FIELD TRAINING

REPORT

MEDICAL PHYSICS

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FAKULTY OF MATHEMATICS AND NATURAL SCIENCES

UNIVERSITAS INDONESIA

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Diagnostic Radiology

Hospital Name	*Rumah Sakit Kanker Dharmais*
Date	Monday, 27/10/2017
Room Number	12
Estimated Area	5 x 10 m^2
Wall Thickness	20 cm
Apron Thickness (mm Pb) Quantity	Pb 0.35 1
Pb-Equivalent Glass (Control Room)	Available
Instrument Name	Siemens Mobilett
Year of Installation / Age	2014
System Type	Mobile
Usage	Radiography

Radiography

X-Ray Generator Manufacturer: Model: Serial Number: Maximum kVp: Maximum mA/mAs:	 Siemens 1158815 469002 113 kV 485 mA
Filter	Inherent
Focus Indicator	Available
If Mobile: Switch Cable Length Minimum Focus-to-Skin distance	 10 m 100-150 cm
Film Development Process	Automatic & manual
Movement Lateral: Longitudinal: Vertical: Tube: Table:	 Good Good Good Good Good
Locking Mechanism Lateral: Longitudinal: Vertical: Tube: Table:	 Good Good Good Good Good
Collimator Light: Left-Right Field Indicator: Front-Back Field Indicator:	 Good Symmetrical Symmetrical
Grid Table:	 Stationary

Overhead (Spotradiography):	Mobile
Thorax Stand:	Mobile

Fluoroscopy

X-Ray Generator	
Manufacturer:	Siemens
Model:	4803388
Serial Number:	1131618
Focal Point Indicator	Available
Film Development Process	Automatic
Table	Fixed
Protection	Pb-equivalent curtain
Intensifier Tube	
Pb-Equivalent Tassel	Available
Exposure Control	
kVp & mA Indicator:	Available
kVp & mA Selection:	Available
Exposure Indicator:	Available
Monitor	Good

Examination

Patient No.	Target	P/A or Lateral	FFD (cm)	kVp	mAs
1	Cranium	A/P	100	79	18
	Cranium	Lateral	100	79	18
	Shoulder	A/P	100	64.5	14
	Right humerus	A/P	100	64.5	14
	Left Humerus	A/P	100	64.5	14
	Thorax	A/P	100	83	22
	Thorax	Lateral	100	96	32
	Pelvis	A/P	100	83	22
2	Abdomen	A/P	100	81	20
3	Abdomen	P/A	100	81	25
4	Ankle	-	100	70	16

Mobile

Patient No.	Target	P/A or Lateral	FFD (cm)	kVp	mAs
1	Thorax	A/P	100	117	1.3
2	Thorax	A/P	100	105	1.3
3	Thorax	A/P	100	117	1.3
4	Thorax	A/P	100	117	1.3
5	Thorax	A/P	100	117	1.3

6	Thorax	A/P	100	117	1.3
7	Cervical Spine	A/P	100	66	5

Questions

How are thickness and focus size related?

Thickness affects focus size, which subsequently affects mAs. For example, bones result in a small focus size while the thorax or abdomen results in a larger focus size.

How is the beam aimed to reduce the Heel effect?

Anode angle can be increased to reduce Heel effect. Alternatively, detector distance and/or field size can be decreased.

Mammography

Hospital Name	*Rumah Sakit Kanker Dharmais*
Date	Monday, 27/10/2017
Room Number	9
Estimated Area	4 x 5 m^2
Wall Thickness	30 cm
Warning Sign	Indicator light at door
Instrument Name	Mammomat Inspiration
Year of Installation / Age	2012
Target Material	P40MoW
Filter	W/Rh
X-Ray Generator	
Manufacturer:	Siemens
Model:	10139775
Serial Number:	2166
Maximum kVp:	32 kV
Maximum mA/mAs:	110 mA
Grid	Available
Indicator Light	Available
AEC	Available

Questions

What is the purpose of compression?

Compression reduces the thickness of the breast, thereby increasing image quality.

What is an AEC used for?

An AEC is used to stop irradiation automatically after a certain amount of radiation has been reached. This allows for consistent irradiation.

CT

Hospital Name	*Rumah Sakit Kanker Dharmais*
Date	Monday, 3/11/2017
Wall Thickness + Additional Shielding	Pb + Concrete (20 cm)
Warning Sign	Indicator light at door
Instrument Name	Siemens 16 Biograph
Year of Installation / Age	2012
Pb-Equivalent Glass (Control Room)	Available
Apron	Available
Target Material	P40MoW
Filter	W/Rh
X-Ray Generator Manufacturer: Model: Serial Number: Maximum kVp: Maximum mA/mAs:	 Siemens PET Gantry/Siemens 1028 130 kV 3000 mA
Uniformity	Good
Nominal Pitch	Max. 2

CT Examination

Patient No.	Examination	With/Without Contrast	kVp	mAs	Pitch	Slice Size (mm)
1	Abdomen	Without	130	47	0.8	8
	Abdomen	With	130	48	0.8	8
	Pelvis	With	130	58	0.8	8
2	Thorax	With	130	40	0.8	8
3	Abdomen	With	130	63	0.8	10
	Pelvis	With	130	84	0.8	10
4	Thorax	With	130	59	0.8	10
5	Abdomen	With	130	159	0.8	10
	Pelvis	With	130	215	0.8	10

Questions

Explain how a multislice CT (e.g. 64 slices) can be used to generate a real-time image of a moving organ, e.g the heart. What are the conditions?

Scanning speed should be high and the blood vessels should be visible. Additionally, medication may be used to slow down the patient's heartbeats.

USG (Ultrasonography)

Hospital Name	*Rumah Sakit Kanker Dharmais*
Date	Monday, 3/11/2017
Room Number	10
Estimated Area	5 x 6 m^2
Instrument Name	Hitachi HI Vision Avius
Year of Installation / Age	2014
Transducer Type	B-mode, linear, curved linear array, transvaginal
Scanning Capabilities	Colour, Doppler, tissue harmonic imaging
Analysis Capabilities	Distance, area, volume
Documentation	Colorless printer, DICOM-3

Questions

Why must gel be used on the patient's skin?

Air has a high impedance. Gel is used to circumvent this so that the ultrasound wave can be transmitted into the patient's body.

How is the frequency chosen?

Ultrasound frequency affects spatial resolution, with higher-frequency ultrasound yielding better image quality than lower-frequency ultrasound. However, higher-frequency ultrasound cannot penetrate as far as lowe-frequency ultrasound. Thus, lower-frequency ultrasound (3.5-5 MHz) is used for thicker structures (e.g. the abdomen) and higher-frequency ultrasound (7.5-10 MHz) is used on smaller structures or ones closer to the surface of the skin (e.g. the thyroid).

Why can't the lung be examined with USG?

The lungs are filled with air, which results in bad image quality.

MRI

Hospital Name	*Rumah Sakit Kanker Dharmais*
Date	Monday, 10/11/2017
Room Number	MRI Room
Estimated Area	7 x 8 m^2
Instrument Name	Magneton Avanto Tim

Year of Installation / Age	2011
Magnet Strength	1.5 T
Magnet Type	Superconducting electromagnet
Coils	Volume, flat
Pulse Sequence	T1, T2, diffusion

Examination

Patient No.	Examination	Pulse Order	TR	TE	Slices
1	Brain	T2 -> T1	T2:4000 T1: 400	T2: 85 T1: 8.7	19

Rumah Sakit Kanker Dharmais accomodates most methods of medical imaging: radiography, fluoroscopy, mammography, USG, and MRI. Dental imaging is not available and CT, rather than being used by itself, is generally combined with PET.

Radiography at *Dharmais* makes use of film to capture the image. The film is then processed using the appropriate equipment and the image electronically sent to a computer. The film is reset after each use, lest artifacts remain which can interfere with the next image taken.

No examinations were done for USG. Instead, QA is done for the equipment. The Hitachi HI Vision Avius, using a curved probe, is examined with a CIRS model 040GSE phantom. Results are as follows:

Parameter	Baseline	Measured	Error
Depth of Penetration/ FOV			
Depth (cm)	14	13.53	-3.36%
Near Field			
No. of Targets	5	4	-20%
Horizontal Distance (mm)	6 6 6	5.4 6.7 6.7	-10% 11.67% 11.67%
Vertical Distance (mm)	1	1.5	+50%
Vertical Distance			
No. of Targets	16	15	-6.25%
Vertical Distance (mm)	160	135.3	-15.44%
Horizontal Distance (3cm)			
No. of targets	4	6	+50%
Horizontal Distance (mm)	40	53.4	33.5%
Horizontal Distance (9cm)			
No of Targets	7	6	-14.29%
Horizontal Distance (mm)	140	104	-25.71%
Grayscale (3cm)	8	H: 8.7 V: 7.5	H: +8.75 % V: -6.25 %
-9dB diameter (mm)	8	H: 8.7	H: +8.75 %

		V: 8	V: 0.00 %
-6 dB diameter (mm)	8	H: 9.2 V: 10.7	H: +15.00 % V: +33.75 %
-3 dB diameter (mm)	8	H: 6.3 V: 7.8	H: -21.25 % V: -2.50 %
+3 dB diameter (mm)	8	H: 7.5 V: 7.2	H: -6.25 % V: -10.00 %
+6 dB diameter (mm)	8	H: 6 V:6.9	H: -25.00 % V: -26.25 %
>15 dB diameter (mm)	8	H: 8.7 V: 7.5	H: +8.75 % V: -6.25 %
Grayscale (11.5 cm)			
-6 dB diameter (mm)	10	H: 10.7 V: 9.4	H: +7.00 % V: -6.00 %
-3 dB diameter (mm)	10	H: 10.1 V: 10.1	H: +1.00 % V: +1.00 %
+3 dB diameter (mm)	10	H: 9.9 V: 11	H: -1.00 % V: +10.00 %
+6 dB diameter (mm)	10	H: 11 V: 9.5	H: +10.00 % V: -5.00 %
>15 dB diameter (mm)	10	H: 10.7 V: 9.3	H: +7.00 % V: -7.00 %

MRI is done by alternating between T2 and T1 pulses. Like USG, MRI does not use ionizing radiation.

Nuclear Medicine

Radiopharmaceutical Lab and Patient Preparation

Hospital Name	*Rumah Sakit Kanker Dharmais*
Date	Monday, 17/11/2017
Warning Sign	Available
Radionuclide Storage	Available
Wash Basin	Available
Equipment: Dose Calibrator Surveymeter	 Available Available
Radionuclide Labelling Procedure	Medicine and radionuclides are combined
Available Radionuclides	F-18, I-131, Tc-99m
Radionuclide Transfomation Shielding (Specific & Mobile)	Radionuclide is placed in a container which is placed in a box Available
Dose Calibration	Yes
Radionuclide Administration: Oral Injection	 Yes Yes
Examination Type: In Vitro In Vivo	 No Yes
Special Room for Patients with Radionuclides	Available

Questions

I-131 is labelled with:

- DTPA to examine the kidneys
- MDP to examine the bones
- MIBI to examine the heart

Tc-99m is labelled with

- MDP to examine the bones

Why is labelling done to the radionuclide?

Labelling is done so that the radionuclide can “target” a specific organ,.

Are there any other radionuclides used?

F-18.

Gamma Camera

Hospital Name	*Rumah Sakit Kanker Dharmais*
Date	Monday, 17/11/2017
Room Number	Gamma Camera Room No. 8
Estimated Area	5 x 6 m^2
Instrument Name Manufacturer: Model:	 GE Infinia Hawkeye
Equipment: Dose Calibrator Year of Installation / Age	 Available 2007
Collimator Type	HEGP, LEGP, Pinhole, LEHR
Distance from Patient	Dynamic; sensor allows the instrument to move automatically to accomodate patient

Parameters that affect the image quality of a gamma camera include:

Time per pixel, time, and the patient's size. The first two affect the image quality directly, with higher parameters leading to better image quality. The last determines the time it takes to complete the scan; taller patients take more time to scan completely.

SPECT and SPECT CT

Hospital Name	*Rumah Sakit Kanker Dharmais*
Date	Monday, 17/11/2017
Instrument Name Manufacturer: Model:	 GE Infinia Hawkeye
Pb-Equivalent Glass (Control Room)	Available

Nuclear medicine involves the use of radiopharmaceuticals to diagnose and/or treat diseases. The nuclear medicine observed at *Dharmais*, however, was for diagnosis.

Radiopharmaceuticals are labelled the morning they are to be used. Radionuclides such as F-18 are produced on-site, whereas several others are imported. F-18 production involves using a cyclotron to convert O-18 to F-18 with the use of accelerated H^+ ions. The radionuclide is then labelled; into FDG, for example. This involves using a ligand and then hydrolisis on the radionuclide, ultimately resulting in the elution of the radiopharmaceutical. QA is done by testing the resulting product's properties, such as its pH, energy, activity, etc.

Different radiopharmaceuticals bind to different parts of the body. This means that when a specific part of the body requires scanning, it is important to choose the correct radiopharmaceutical. For example, I-131-Iodide is used to examine the thyroid and Tc-99, MDP is used for a bone scan.

On the topic of bone scan, it was observed to be a full-body scan, where the whole body is scanned to find traces of metastasis. Suspicious areas where metastasis may be present appear dark and “cloudy” whereas the bones appear solid and white. These areas can be further scanned to discover where exactly the cancerous cells lie.

Radiation Therapy

Simulator

Hospital Name	*Rumah Sakit Kanker Dharmais*
Date	Monday, 22/9/2017
Room Name / Number	Simulation Room
Estimated Area	3 x 3.5 m^2 (panel), 4 x 7 m^2 (equipment)
Estimated Wall Thickness	28 cm
Laser Localization	Good, no displacement
Distance Indicator	Inside, near the system
Field Area Indicator	On the control panel
Gantry and Collimator Angle Indicator	Present
Crosshair Centering	Done on the panel, tolerance < 2 mm
Fluoroscopy Image Quality	Good
Emergency / Impact Avoidance	No internal system
Collimator Isocenter Rotation	On arm
Gantry Isocenter Rotation	On system
Table Isocenter Rotation	On floor
Axis Precision	Precise, system in good condition
Vertical Movement	Precise
Daily Check	Done in the mornings

Questions

What is the purpose of the daily check?

The equipment is tested daily to make sure that they are working adequately. If necessary, calibration should be done.

Why are a minimum of 3 points of measurement required? Explain.

This is required to ensure that the results of the testing are consistent.

Simulation

Modality	: External : LINAC

External

Patient Number	1
Cancer Type	Bladder cancer
Number of Beams / Fields	4 (every 90^o)
Irradiation Technique	SSD
Immobilization	No

Observe how the field, isocenter, gantry angle, collimator angle, and bolus are determined. Explain. They are measured and determined using the control panel, with adjustments then made on the equipment itself.

Patient Number	2
Cancer Type	Thyroid cancer
Number of Beams / Fields	1 (conventional 2D)
Irradiation Technique	SSD
Immobilization	No
Observe how the field, isocenter, gantry angle, collimator angle, and bolus are determined. Explain. They are initially determined with the control panel. Manual adjustments are made to the table rotation, gantry rotation, collimator rotation, table height, and horizontal position, in that order. The field is then readjusted using the control panel.	

Patient Number	1
Cancer Type	Brain metastasis
Number of Beams / Fields	2 (left and right)
Irradiation Technique	SSD
Immobilization	No
Observe how the field, isocenter, gantry angle, collimator angle, and bolus are determined. Explain. They are initially determined with the control panel. Manual adjustments are made to the table rotation, gantry rotation, collimator rotation, table height, and horizontal position, in that order. The field is then readjusted using the control panel.	

Bolus Production Room

Date	Monday, 22/9/2017
Name of Styrofoam Cutter	Siemen's (not functional)
Is the styrofoam cutting software connected directly to the TPS?	No
Name of Cerrobend Maker	Name unknown
Room Number	
Estimated Area	5.5 x 3.5 m^2
Ventilation	Good, plenty of air vents
Maximum Oven Temperature	400 ^{o}C
Equipment for Block Smoothing	Available
Bolus Material	Wax, styrofoam

Questions

Why is air circulation important?

Cerrobend and its fumes are toxic, and an exhaust is needed so that they do not accumulate in the room.

Why is cerrobend chosen over Pb?

Pb has a higher melting point and is thus more difficult to melt and reshape.

What is the function of a bolus?

A bolus is used to replace missing tissue or compensate for irregular tissue shape so that dose is spread evenly.

TPS Room

Date	6/10/2017
TPS Name	CX Eclipse (3D), Elekta PrecisePlan (2D)
Room Number	
Estimated Area	5 x 7 m^2
Planning	External therapy, LINAC, brachytherapy
PDD List	Available
TAR List	Available
TMR List	Availabe
TPS	2D (LINAC, brachytherapy), 3D (external)
Digitizer	Good condition
Brachytherapy Source Activity List	Available

External Radiotherapy Planning

Patient 1 (Male)

Cancer Type	Brain
Image	CT, simulator
Dosimetry	Direct calculation
Method	SSD
Number of Beams	4
Field Size (cm^2)	Field 1: 15.6 x 9.4 Field 2: 16.1 x 9.4 Field 3: 14.8 x 9.4 Field 4: 15.4 x 9.4
Gantry Angle	Field 1: 280^o Field 2: 80^o Field 3: 298^o Field 4: 110^o
Collimator Angle	Field 1: 0^o Field 2: 0^o Field 3: 0^o Field 4: 0^o
Target Depth (cm)	Field 1: 1.1 cm Field 2: 1.1 cm Field 3: 1.1 cm Field 4: 1.1 cm
Accessory	None
Isodose Curve: Target Volume: Organs at Risk:	 100%, mean 4000 cGy Left eye: Mean 216.5 cGy Brainstem: Mean 2696.7 cGy
Dose Prescription	20 cGy / fraction to the head (200 fractions)

Patient 2 (Female)

Cancer Type	Breast
Image	CT, simulator
Dosimetry	Direct calculation
Method	SSD
Number of Beams	4
Field Size (cm^2)	Field 1: 16 x 12.2 Field 2: 16 x 12.2 Field 3: 18 x 17.2 Field 4: 15.9 x 16.2
Gantry Angle	Field 1: 132^o Field 2: 312^o Field 3: 350^o Field 4: 140^o
Collimator Angle	Field 1: 0^o Field 2: 0^o Field 3: 0^o Field 4: 0^o
Target Depth (cm)	Field 1: 5 cm Field 2: 5 cm Field 3: 5 cm Field 4: 5 cm
Accessory	Breast board
Isodose Curve: Target Volume: Organs at Risk:	 100%, mean 4898.5 cGy Total Lung: Mean 1562.3 cGy Brainstem: Mean 1264.5 cGy Spinal cord: Mean 162.5 cGy
Dose Prescription	200 cGy / fraction to the breast (25 fractions)

Patient 3 (Male)

Cancer Type	Lung
Image	CT, simulator
Dosimetry	Direct calculation
Method	SSD
Number of Beams	4
Field Size (cm^2)	Field 1: 17.3 x 21.4 Field 2: 19.7 x 20.4 Field 3: 18.4 x 11.2 Field 4: 20.3 x 21.4
Gantry Angle	Field 1: 134^o Field 2: 30^o Field 3: 315^o Field 4: 210^o
Collimator Angle	Field 1: 0^o Field 2: 0^o Field 3: 0^o Field 4: 0^o
Target Depth (cm)	Field 1: 2.5 cm Field 2: 2.5 cm Field 3: 2.5 cm Field 4: 2.5 cm
Accessory	None
Isodose Curve: Target Volume: Organs at Risk:	 100%, mean 3405.8 cGy Spinal cord: Mean 617.9 cGy Heart: Mean 2105.1 cGy Esophagus: Mean 2105.1 cGy
Dose Prescription	200 cGy / fraction to the lung (20 fractions)

Patient 4 (Male)

Cancer Type	Rectum
Image	CT, simulator

Dosimetry	Direct calculation
Method	SSD
Number of Beams	4
Field Size (cm^2)	Field 1: 19.5 x 25.4 Field 2: 19.5 x 25.4 Field 3: 26.8 x 18.4 Field 4: 26.8 x 16
Gantry Angle	Field 1: 90^o Field 2: 270^o Field 3: 0^o Field 4: 180^o
Collimator Angle	Field 1: 0^o Field 2: 0^o Field 3: 0^o Field 4: 0^o
Target Depth (cm)	Field 1: 3.1 cm Field 2: 3.1 cm Field 3: 3.1 cm Field 4: 3.1 cm
Accessory	None
Isodose Curve: Target Volume: Organs at Risk:	 100%, mean 4847.5 cGy Bladder: Mean 617.9 cGy Rt femoral head: Mean 3093.8 cGy Lf femoral head: Mean 3362.4 cGy
Dose Prescription	200 cGy / fraction to the femur (25 fractions)

Patient 5 (Male)

Cancer Type	Nasopharyngeal
Image	CT, simulator
Dosimetry	Direct calculation
Method	SSD
Number of Beams	4
Field Size (cm^2)	Field 1: 10.6 x 11.2 Field 2: 10.9 x 11.2 Field 3: 10.3 x 22.1 Field 4: 10.3 x 22.1
Gantry Angle	Field 1: 90^o Field 2: 270^o Field 3: 0^o Field 4: 180^o
Collimator Angle	Field 1: 0^o Field 2: 0^o Field 3: 0^o Field 4: 0^o
Target Depth (cm)	Field 1: 2.5 cm Field 2: 2.5 cm Field 3: 2.5 cm Field 4: 2.5 cm
Accessory	None
Isodose Curve: Target Volume: Organs at Risk:	 100%, mean 3999.2 cGy Brain: Mean 4709 cGy Rt eye: Mean 255.7 cGy Lf eye: Mean 384.5 cGy Rt inner ear: Mean 807.7 cGy Lf inner ear: Mean 616.4 cGy Rt parotid: Mean 3961.7 cGy Lf parotid: Mean 3793.7 cGy Rt cochlea: Mean 1765.2 cGy Lf cochlea: Mean 1299 cGy
Dose Prescription	200 cGy / fraction to the head/neck area (20 fractions)

LINAC External Radiotherapy Planning

Patient 1 (Male)

Cancer Type	Rectum
Image	CT, simulator
Dosimetry	Direct calculation
Modality	10MV X-ray
Method	SSD (90 cm)
Number of beams / fields	4
Target Depth (cm)	Field 1: 10 Field 2: 7 Field 3: 15 Field 4: 1.5
Field Size (Collimator) (cm^2)	Field 1: 15 x 19 Field 2: 15 x 19 Field 3: 13 x 19 Field 4: 13 x 19
Weighting	Field 1: 25% Field 2: 25% Field 3: 25% Field 4: 25%
Gantry Angle	Field 1: 0^o Field 2: 180^o Field 3: 270^o Field 4: 90^o
Collimator Angle	Field 1: 0^o Field 2: 0^o Field 3: 0^o Field 4: 0^o
Accessory	None
Dose Prescription (Total)	50 cGy to the target
MU / Fraction	Field 1: 54 Field 2: 50 Field 3: 62 Field 4: 62

Patient 2 (Male)

Cancer Type	Rectum
Image	CT, simulator
Dosimetry	Direct calculation
Modality	10MV X-ray
Method	SSD (90 cm)
Number of beams / fields	4
Target Depth (cm)	Field 1: 10 Field 2: 7 Field 3: 15 Field 4: 1.5
Field Size (Collimator) (cm^2)	Field 1: 15 x 19 Field 2: 15 x 19 Field 3: 13 x 19 Field 4: 13 x 19
Weighting	Field 1: 25% Field 2: 25% Field 3: 25% Field 4: 25%
Gantry Angle	Field 1: 0^o Field 2: 180^o
Collimator Angle	Field 1: 0^o Field 2: 0^o
Accessory	None
Dose Prescription (Total)	100 cGy to the target
MU / Fraction	Field 1: 111 Field 2: 111

Patient 3 (Female)

Cancer Type	Thyroid
Image	CT, simulator
Dosimetry	Direct calculation
Modality	6MV X-ray
Method	SSD (89.5 cm)
Number of beams / fields	1
Target Depth (cm)	5
Field Size (Collimator) (cm^2)	15 x 15
Weighting	100%
Gantry Angle	0^o
Collimator Angle	0^o
Accessory	None
Dose Prescription (Total)	300 cGy to the target
MU / Fraction	306

Patient 4 (Female)

Cancer Type	Breast, thoracial and lumbar metastasis
Image	CT, simulator
Dosimetry	Direct calculation
Modality	6MV X-ray
Method	SSD (95 cm)
Number of beams / fields	2 (Field 1 = thorax, Field 2 = lumbar region)
Target Depth (cm)	Field 1: 5 Field 2: 6
Field Size (Collimator) (cm^2)	Field 1: 5 x 15 Field 2: 7 x 18
Weighting	Field 1: 50% Field 2: 50%
Gantry Angle	Field 1: 180^o Field 2: 180^o
Collimator Angle	Field 1: 0^o Field 2: 0^o
Accessory	None
Dose Prescription (Total)	400 cGy to each target
MU / Fraction	Field 1: 431 Field 1: 408

Radiotherapy involves the use of ionizing radiation from a source to kill cancerous cells. Radiotherapy can be done externally, with the use of a LINAC or other such instruments, or internally, as in brachytherapy. The radiotherapy methods available in *Rumah Sakit Kanker Dharmais* are external radiotherapy (3D and 2D) and brachytherapy.

The first method of radiotherapy observed in *Dharmais* is external radiotherapy that utilizes the simulator. Essentially, the instrument uses beams of electrons or x-rays to irradiate a target volume in the patient. Depending on the location and stage on the cancer, one or more beams may be required. A tumor located near the surface of the skin would only require one field (and thus, one beam) while one located deeper within a patient's body may require several to prevent dose from accumulating in structures other than the target.

The second method is brachytherapy, where sources are directly placed within the patient and in close proximity to the target. Brachytherapy can be temporary or permanent, with temporary brachytherapy usually being high-dose rate (HDR) brachytherapy and permanent brachytherapy usually being low-dose rate (LDR) brachytherapy. Additionally, brachytherapy can also be classified into two groups depending on placement: interstitial and contact. Interstitial brachytherapy involves placing the sources directly on the target organ, such as the breast or prostate, while contact brachytherapy involves placing the sources in some space near the target, such as a cavity, lumen, or externally.

Before treatment is carried out, a treatment plan is made. At *Dharmais*, treatment planning systems (TPSs) are used. Three systems were observed: a 3D system that accomodates intensity modulation, a 2D system for LINAC that doesn't accomodate intensity modulation, and a system for brachytherapy.

The first is a CX Eclipse. This system uses 3D images, such as those taken with CT, as a base to plan the treatment. First, the target volume is identified; the gross target volume (GTV) generally contains the main tumor and is to be given 100% of the prescribed dose. Other organs at risk (OARs) are then identified, so as to limit the dose delivered to them, in a process called contouring. The beams and beam strength are then adjusted so as to deliver the prescribed dose to the GTV while staying within certain dose limits for the OARs. This process is done manually by the medical physicist, and can take 20-40 minutes. The resulting treatment plan is then delivered to a doctor to be evaluated.

The second is an Elekta Preciseplan. This system makes use of 2D images, such as those taken with radiography. Since this planning system is in 2D, contouring works a bit differently than with the Eclipse. Should an irregularly-shaped (i.e. not rectangular) field be required, a digitizer is used to trace the field shape, with the image as reference. Either 6MV or 10MV x-rays are used depending on the depth of the tumor. 6MV x-rays are sufficient for tumors close to the surface of the skin, while tumors deeper within the patient require 10MV x-rays.

The third is an Oncentra. Treatment planning for brachytherapy generally involves determining where each individual source is placed. The volume irradiated by each source is displayed, and the goal is to minimize irradiation to surrounding tissues in general and important organs (i.e. testes, uterus) in particular. At *Dharmais* a fluoroscopic image was seen to be used as the basis of treatment planning.