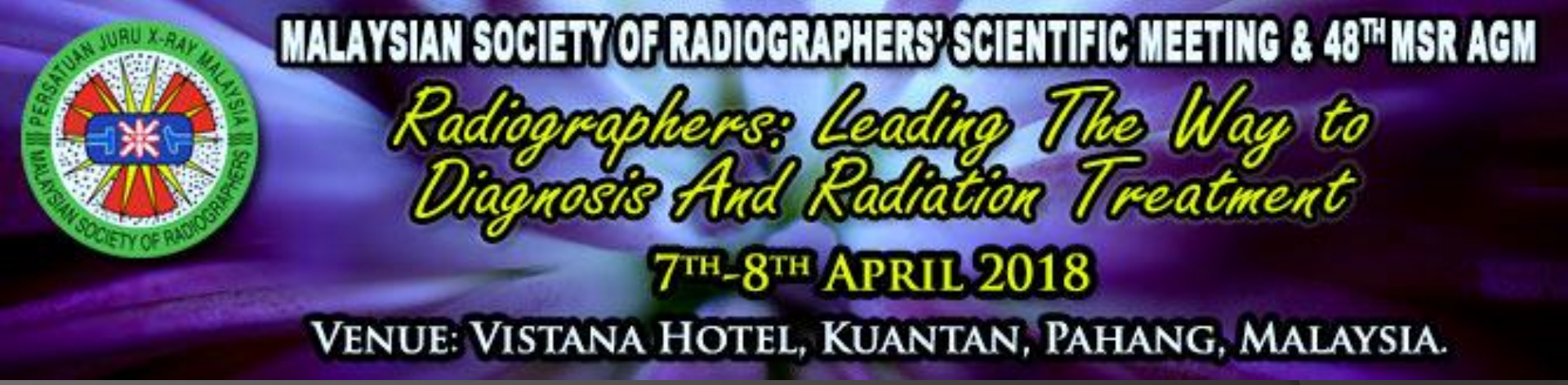

NEW DIMENSION IN BREAST CANCER TREATMENT : VOLUMETRIC MODULATED ARC THERAPY (VMAT), IS IT RELEVANT?

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INSTITUT KANSER NEGARA

OUTLINE

- Breast Cancer Treatment Overview
- VMAT – an overview
- RT Techniques
- Comparison : 2D, 3D, IMRT, VMAT
- Case study
- Discussion
- Conclusion

BREAST CANCER TREATMENT

Breast cancer is treated in several ways, including Surgery, Chemotherapy, Hormonal Therapy, Biological Therapy and Radiotherapy.

Treatment category	Specific Treatment
Surgery surgeon	Lumpectomy
	Lymph Node Dissection (seminal and axillary)
	Mastectomy
Radiation Therapy Radiation Oncologist	EBRT (2D, 3D Conformal, IMRT, VMAT)
	Brachytherapy (HDR/LDR)
	Intraoperative Radiation (IORT)
Systematic Therapy Medical Oncologist	Chemotherapy
	Hormone Therapy
	Targeted Drug Therapy

VMAT

- Volumetric modulated arc therapy (VMAT) is a novel radiation technique, which can achieve highly conformal dose distributions with improved target volume coverage and sparing of normal tissues compared with conventional radiotherapy techniques. VMAT also has the potential to offer additional advantages, such as reduced treatment delivery time compared with conventional static field intensity modulated radiotherapy (IMRT). The clinical worldwide use of VMAT is increasing significantly.

Br J Radiol. 2011 Nov; 84(1007): 967–996.
An International Journal of Radiology

TECHNIQUE FOR RADIOTHERAPY

1. Positioning
2. Immobilization
3. Simulation
4. Target Volume
5. Treatment Planning
6. Dose & Fractionation
7. Set Up Verification
8. Sequelae Of Radiotherapy

Positioning & Immobilization

Most crucial parts of RT treatment for

- accurate delivery of a prescribed radiation dose
- sparing surrounding critical tissues

Primary goal:

1) reproducibility of position
2) reduce positioning errors

Other benefits :

1) can reduce time for daily set up.
2) make patient feel more secure & less apprehensive.
3) help to stabilize relationship between external skin marks & internal structures

Treatment Planning

OBJECTIVE :

- **Deliver uniform dose distribution throughout target volume**
- **ensure adequate tumor coverage**
- **minimize doses to normal tissue**

TWO-DIMENSIONAL (2D) → THREE-DIMENSIONAL (3D) → IMRT → VMAT

Conventional 2D

WBRT uses tangential field technique; however, dose distribution is complicated because of

- irregularities in the chest-wall contour
- varying thickness of the underlying lung tissue.

Therefore beam modification is required to improve dose planning target volume (PTV) should be within the 95% and 107% isodose for homogenous dose distribution

Beam Modification Devices in breast radiotherapy

WEDGE

COMPENSATOR

BOLUS

Conventional 2D

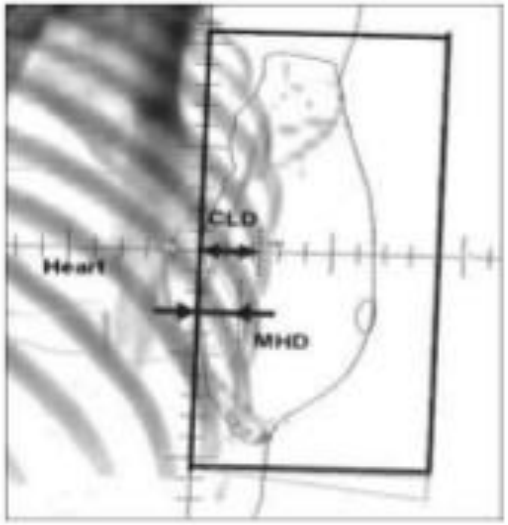
Doses To Heart & Lung By Tangential Fields

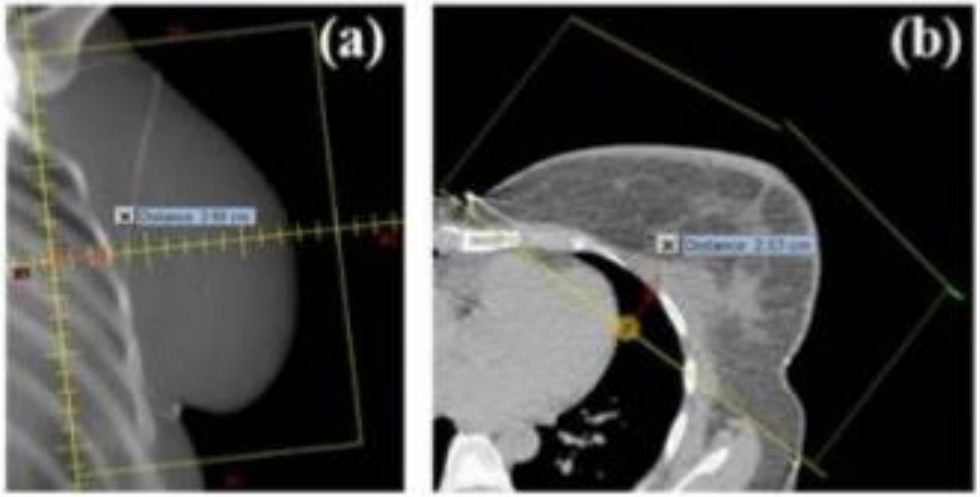
- The amount of lung included in the irradiated volume is greatly influenced by the portals used
- Various parameters are used to determine the amount of lung & heart in tangential field

Doses To Heart & Lung By Tangential Fields

- CLD: perpendicular distance from the posterior tangential field edge to the posterior part of the anterior chest wall at the center of the field

- MLD: maximum perpendicular distance from the posterior tangential field edge to the posterior part of the anterior chest wall





Central lung distance marked on the digitally reconstructed radiograph (a) and on the central axial slice (b)

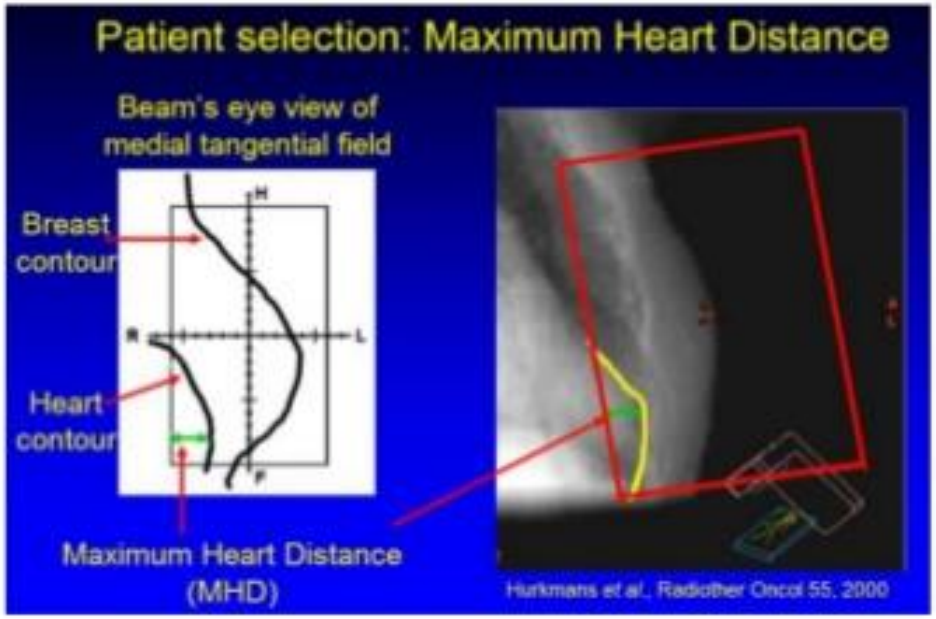
Doses To Heart & Lung By Tangential Fields

MAXIMUM HEART DISTANCE: maximum perpendicular distance from the posterior tangential field edge to the heart border

When the CLD is >3 cm, in treatment of the left breast, a significant volume of heart will also be irradiated

Dose to heart can be minimized by

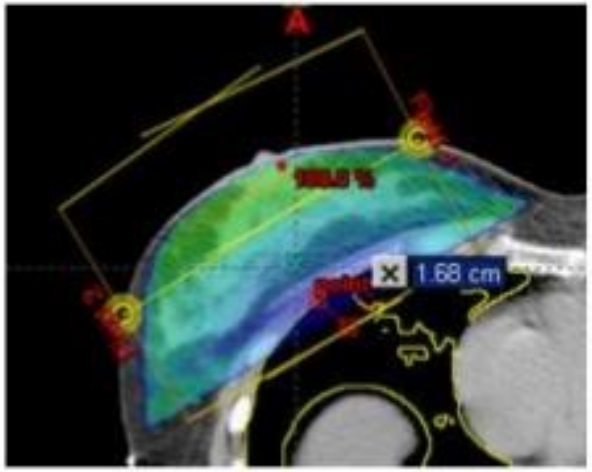
- Median tangential breast port
- Cardiac block & electron field
- breath hold
- gating



Doses To Heart & Lung By Tangential Fields

Central lung distance

- Best predictor of %age of ipsilateral lung vol. treated by tangential fields



CLD (cm)	% of lung irradiated
1.5 cm	6%
2.5 cm	16%
3.5 cm	26%

Usually up to 2 to 3 cm of underlying lung may be included in the tangential portals

Radiation pneumonitis risk <2% with CLD<3 cm.
Risk upto 10% with CLD 4-4.5 cm.

With Conventional 2D : cause

- Acute skin toxicity: moist desquamation in 30% to 50% of patients
- Erythema and edema of the irradiated breast
- Telangiaectasia and fibrosis of the skin
- Effect cosmetic result and QOL

Clin Oncol 2004; 16:12-16
Eur J Cancer 2008 ; 44: 2587-2599
Radiother Oncol 1994; 33: 106-112
IJROBP 2007 ; 68: 1375-1380

3D CONFORMAL RT

Standard opposed tangential fields with appropriate use of wedges to optimize dose homogeneity remains the most commonly employed method for delivery of whole breast irradiation

3DCRT may improve

- dose to target volume &
- reduction in dose to normal tissues & critical organs
- Better cosmetic results
- Less dose to heart and lung

IMRT

- With IMRT, the radiation beam can be broken up into hundreds of “beamlets,” each of which can be adjusted to a different degree of intensity. In some cases, because of its extreme focus, IMRT can safely allow a higher dose of radiation to be delivered to a tumor

Volumetric Modulated Arc Therapy (VMAT)

- VMAT is an advanced form of IMRT in which a single or multiple radiation beams sweep in arcs around the patient rather than remaining static. VMAT delivers a high-powered, targeted dose of radiation with minimal damage to surrounding tissue and critical anatomy, and because of its accuracy is often used for tumors that are adjacent to organs.

VMAT cuts treatment time significantly, which both lessens the amount of time patients must remain motionless

IMRT/VMAT

Advantages:	Disadvantages:
1. Better dose homogeneity for whole breast RT 2. Better coverage of tumor cavity 3. feasibility of SIB 4. Decrease dose to the critical organs 5. Left sided tumors -decrease heart dose	1. May increase the volume of tissue exposed to lower doses of radiation. 2. May increase the risk of second malignancies

- IMRT/VMAT advantages over 3DCRT:
  - Improved Conformity of dose to PTV
  - Lower dose to most OARs
- IMRT/VMAT diadvantages over 3DCRT:
  - Increase mean dose to heart and contralateral lung
  - Higher integral dose

CASE STUDY

- 40 years-old Malay lady/ No underlying medical history/No family history of malignancy
- Diagnosis : Left breast metastatic carcinoma with regional nodal, lung and possible liver mets
- Problem : Referring for palliative chemotherapy
- TNM : cT4bN1M1
- Stage : IV

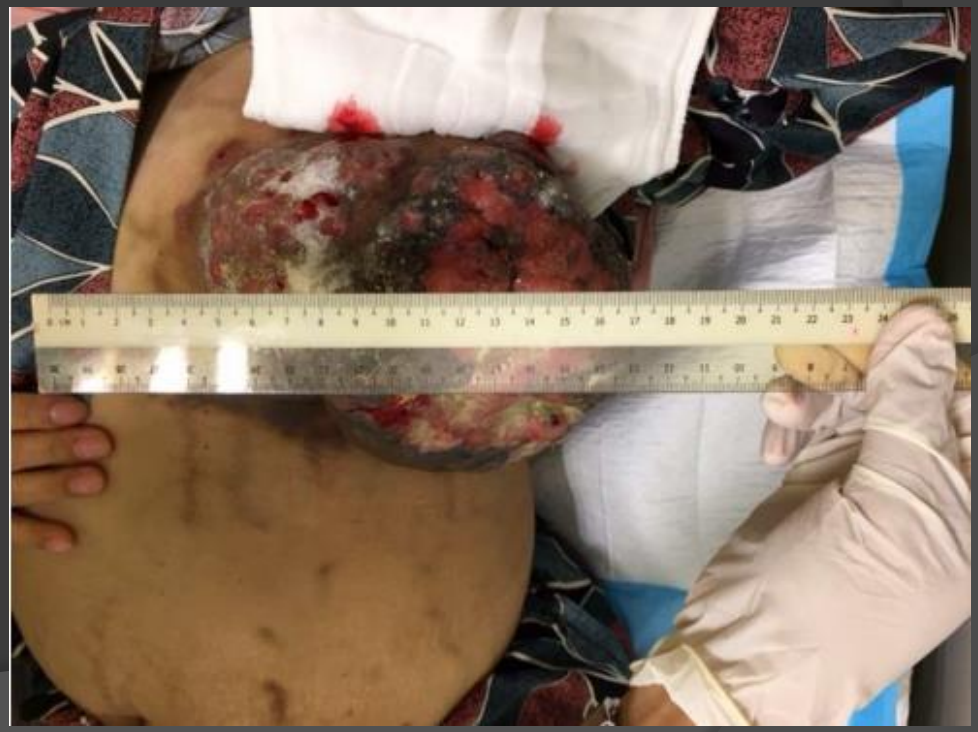
13/9/2017

History of Presenting Illness:

- No medical co-morbids
- Known case of left breast carcinoma since 2014
- Refer for Breast conserving surgery, however decline and decided to see traditional treatment, however breast mass gradually increasing in size and started to ulcerate and bleed.
- Presented back to Hospital Kuala Pilah in August with a huge left breast mass measuring size of 14cm by 10cm in dimension with central ulceration, fungating in appearance and with areas of minute bleeding. Foul smelling from near

Had restaging done on 25/08/17 showed:

- mass 14cm x 11cm x 12.6cm in size with satellite nodule, regional LN involvement with lungs and possible liver mets
- Thus, patient was referred to us for further management ie palliative chemotherapy.



5/2/2018

*completed 3 cycles FEC in Hospital Kuala Pilah

Treatment Plan :

- for consolidation RT to the Left Breast and left axilla 55Gy in 20#
- RP and LFT normal (no other failure sx)

RT Tx plan (Request Order)

- 3D Conformal
  - CT- SIM use breast board set-up
  - Use Wax bolus

MOSAIQ - Institut Kanser Negara

File Schedule eChart Tools Code Mgmt Window Help

RT** Siti Sabarini Binti Mat Yusoff

Home | Chart | D and I | Images | RO Treat | Help | QCL | Assessments | Demographics | Documents | CWS | Navigator | CT Sim

Select Patient

Site Setup Definition

Rx Site: Lt Breast Dose: 0 cGy/5,500 cGy Fractions: 0/20 Approved:

OK | Cancel | Approve | Plan Docs

Site Setup

Patient Orientation: Head In, Supine
Verification: Verify
Machine: LINAC1
Tolerance: Site Setup

Created: MAM 15/2/2018
Approved:
Last Modified: MMZ 20/3/2018

Setup | Planar Images/Couch Movement | Volume Reference Data

Accessories

Device 1:	Breast Board
Device 2:	
Device 3:	
Device 4:	

Setup Instructions

SETUP
Head: Straight
Ang: STRAIGHT, Pin: 5/20°
Head Cup: REMOVED/ Bolus (15cm x 15cm) under head
Hipstop: I

Origin at BB Scale: 32.2cm
Lt/ Rt Wrist Placement: 3, Position: A/1/2
Lt/ Rt Arm Support: A/4, Rotation: -10°
LANDMARK
ML: SSN match with XSN
ML: 2.5cm from Lt COM (corner of mouth)

4 Tattoos (3 point @ Origin, 1 at ML)
SUP Tattoo: 19cm from Origin Tattoo

* Origin at inferior border, Tx without dressing

Geometrics/SSD

Gantry Settings

		Tolerance
Gantry (deg):	0.0	0.0
Field X (cm):	0.0	0.0
Field Y (cm):	0.0	0.0

Couch Settings

Vertical (cm):	0.0	0.00
Lateral (cm):	0.0	0.00
Longitudinal (cm):	0.0	0.00
Angle (deg):	0.0	0.0
Pedestal (deg):	0.0	0.0
Pitch (deg):	0.0	0.0
Roll (deg):	0.0	0.0

SSD

SSD (cm):	0.0

Photos/Diagrams

Setup Offsets (Anatomy)

Prescribed (cm)		Localization (cm)	Total (cm)	
	0.0		Superior	0.0
	0.0		Left	0.0
	0.0		Anterior	0.0

☐ Completed

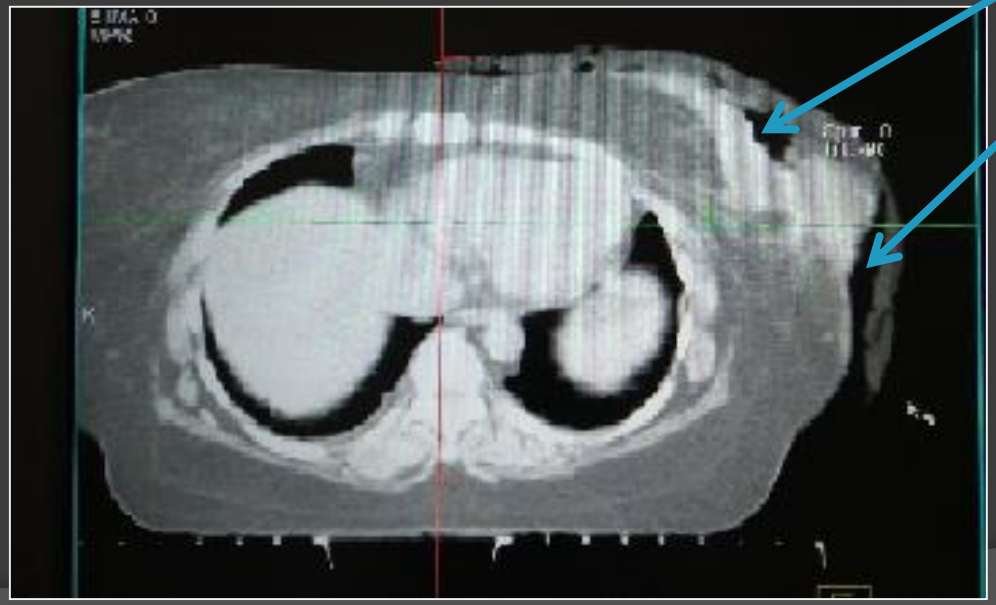
Site Setup Definition Will Be Changed

12:50 PM
21/3/2018

CT Sim

Wax Bolus

Air gap



IMRT in Tomotherapy?

- Resim
- Use Wing board
- No bolus

- Compare to VMAT Plan…

IMRT vs VMAT prescription

Number of Fractions	Duration (sec)	Gantry Rotations	Gantry Period	Expected MU	Couch Travel (cm)	Couch Speed (cm/sec)	Planned Field Widths
20	906.7	40.8	22.2	12,898	22.0	0.02421	9.8

Prescription Information: [A]

Rx Site	Prescribe To:	Rx Dose (cGy)	Fractional Dose (cGy)	Number of Fractions
	Plan Isocenter	5500.0	275.0	20

Actual Dose(cGy): 5610.4

Rescale: No user normalization applied

Algorithm: Monte Carlo Photon

Statistical Uncertainty (%) per Calculation: 1.00

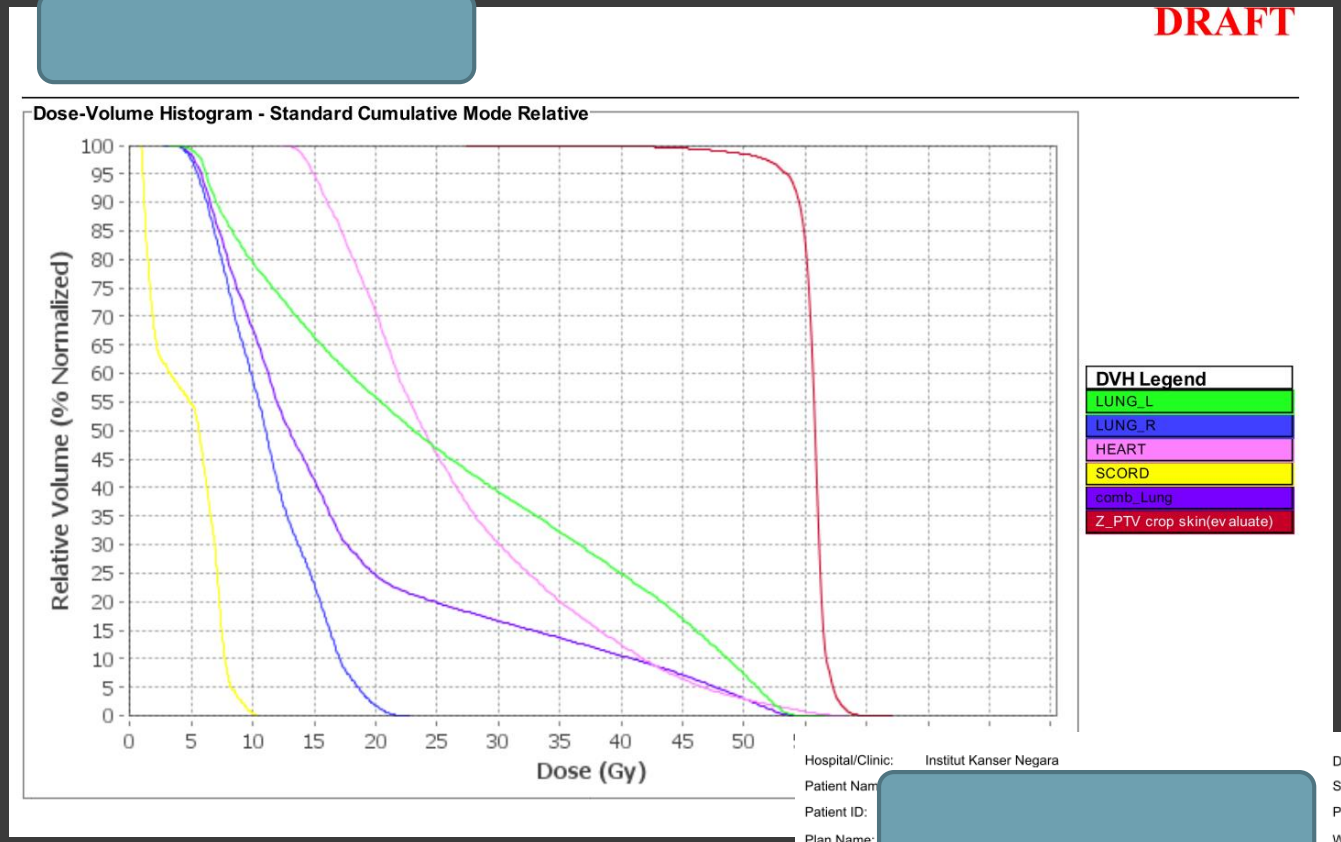
Delivery Mode: VMAT

Beam Information

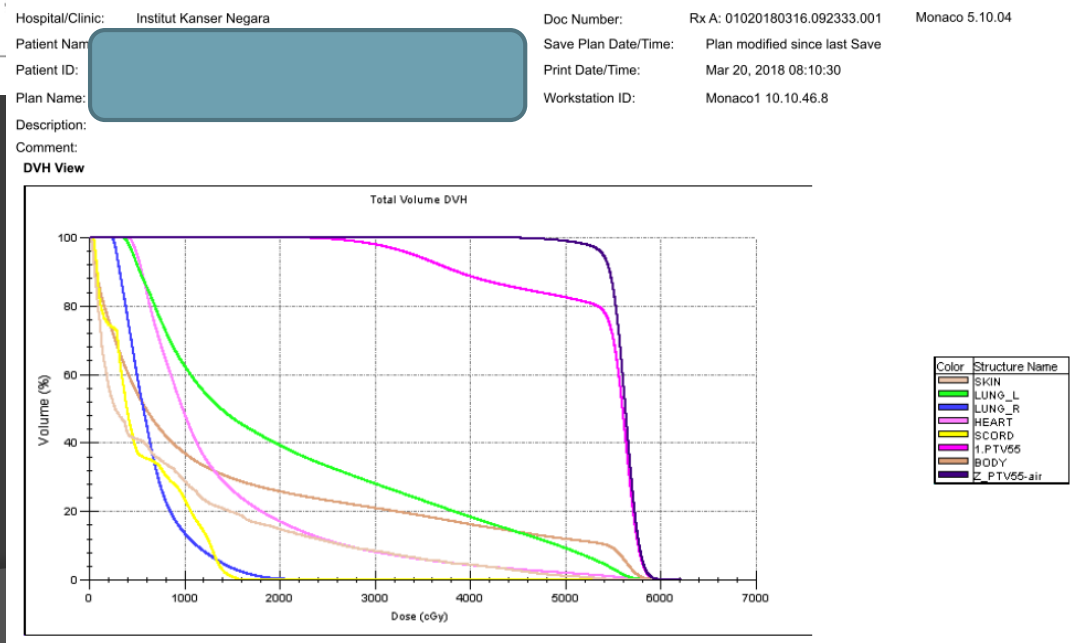
Scan Reference Coordinates (cm): No Scan Reference Point has been selected

Seq.	Description	Treatment Unit	Modality	Energy	Gantry (deg)	Coll. (deg)	Couch (deg)	Isocenter X(cm)	Y(cm)	Z(cm)	# of Segs	MU/Fx
1	VMAT	ElektaAgility	Photon	6.0 MV	340.0/200.0	0.0	0.0	7.00	12.00	26.00	338	1825.35
										Total:	338	1825.35

IMRT DVH



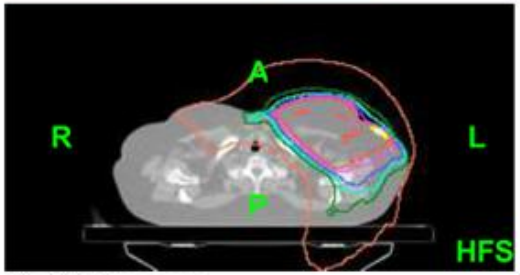
VMAT DVH



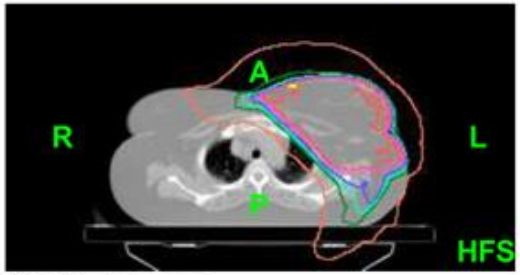
IMRT vs VMAT

Plan Name: HM_Copy_24

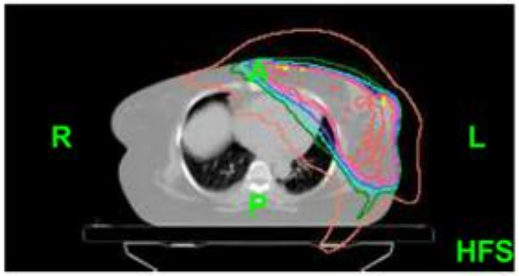
20.01	34.974	40.02	45.008	52.2	54.984	58.812	60.494



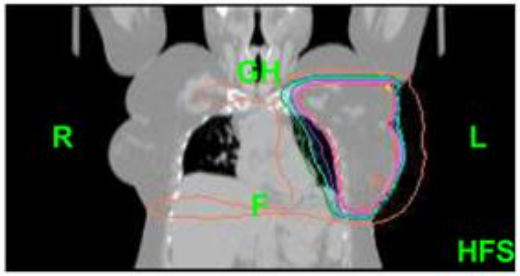
Slice 26 - Transverse



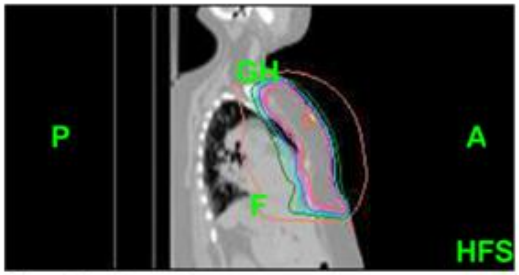
Slice 33 - Transverse



Slice 52 - Transverse



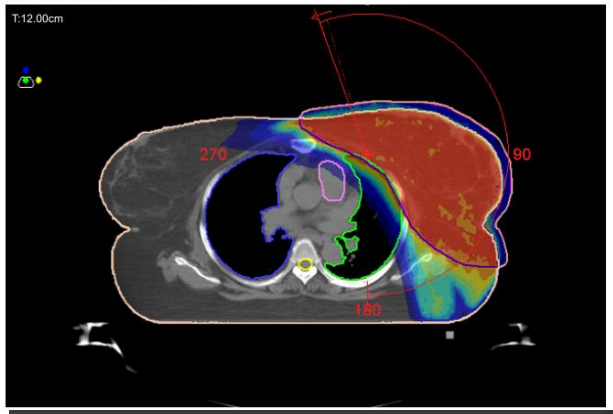
Slice 129 - Coronal



Slice 148 - Sagittal

Doc Number: Rx A: 01020180316.092333.001 Mo
Save Plan Date/Time: Plan modified since last Save
Print Date/Time: Mar 20, 2018 08:10:30
Workstation ID: Monaco1 10.10.46.8

Description:
Comment:
SPV Passing Through Plan Isocenter



IMRT / VMAT Dose Summary

Target Planning	Aim	Tomo Planning	VMAT Planning
PTV 55 Gy	$D_{98\%}$	92.5	94.5
	$D_{95\%}$	97.1	98
	$D_{50\%}$	101.4	102.4
	$D_{2\%}$ <107	105.1	106.5

OAR		Aim	Tomo Planning	VMAT Planning
Heart		V 40< 30%	29%	4.23%
		V 30< 46%		8.08%
Lung	Rt	V 20< 30%	1.4%	0.2%
	Lt	V 20< 30%	55%	39.2%
	Total	V 20< 30%	24%	16.85%
Spinal Cord		D_{max} < 50Gy	10.3%	16.2%
TREATMENT TIME			15 min 7 sec	4 min 20 sec

DISCUSSION

- Limitation of 3D Conformal – to include whole skin on left breast.
- Bolus controversion – uneven skin surface, wax bolus, low reproducibility, air gap
- IMRT plan
  - use wing board
  - compared to VMAT plan- PTV and OAR
- Currently undergoing VMAT tx-
  - daily IGRT
  - Challenges

DISCUSSION

- IMRT/ VMAT: Solution
  - Expand PTV & Optimize Coverage of entire PTV
  - Portion of PTV in air > add virtual tissue / manually open certain imrt segments to take care of skin flash
- Interest in IMRT/ VMAT
  - Left Ca Breast
    - Spare myocardium from high dose region
    - Improve PTV coverage

CONCLUSION: HOW RELEVANT VMAT IS FOR BREAST RT?

Conclusion

- The three types of plans can meet the clinical dosimetry demands of postoperative radiotherapy for breast cancer. The target of IMRT and VMAT plans has a better conformity, and the VMAT plan takes the advantages of less MU and treatment time.

https://www.ncbi.nlm.nih.gov/pubmed/27838084

CONCLUSION

The advantages of VMAT are used for reducing the risk of late radiation-induced toxicity related to low-to –moderate doses in critical organs. VMAT is therefore considered the best treatment option for breast cancer. (D. Adam *et al*)

THANK YOU