

Version

5.0

ProjectionVRTM

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Student Workbook

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Introduction



This software is used to support radiography education. ProjectionVR™ is a fully featured simulation of radiographic positioning practice. This virtual radiography™ simulator is currently supporting students' studies at over 80 universities in USA, Canada, Sweden, Poland, Portugal, Saudi Arabia, South Africa, New Zealand, Finland, Australia and the UK.

This workbook contains 23 Laboratory sessions that can be used in class or for individual study. It is to be used in conjunction with the User Guide.

"... healthcare professionals... should learn skills in a simulation environment and using other technologies before undertaking them in supervised clinical practice."

Great Britain: Department of Health, 2011

Introduction to ProjectionVR™

This chapter contains four Labs that develop the students study skills, introduce concepts and terms and start to develop an appreciation of each object, its size and operation. Students are also made aware of the equipment handling skills they will need.

Lab 1 - ProjectionVR™ syllabus

Aims of Lab

- Familiarise the student with the computer lab environment.
- Introduce the syllabus and learning and teaching strategy.
- Resource the students with materials and a demonstration.

Lab 2 - ProjectionVR™ X-ray room

Aims of Lab

- Familiarise the student with navigation in a computer mediated 'first person' virtual environment.
- Introduce the student to the x-ray room. Describing the equipment and procedures carried out.

Lab 3 - Work-lists, studies, and exposures

Aims of Lab

- Introduce the student to the console and modality worklist.
- Describe the equipment and procedures carried out.
- Introduce basic radiographic terminology

Lab 4 - Receptors, side markers and patient movements

Aims of Lab

- Demonstrate radiographic image formation on a receptor by irradiation from an x-ray tube. Students produce their first radiograph.
- Introduce & use radiographic and anatomic terminology

Lab 1 - learning from a simulator

Outcomes

At the end of the Lab, students will be able to:

1. Record observations and reflections on a provided worksheet from simulated experiences to aid future learning
2. Access ProjectionVR™ (on the provided computers), the user guide and the student workbook.
3. List the aims of the syllabus
4. Clarify expectations with the tutor.

Activities

Distribution of the ProjectionVR™ user guide to each student

Tutor walk through of the user guide while students follow and take notes

Make notes from demonstration of ProjectionVR™ simulator

Notes: (radiography specific, continue overleaf if necessary)

What are the differences between using a simulation for learning and listening to a lecture?

What questions would you like to ask?

Mind map - draw a mind map to represent the radiography room

(Turn page landscape)

Description of the ProjectionVR™ simulation syllabus

This syllabus is for students with no, or very little, experience of radiographic equipment handling; it represents over 16 hours of learning time.

Aims of the syllabus

- Provide an authentic experience for the student that utilises experiential learning in a simulated, safe, environment facilitated by an academic radiographer to prepare for clinical practice.
- Expose the students to a faithful virtual radiographic model of geometry and physics; enabling exploration and familiarisation with radiographic constructs such as 'position', 'projection', 'exposure', 'receptor', 'scatter', 'dose', 'windowing', etc.
- Foster student peer-to-peer collaboration to minimise feelings of isolation and difference, during a time where new unfamiliar language and environment increase student anxiety.
- Provide accurate formative objective feedback from the simulator for learning.
- School students in radiographic procedure in a behaviourist model of learning, by repeating steps until competence demonstrated.

This workbook is split into seven chapters:

1. Introduction
2. Radiographic Technique
3. Radiographic Procedure
4. Radiographic Science one
5. Radiographic Science two
6. Radiographic Science three
7. Patient Practice

It is designed to be worked through in sequence, and the learning outcomes are therefore sequentially numbered from 1 to 81. However, it can also be dipped into as you see fit.

1. Introduction	LAB 1 (45 min) The ProjectionVR™ demonstration and syllabus
	LAB 2 (45 min) Navigating the ProjectionVR™ X-ray room
	LAB 3 (45 min) Sessions, visits, studies, projections and exposures
	LAB 4 (45 min) Moving receptors, side markers and the patient
2. Radiographic technique	LAB 5 (45 min) Patient positioning terminology
	LAB 6 (45 min) Radiographic projection terminology one
	LAB 7 (45 min) Radiographic projection terminology two
3. Radiographic Procedure	LAB 8 (45 mins) Radiographic procedural sequence
	LAB 9 (45 min) Image criteria terminology & process
4. Radiographic Science one	LAB 10 (45 min) Magnification
	LAB 11 (45 min) Distortion one
	LAB 12 (45 min) Distortion two
	LAB 13 (45 min) Source Image Distance (SID)
5. Radiographic Science two	LAB 14 (45 min) Effect of Tube Charge on X-ray quantity and quality
	LAB 15 (45 min) Effect of Tube Charge on X-ray penetration
	LAB 16 (45 min) Effect of Tube Voltage on X-ray quantity and quality
6. Radiographic Science three	LAB 17 (45 min) Effect of irradiated part thickness on the image
	LAB 18 (45 min) Effect of beam restriction on the image
	LAB 19 (45 min) Scatter rejection using air-gaps
	LAB 20 (45 min) Use and pitfalls of scatter rejection grids
7. Patient Practice	LAB 21 (45 min) Supine abdomen radiography
	LAB 22 (45 min) Supine chest radiography
	LAB 23 (45 min)
	Formative assessment

Lab 2 –ProjectionVR™ room

Outcomes

At the end of the Lab, students will be able to:

5. Run ProjectionVR™ and manipulate their viewpoint in the radiographic room
6. Correctly name objects in the radiography room
7. Use of 'locks' and 'detents' to move a virtual x-ray tube gantry, table and Bucky
8. Name and use a virtual light beam diaphragm to collimate an x-ray beam

Activity:

- a) **Work individually or in pairs to read chapters 1 and 2 of the user guide at your own pace and try out the software controls mentioned.**

Notes: (radiography specific, continue overleaf if necessary)

What questions would you like to ask?

- b) **Review the pictures on the next page. What are the following objects?**

A

E

B

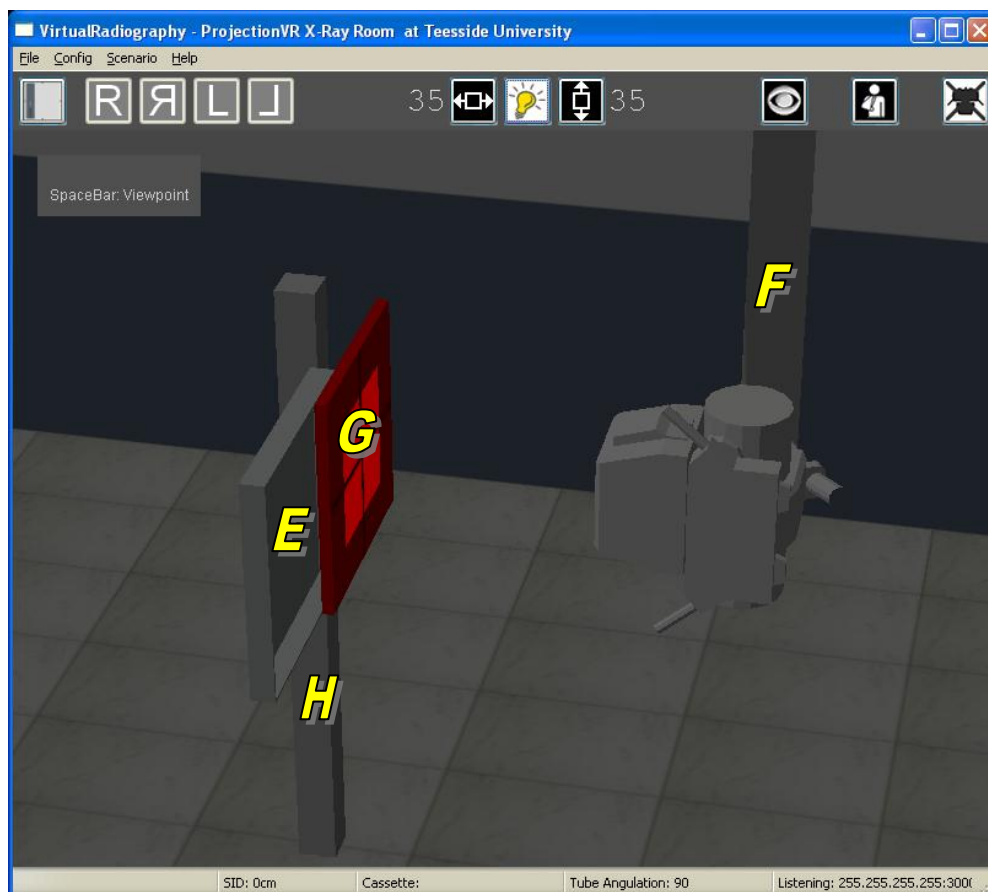
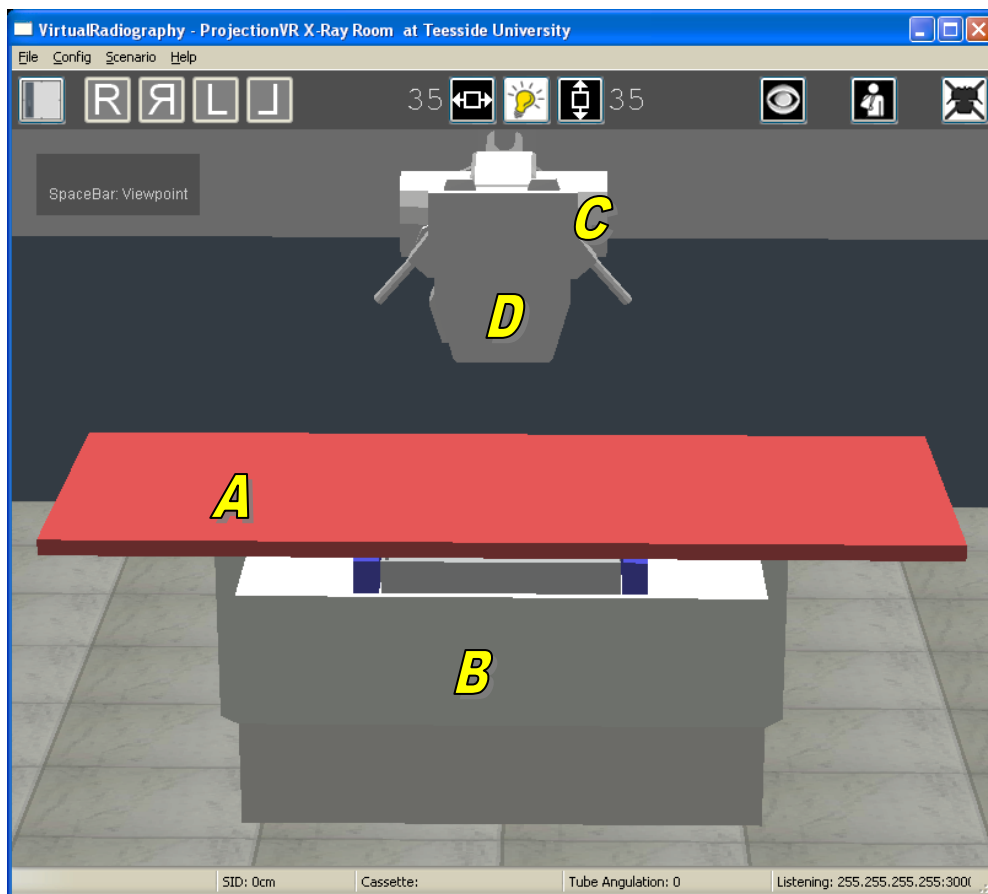
F

C

G

D

H



Lab 3 - Sessions, visits, studies, projections and exposures

Outcomes

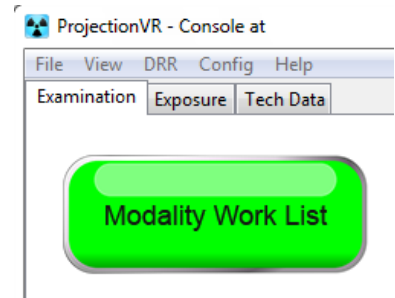
At the end of the Lab, students will be able to:

9. Use the Modality Worklist (MWL) to select from the available sessions, visits, and studies
10. Chose a projection from the Automatically Programed Radiography (APR) database
11. Alter focus, tube voltage (kV), tube charge (mAs), and care filter values from defaults
12. Select a receptor
13. Prepare the x-ray tube and describe the stator noise
14. Make a test exposure

Activity: (console instructions in blue, room instructions in red)

a) **Test Exposure**

- i) On the console, select the 'Study Tab' - Select 'Modality Work List...'



- ii) Select visit v0183 , 'Stepwedge' from Session one.

Modality Work List

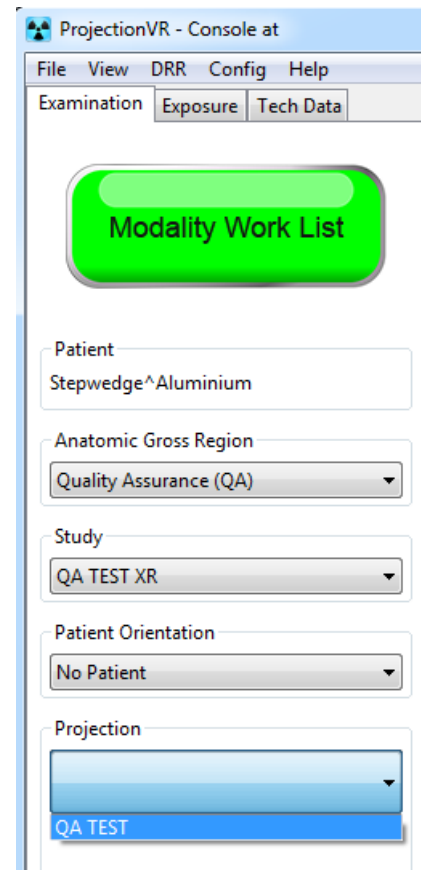
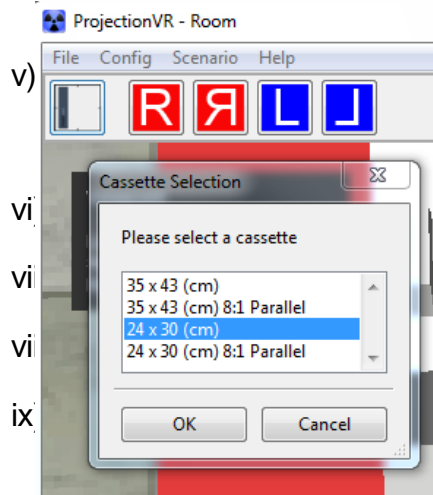
	Visit.	Accession No.	Patient ID	Patient Name	Transport	DOB	Sex	Study
1	V0006	ac0006	D0400003786	Simpson^Marjorie^Jacqueline^Mrs	Walking	19 Mar 1976	Female	Whole Spine XR (Scoliosis)
2	V0055	ac0068	D0400003786	Simpson^Marjorie^Jacqueline^Mrs	Walking	19 Mar 1976	Female	Knee XR Lt
3	V0098	ac0115	D0400003786	Simpson^Marjorie^Jacqueline^Mrs	Walking	19 Mar 1976	Female	Chest XR
4	V0110	ac0127	D0400003786	Simpson^Marjorie^Jacqueline^Mrs	Walking	19 Mar 1976	Female	Chest XR
5	V0114	ac0132	D0600003786	Simpson^Penelope^Mona^Mrs	Trolley	15 Jul 1929	Female	Abdomen XR
6	V0120	ac0138	D0800003786	Simpson^Abraham^Jedediah^Mr	Trolley	08 Sep 1926	Male	Abdomen XR
7	V0132	ac0155	D0300003786	Flanders^Edna^^Ms	Chair	01 Dec 1980	Female	Facial Bones XR
8	V0160	ac0193	D0900003786	Simpson^Homer^Jay^Mr	Chair	12 May 1974	Male	Ankle XR Lt
9	V0168	ac0206	D0700003786	Bouvier-Terwilliger-Hutz-McClure-Stu-Simpson-D'Amico^Selma^^Mrs	Trolley	04 Apr 1968	Female	Abdomen XR
10	V0182	ac0224	D0100003786	Slab^PMMA	Not Specified	04 Aug 2006	Other	QA TEST XR
11	V0183	ac0225	D0200003786	Stepwedge^Aluminium	Not Specified	04 Aug 2006	Other	QA TEST XR

Other
Other

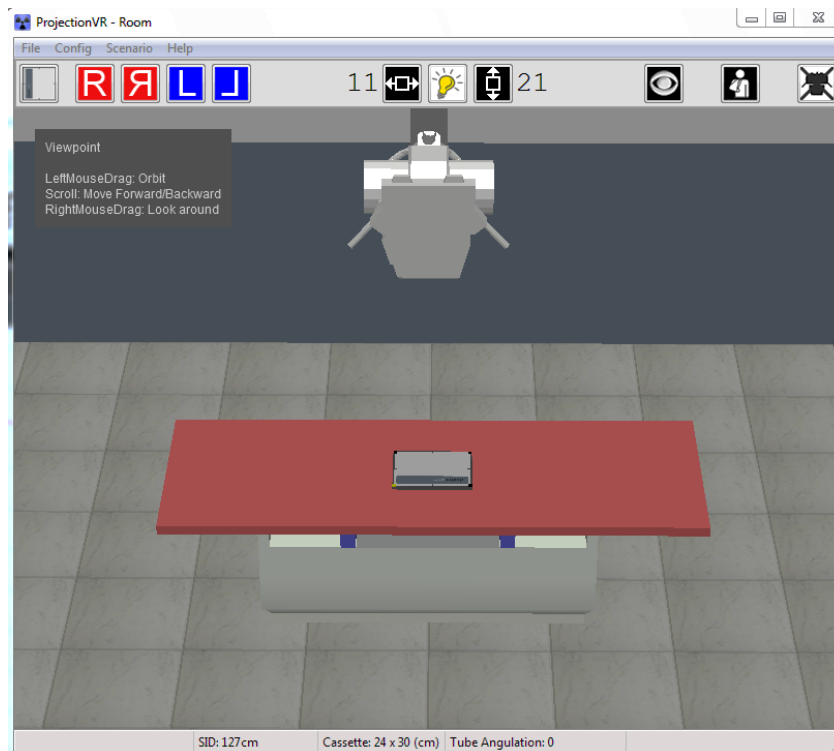
Make Selection Cancel Help

iii) To complete the Study set up, select Quality Assurance (QA) test as the projection.

iv) In the x-ray room, select the largest receptor size (at the top of the list).

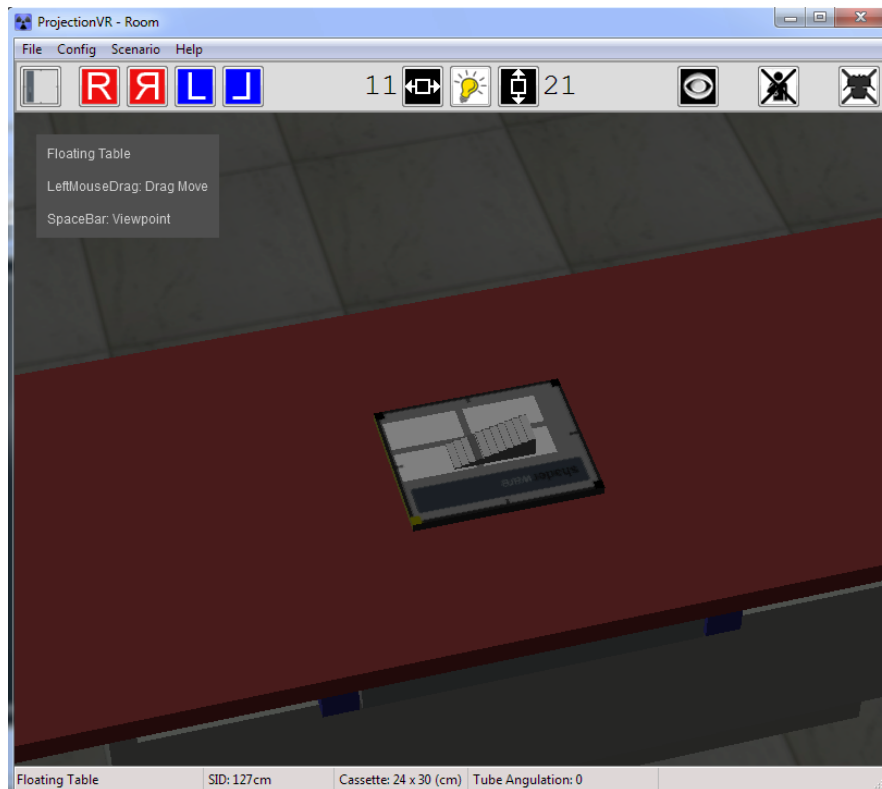


v) In the room, place the receptor on the table top.



vi) Admit the test object by selecting the 'patient' icon  on the tool ribbon, Position it on top of the receptor.

- vii) Turn on the collimation light using the LBD controls.

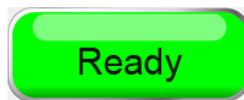


- viii) Orbit the scene to see where the x-ray beam is aiming. Move the floating table top until the cross (indicating the central ray) is aiming through the middle of the stepwedge and the collimation light is nicely framing the stepwedge on the receptor.

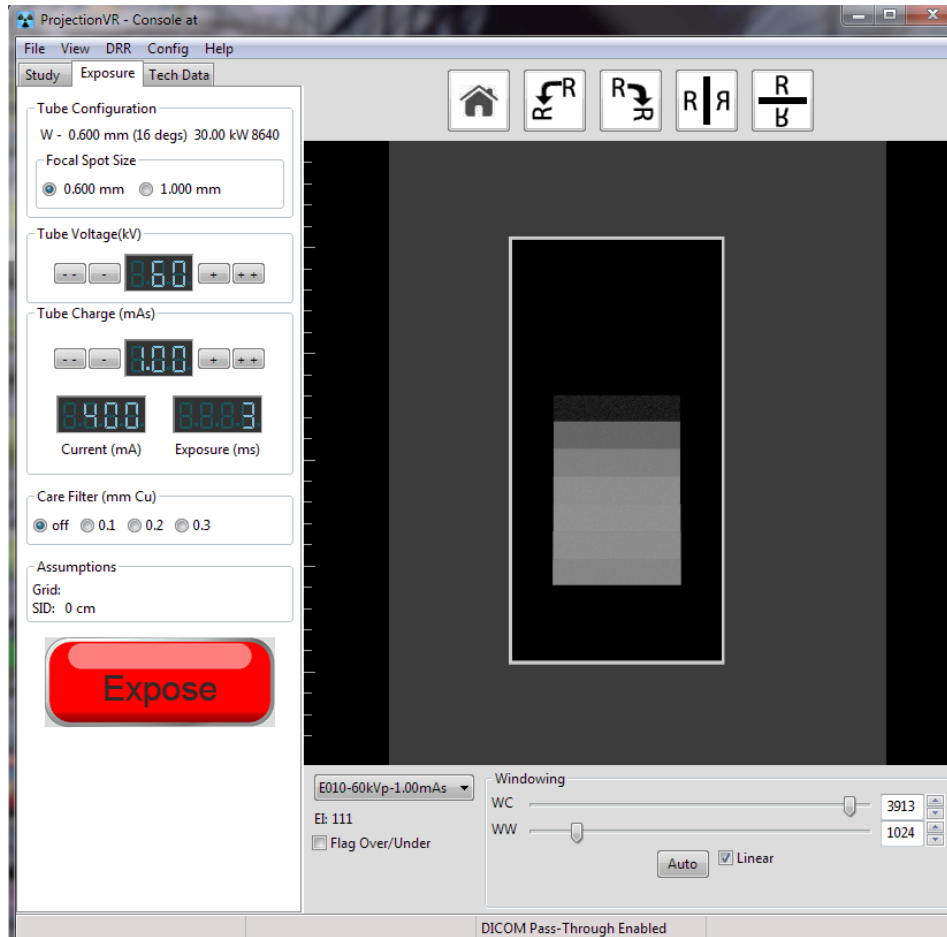
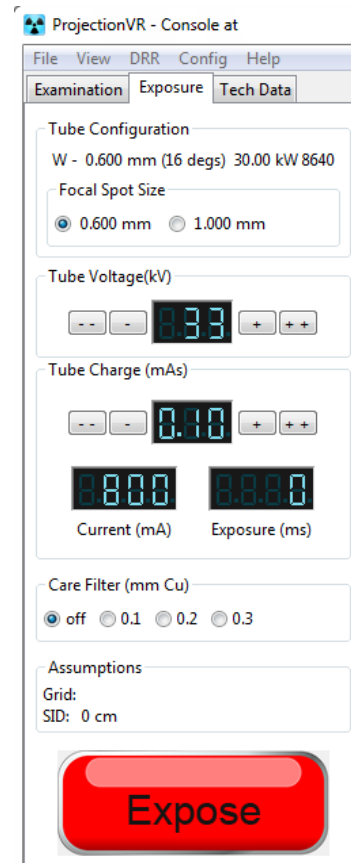


ix) Select the 'expose' tab on the console. Change the Tube Voltage to 65,000 Volts (65kV) and the Tube Charge to 1.00 milliAmpere x seconds (1.00 mAs)

x) Hover the mouse pointer over the 'expose' button. When 'prep-ready' is declared, left click on the expose button and release to initiate the exposure.



xi) Review your first virtual radiograph. The white rectangle indicates the edge of the area of irradiation. The black areas inside this are where the receptor received a 'large' dose of x-radiation, the lighter areas indicate that something stopped some of the x-rays getting to the receptor. The pattern is consistent with the pattern of the steps in the aluminium.



b) **Questions**

1. How many steps did you carry out. Do you think the order important? Why?
2. What is a Modality Worklist (MWL)? How do patients names get on the list?
3. What does Automatically Programed Radiography (APR) database hold? List some of the factors.
4. What happens when you 'Prepare' the x-ray tube?

Make notes:

What questions would you like to ask?

Lab 4 - Receptors, side markers and patients

Outcomes

At the end of the Lab, students will be able to:

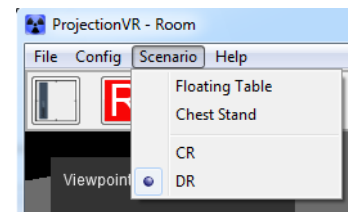
5. Place a receptor ON an erect Bucky
6. Annotate a receptor with a correctly oriented side marker
7. Admit the patient and move them into position
8. Collimate to a given anatomical area

Activity:

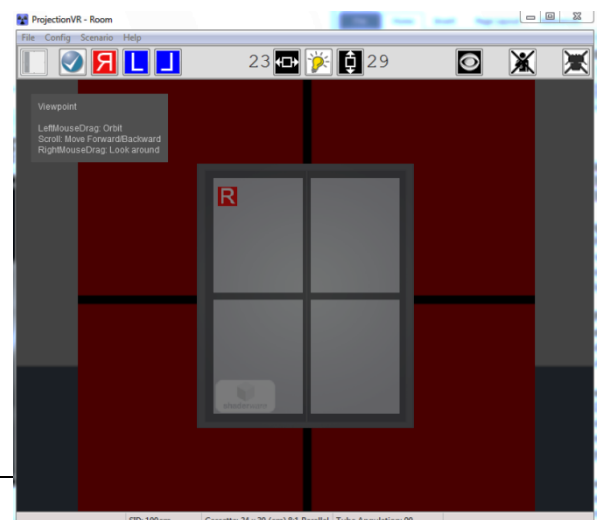
a) Shoulder Study

- i) On the Modality Worklist, select Session 10 and select Patricia Bouvier-Swisher's visit for Rt Shoulder Study (V0036). *"Pain and limited range of motion at Rt Shoulder. Local swelling. ?Giant Cell Tumour"*
- ii) The patient transport is 'Chair', so the patient will probably be able to stand. 'Patient orientation' will therefore be 'Erect'. Set 'AP Neutral Rotation' as the projection.

- iii) In the room, use the remote setting to quickly position the tube and gantry correctly for an erect patient orientation. Select 'Chest stand' from the 'Scenario' menu



- iv) Select a 24 x 30cm (12 x 10in) 8:1 Parallel receptor, and place it, in the centre, on the erect Bucky surface with the yellow edge uppermost.
- v) Select the 'R' side-marker and place it on the receptor to appear on the lateral aspect of the patient.
- vi) Move the x-ray tube until SID is 100cm (40in). (depress the F key to unlock the tube)
- vii) Move the tube down so it lines up roughly with the receptor (D key)
- viii) Aim and collimate to just within the receptor boundaries using the LBD



ix) Admit the patient into the x-ray room



x) Position patient, receptor, chest stand and tube to include right shoulder region as shown (***make sure you orbit the scene to check***)

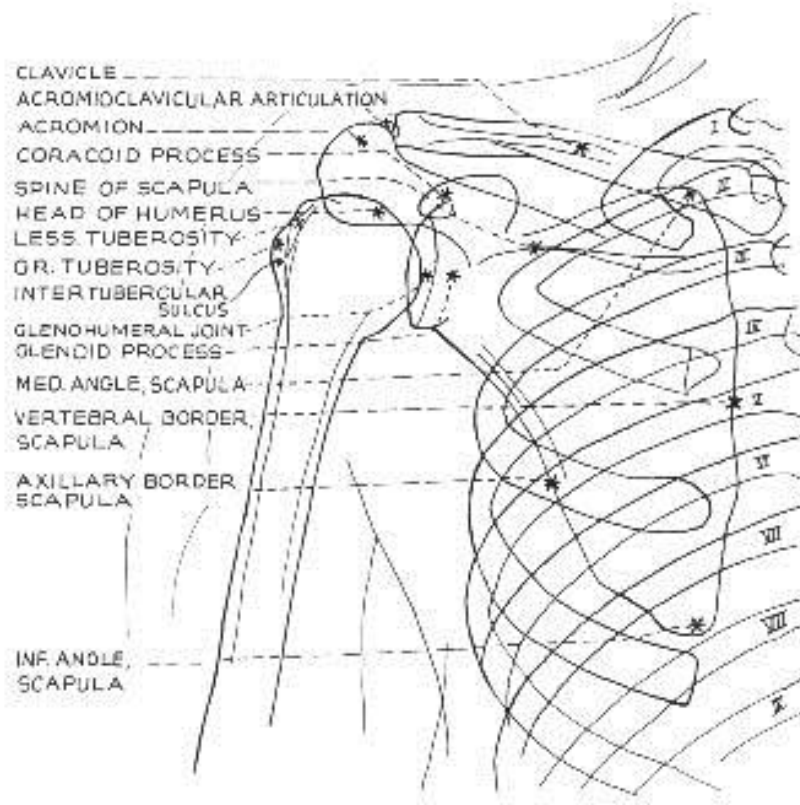


xi) Check tube voltage is 70kV and tube charge is 6.3mAs; expose the patient and review the result.

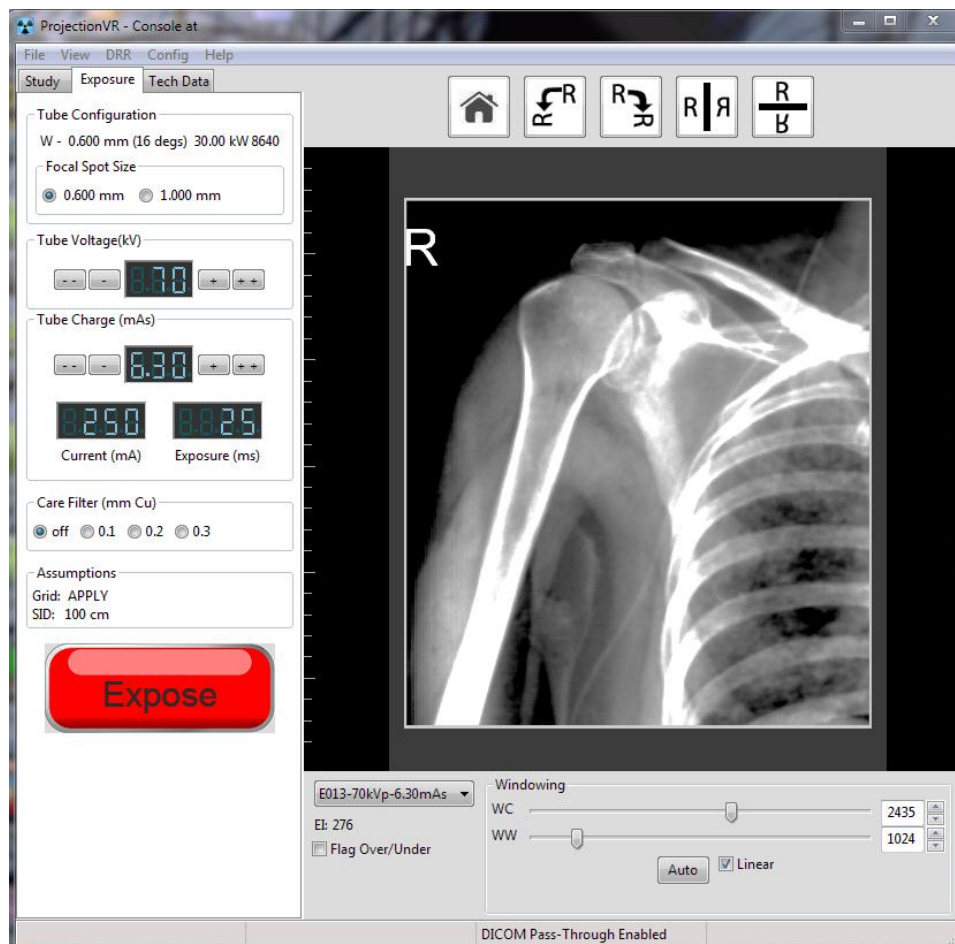
xii) View the image in the image pane, how does it compare to the line drawing overleaf?

Make notes:

What questions would you like to ask?



Meschan, I. 1951 *An Atlas of Normal Radiographic Anatomy* Saunders, London



b) **Questions**

What does the light beam diaphragm (LBD) control and what should the maximum setting depend on?

Which key unlocks the tube height movement?

Which key unlocks the tube movement toward and away from the erect bucky/

Why do we need a R marker? Why is the marker where it is?

c) **There are no further Studies in this attendance, discharge the patient**



Radiographic Technique

This chapter contains three Labs that discuss radiographic positioning and projection, introducing terms and concepts.

Lab 5 - Patient positioning terminology

Aims of Lab

- Discuss patient positioning in isolation
- Practice simple 'out of Bucky' Studies

Lab 6 - Radiographic projection terminology one

Aims of Lab

- Understanding the principles of radiographic projection
- Practice simple 'out of Bucky' Studies

Lab 7 - Radiographic projection terminology two

Aims of Lab

- Begin to build a lexicon of radiographic projection terms
- Practice simple 'out of Bucky' Studies

Lab 5 - Patient positioning terminology

Outcomes

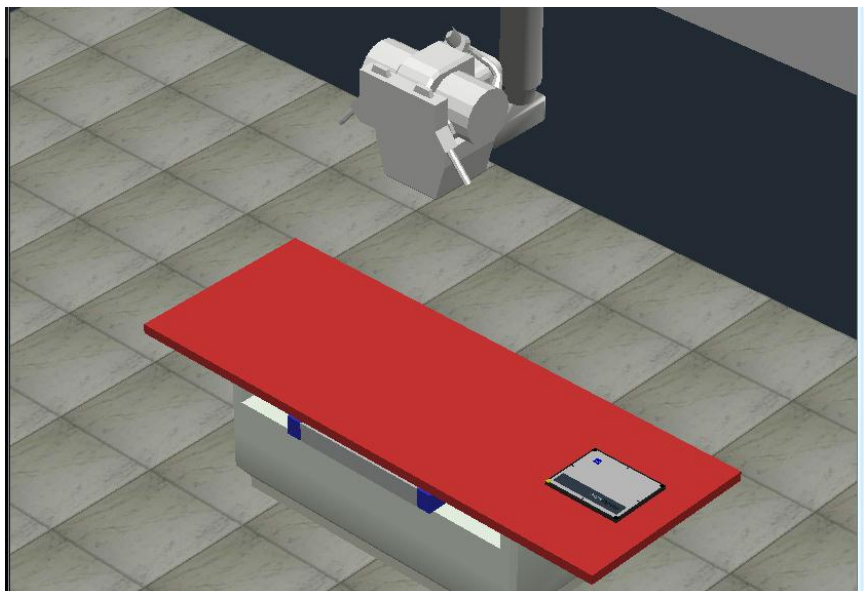
At the end of the Lab, students will be able to:

9. List the named general and specific patient positions
10. Select the correct patient pose from the three available
11. Set receptor type, size, SID, tube charge and tube voltage values given
12. Collimate, within the receptor, to a given anatomical area
13. Select the correct side marker and position it correctly
14. Alter the window centre and width to provide bone detail

Activity:

a) Left Knee Study

- i) In the Console modality worklist, select Session 9, Homer Simpson, visit v0040. *"Bony swelling over tibia - increasingly painful in last 6 to 12 weeks. Increased skin temperature around the bone. ?Aneurysmal Bone Cyst"*
- ii) As it is the lower limb, the patient will likely be asked to get up onto the table to examine their knee. Select Recumbent and patient position.
- iii) Select the 'AP' Projection
- iv) In the room, check that the tube is in place pointing down over the table (Scenario\Floating Table)
- v) Select the 24 x 30cm (12 x 10in) receptor and place it at the foot of the table.
- vi) Choose and position the 'L' side marker

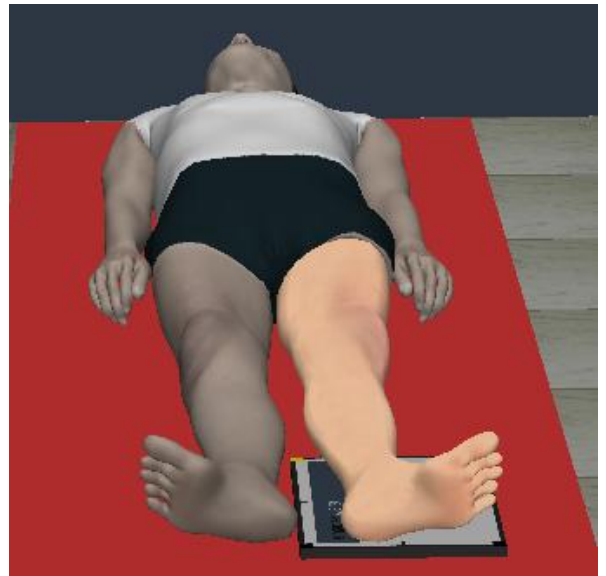


vii) Admit the patient into the x-ray room and lay them on the table

viii) Select the 'left leg only' pose from the three available by clicking on the patients foot

ix) Raise the table to working height (D key) and check the SID is 100cm (40in)

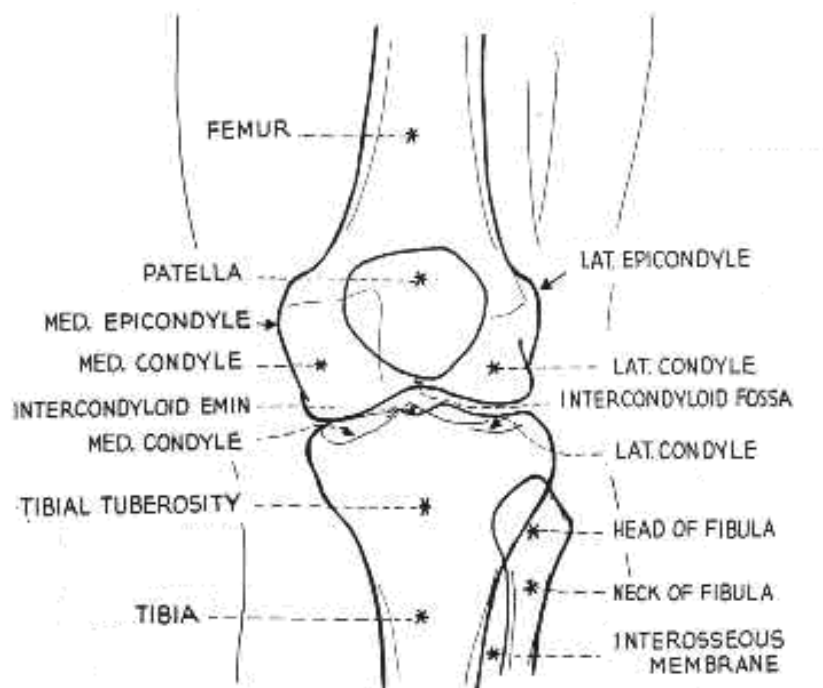
x) Position patients left leg, receptor, floating top table and x-ray tube to include the Lt. Knee as shown



xi) Select a tube voltage of 60 kV and a tube charge of 3.2 mAs

xii) Expose the patient

xiii) Review image



Meschan, I. 1951 *An Atlas of Normal Radiographic Anatomy* Saunders, London

Make notes:

What questions would you like to ask?

- b) **Extension activity. Most radiographic studies need two images to completely examine the anatomy. Continue the Study of the Left Knee by taking a left lateral projection**

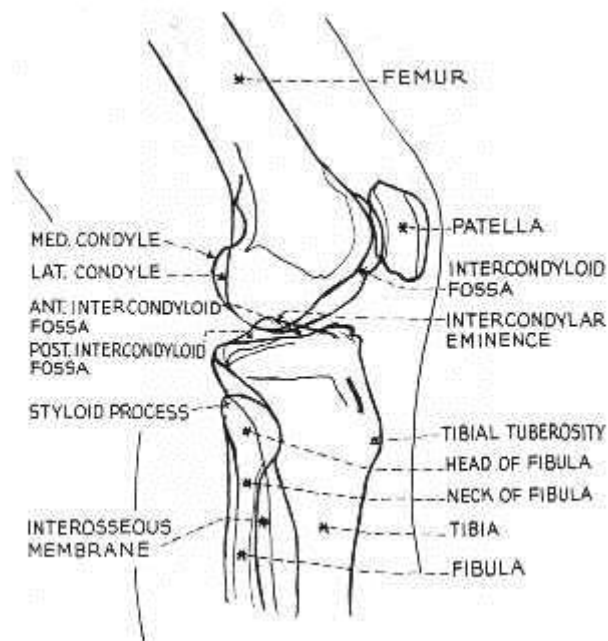
xiv) On the console, select 'Lateral' as the projection.

xv) In the room, rotate the patient onto their left side

xvi) Position patients left leg, receptor, floating top table and x-ray tube to include the Lt. Knee as shown in the diagram overleaf



xvii) Review image



Meschan, I. 1951 *An Atlas of Normal Radiographic Anatomy* Saunders, London

c) **Discuss Patient positions**

Many radiography books are confused on this point. However, it is important to be specific. Position only refers to posture and gravity. It only refers to the patient, not the patient table or x-ray tube; one can describe a patient's position without any mention of the equipment.

<p>With respect to gravity</p> <ul style="list-style-type: none"> • Erect (Upright) <ul style="list-style-type: none"> ○ Anatomic ○ Weight-bearing • Semi-erect (Fowlers, Semi-recumbent) • Recumbent <ul style="list-style-type: none"> ○ Supine (Dorsal Decubitus) ○ Prone (Ventral Decubitus) ○ Trendelenburg ○ Laterals (Right/Left Decubitus) ○ Obliques <ul style="list-style-type: none"> ▪ Left/Right Prone Decub. ▪ Left/Right Supine Decub. 	<p>Notes:</p> <p>1) When a patient is stood erect, there is no way of telling where they are facing using positioning language</p> <p>2) A seated patient is erect, semi-erect or recumbent depending on what body part is being examined. So you might say "the patient was seated with the right hand recumbent" or "the patient was seated erect for examination of their facial bones"</p>
<p>Specific posture</p> <ul style="list-style-type: none"> • Flexion/Extension • Internal/External rotation • Moving (auto-tomography) • Stress 	<p>3) Both recumbent and decubitus mean 'lying down'</p>
<p>Hand/wrist</p> <ul style="list-style-type: none"> • Norgaard (Ball-catcher's) • Stecher • Ulna/Radial deviation 	<p>4) Very rarely the patient is asked to move while being exposed. This is called Auto-tomography. It is used to blur structures that are projected over areas of interest, e.g. ribs or mandible</p>
<p>Elbow/Forearm</p> <ul style="list-style-type: none"> • Supinated • Pronated 	<p>5) Sometimes patients are asked to hold weights or bear their own weight to test joints. A special case is where a joint is stressed with lateral forces while exposed.</p>
<p>Foot</p> <ul style="list-style-type: none"> • Inversion/Eversion 	
<p>Pelvis and Hips</p> <ul style="list-style-type: none"> • Frog-Leg (Cleaves) 	
<p>Cervical Spine</p> <ul style="list-style-type: none"> • 'Open Mouth' • 'Swimmers' 	

Lab 6 - Radiographic projection terminology

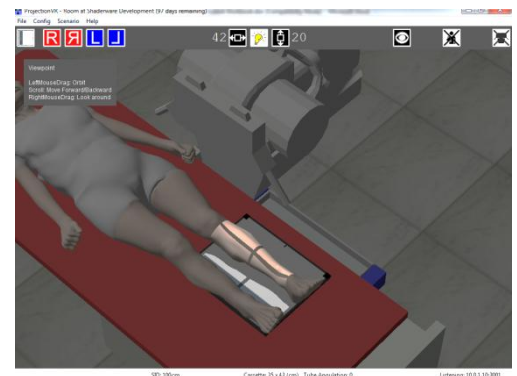
Outcomes

At the end of the Lab, students will be able to:

15. List the named radiographic projections and understand the need for orthogonal projections
16. Tailor receptor position, collimation and side marker placement to achieve required aesthetic outcome
17. Apply basic anatomical knowledge to achieve the required projection
18. Manually alter receptor size, SID, mAs and kV values given

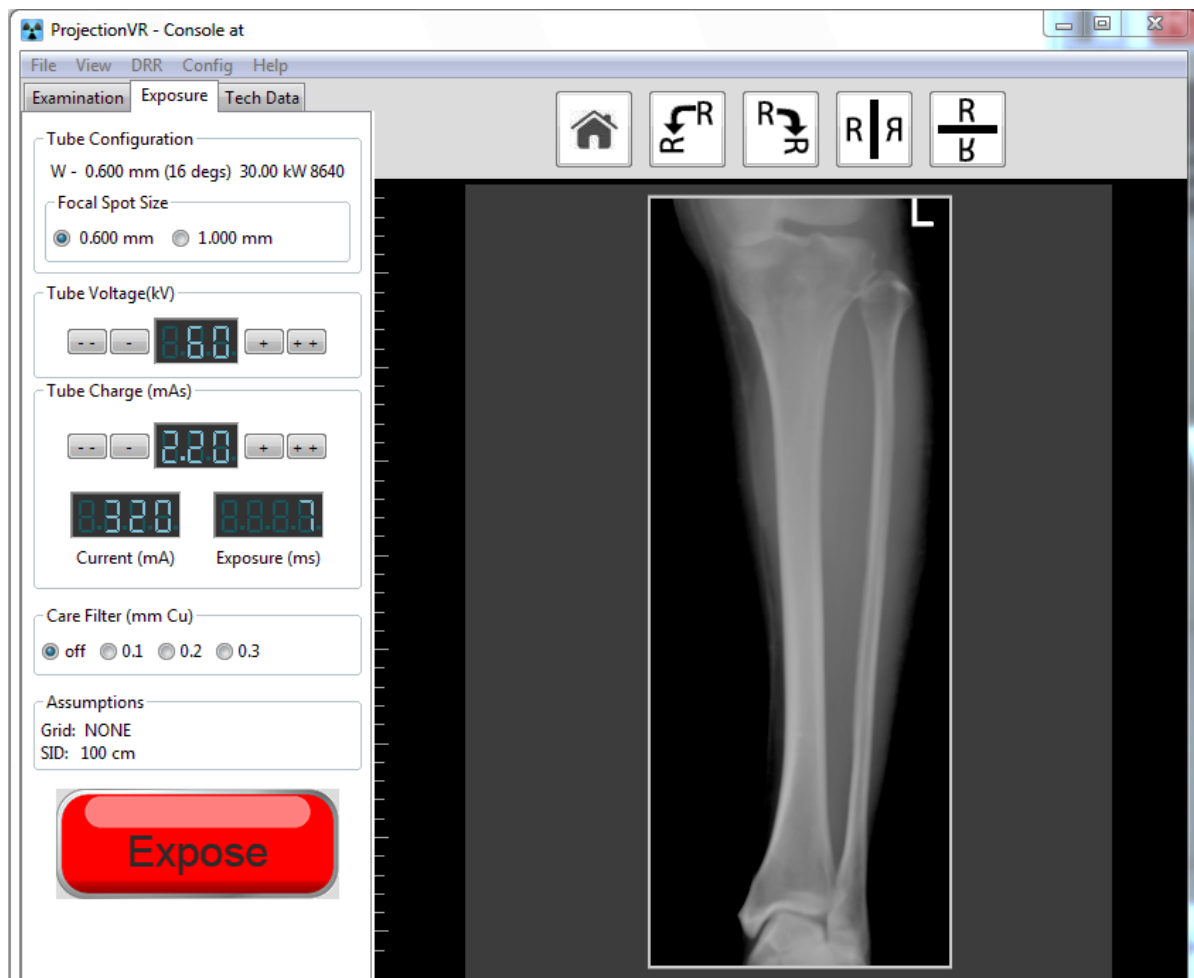
a) Left Leg Study

- i) On the Modality Worklist, pick session 6, visit v0166, Pattie Bouvier for a Left Leg study *"Bitten by dog 3/7. Local inflammation in gastrocnemius. ?FB In Wound ?Tooth Fragment ?"*
- ii) Set the projection to be 'AP for Tibia and Fibula' or 'Lateral'
- iii) In the room, choose the 35x43cm (17x14in) receptor and place it at the foot of the table on the table top.
- iv) Pick the L side marker and position it on what will be the Lateral aspect of the patient
- v) Admit the patient into the x-ray room and lay them supine on the patient table
- vi) Cycle through the available poses and choose 'left lower limb only'
- vii) Raise the table to working height.
- viii) Pose the patient's lower limb and position the receptor, table top and x-ray tube to include the anatomy as shown, with the collimation following the long axis of the long-bone

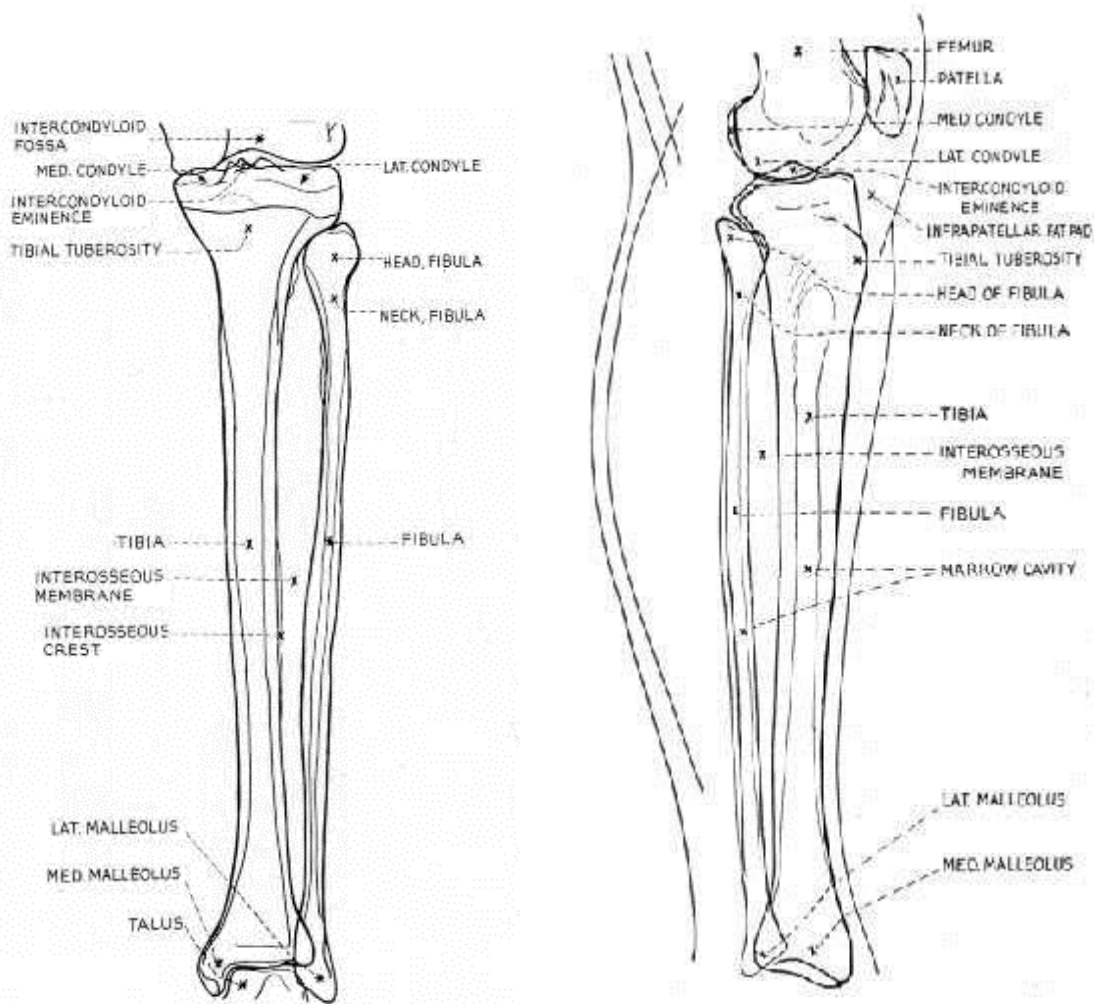


ix) Select a tube voltage of 60 kV and a tube charge of 2.2 mAs and expose the patient

x) Review image



b) Extension activity. Repeat these steps to achieve the lateral projection



Meschan, I. 1951 *An Atlas of Normal Radiographic Anatomy* Saunders, London

c) Discuss Projections

Projection specifies a) the direction of travel of the x-rays, specifically the central ray, through the patient, so it is described in terms of the surfaces of the patient and b) the position of the receptor plane, again, in respect to the patient. The patient surfaces mentioned include: Anterior, Posterior, Oblique, Dorsal, Palmar/Plantar, Lateral, Medial, Inferior, and Superior. The projection is named for the surfaces in the order x-rays are incident on them.

If the receptor is parallel to the patient's axial plane, then the projection is called 'Axial', but this is where the logic breaks down. If the receptor is parallel to the patient's sagittal plane it is called 'Lateral', being parallel to the patient's coronal plane is simply ignored. There is an assumption that the receptor plane will be perpendicular to the central ray, otherwise an angle away from perpendicular will be given.

Lab 7 - Radiographic projection terminology

Outcomes

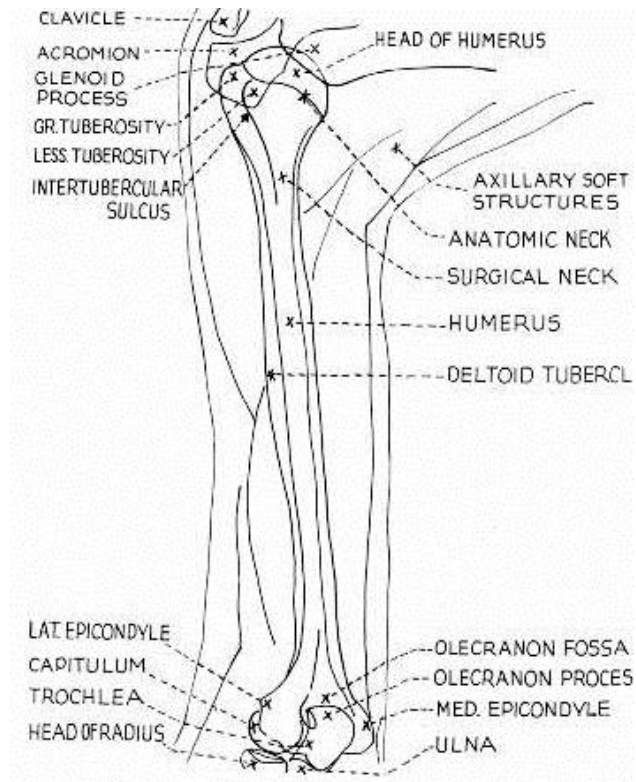
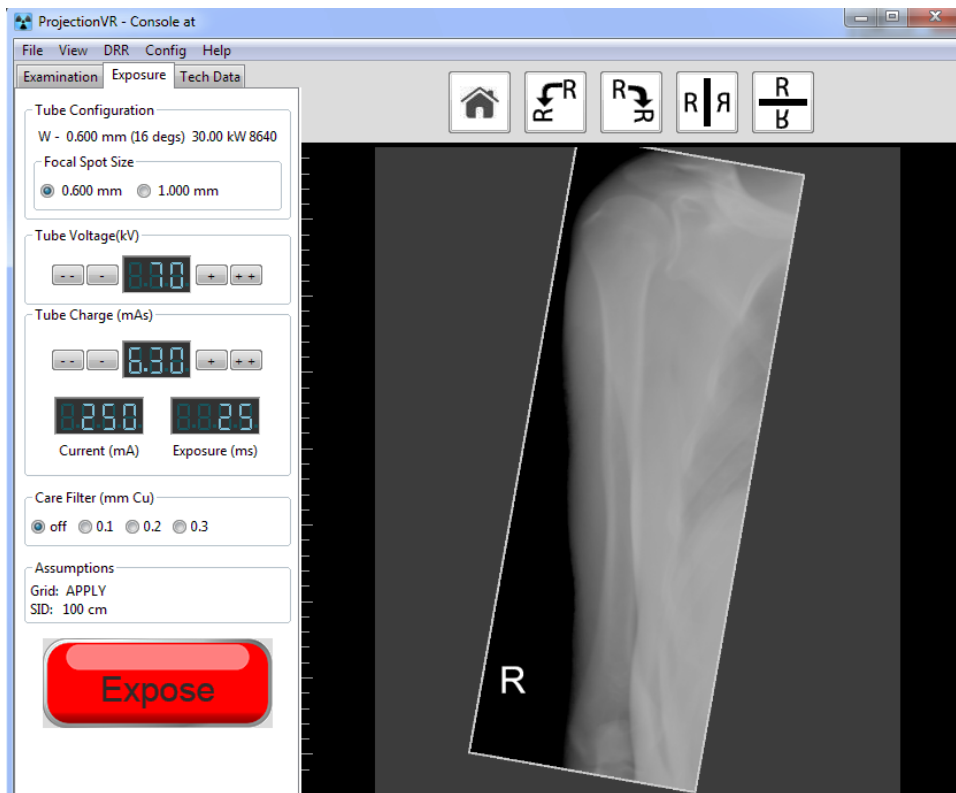
At the end of the Lab, students will be able to:

26. List the named radiographic projections and understand the need for orthogonal projections
27. Use the LBD rotation to protect the patient
28. Choose the correct projection according to the path of the central ray through anatomy

a) AP Humerus Study

- i) On the Modality Worklist select Session 7, Visit V0151 (Homer Simpson for a Rt Humerus “Sudden pain during functional rehabilitation of the upper extremity. ?# NOH”)
- ii) Set projection to be ‘AP’ (or ‘Lateral...’)
- iii) Select a 35 x 43 8:1 parallel receptor and place it ON the erect Bucky surface.
- iv) Select the R side marker
- v) Move the x-ray tube to the required position (use scenario to remotely move the gantry and tube assembly).
- vi) Check SID is 100cm (40in)
- vii) Admit the patient into the x-ray room
- viii) Position the patient to achieve the required radiographic projection
- ix) Collimate to include the R Humerus as shown in the diagram
- x) Rotate the LBD to protect the patient
- xi) Expose the patient using exposure factors of 70 kV, 6.3 mAs
- xii) Window the image to see the Humerus along its whole length





Meschan, I. 1951 *An Atlas of Normal Radiographic Anatomy* Saunders, London

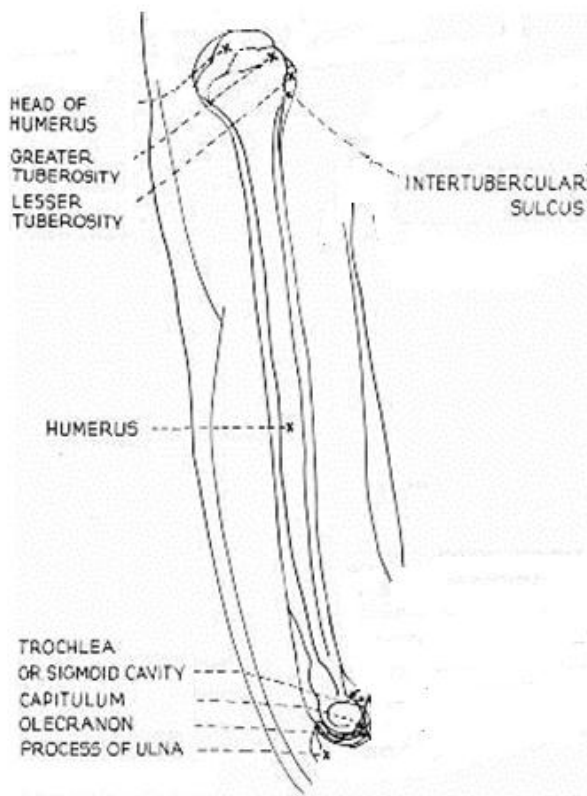
b) Lateral Humerus Study

- xiii) Repeat steps iv-ix, selecting 'Humerus: Lateral (Scapula Y)'
- xiv) Make sure you use an inverted R marker

Make notes:



a) Review images



b) Questions

Are these projections AP and Lateral?

Are they Orthogonal?

c) Discuss Projections

As in this case, the whole patient's body does not have to be in a standard pose to allow the correct projection of a single limb to be achieved.

On the next page are some notes concerning projections or methods. This gives some commonly named projections as well.

Antero-Posterior (AP) Postero-Anterior (PA) Medio-Lateral (Lat) Latero-Medial (Lat) Antero-Posterior Oblique <ul style="list-style-type: none"> • Right Posterior Oblique (RPO) • Left Posterior Oblique (LPO) Postero-Anterior Oblique <ul style="list-style-type: none"> • Right Anterior Oblique (RAO) • Left Anterior Oblique (LAO) Axial <ul style="list-style-type: none"> • Inferosuperior (IS) • Superoinferior (SI) 	<i>Notes:</i> 1) Projection does not specify the patient's posture or how the patient is oriented with respect to gravity; that is position. 2) So called 'Lateral' projections of upper limbs are nearly always Latero-Medial projections, with the medial aspect resting against the receptor. 3) The only 'true' Axial projections are where the receptor is parallel to the patients' axial plane. Where this is not the case the projection is named a 'half-axial' or as a standard projection with the addition of '...with cranial (or caudal) angulation'. In these cases the central ray is not perpendicular to the plane of the receptor. 4) There are eponymous projections, named after the first person to describe them, e.g. 'Townes' these can be called projections or methods (view is NEVER correct) 5) An oblique projection can be taken by moving the patient with a fixed central ray OR angling the central ray, e.g. a trauma patient will be supine when having 'trauma obliques'. Unless special equipment is used, the central ray will not be perpendicular to the receptor during these projections. 6) Despite possible complex angulations of the central ray and receptor to obtain a simple projection when a patient is immobile, the resultant projection will still be called by it's simple name
Specific <ul style="list-style-type: none"> • Tangential 	
<i>Foot/toes</i> <ul style="list-style-type: none"> • Dorsi-plantar (DP) 	
<i>Hand/fingers/thumb</i> <ul style="list-style-type: none"> • Dorsi-palmar (DP) • Robert's Method* 	
<i>Elbow</i> <ul style="list-style-type: none"> • Coyle Method 	
<i>Shoulder</i> <ul style="list-style-type: none"> • Neer Method • Garth Method 	
<i>Pelvis and Hips</i> <ul style="list-style-type: none"> • Clements-Nakayama Method • 'Lateral shoot through' (Danelius-Miller Method) 	
<i>Skull/Face</i> <ul style="list-style-type: none"> • Townes Method (Half-Axial) • 'Reverse Townes' (Haas Method) • Occipito-Frontal (OF) (Caldwell Method) • Optic Foramina (Rhese Method) • Schuller method (TMJ) • Sub-Mento Vertex (SMV) • Verto-Mental 	

Radiographic Procedure

This chapter contains two Labs that develop the student's procedural awareness.

LAB 8 - Radiographic procedural sequence

Aims of Lab

- Understanding both table top and table Bucky procedural steps for projection radiography
- Practice simple Bucky Studies

LAB 9 - Image criteria terminology & process

Aims of Lab

- Point out the task of internalising radiographic criteria for all Studies
- Explain the fundamental nature of image critique and the AABCS Method
- Practice 'hanging' a radiograph
- Make students aware of DICOM and DICOM image tools

LAB 8 - Radiographic procedural sequence

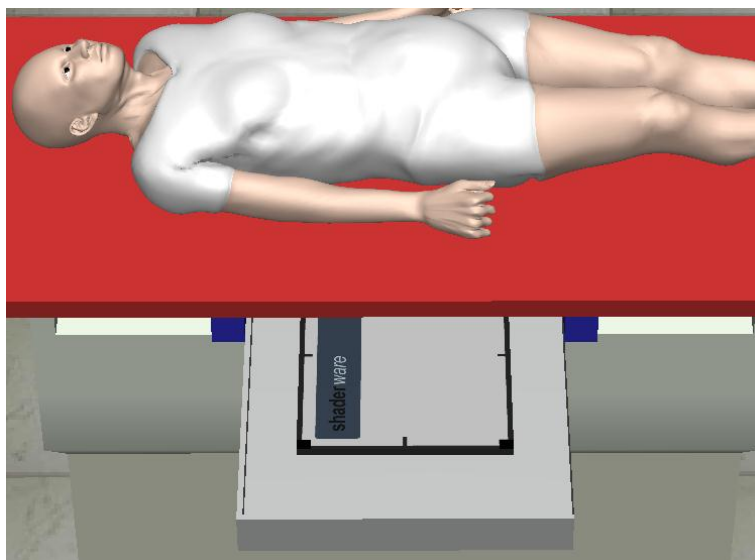
Outcomes

At the end of the Lab, students will be able to:

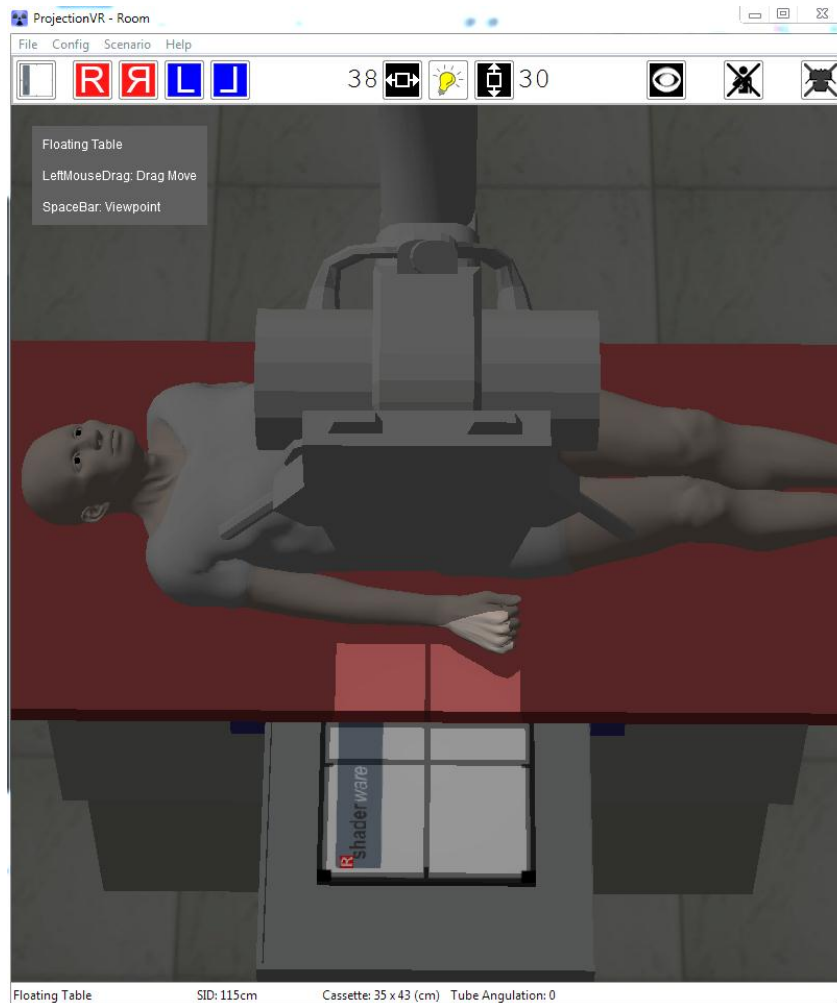
29. List the procedural steps outlined and identify the differences between table top and Bucky procedures
30. Place a receptor in a Bucky tray, and keep the centre of the receptor and the central ray in sync.
31. Collimate to a receptor in the Bucky
32. Identify an image orientation e.g. Head-First (Portrait), Transverse (Landscape)
33. Correctly orientate a radiograph

a) Pelvis Study - AP

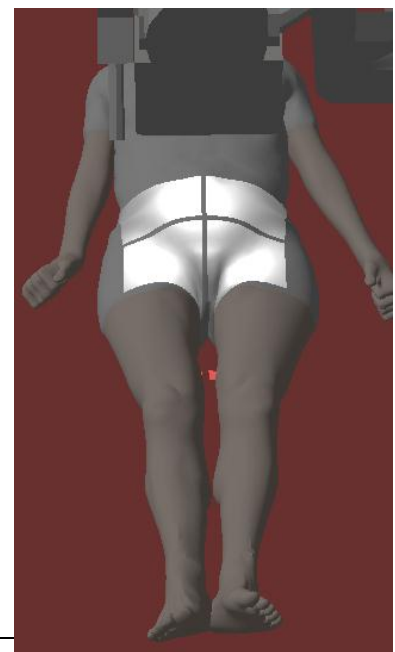
- i) On the Modality Worklist, select session 6, visit V0056, Patty Bouvier for a Pelvis, LT and RT Hips and Sacro-Iliac Jts *"Hip and low back pain. With accompanying conjunctivitis and infection of the urethra. ?Arthropathy ?Infection ?Reactive Arthritis"*
- ii) Select Pelvis and the projection to be 'AP'
- iii) Admit the patient to the room and have them lie recumbent on the table
- iv) Raise the table to working height and use the scenario to remotely position the tube support and gantry (Scenario\Floating table)
- v) Select a 35 x 43cm (14 x 17in) receptor and place it in the Bucky tray LANDSCAPE (remember the yellow dot top!)



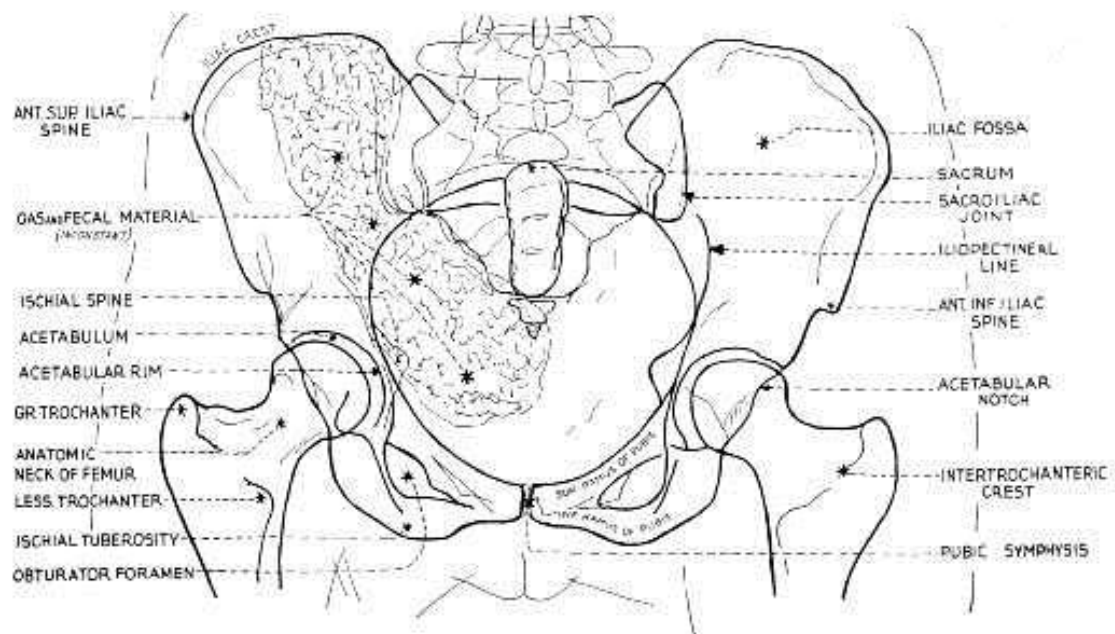
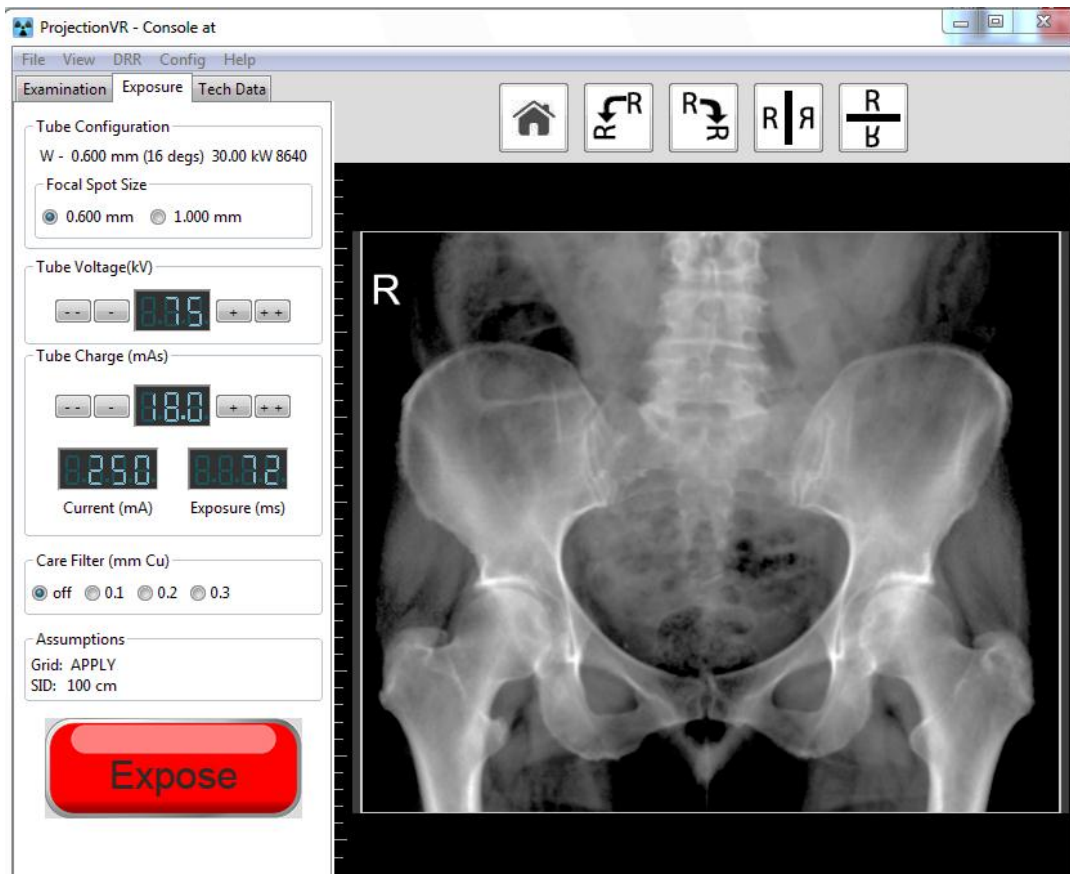
- vi) Check the SID is 115cm (45in)
- vii) Collimate to the receptor size (pull tube across table and line up collimation, S key. Replace @ detent position after)
- viii) Select the appropriate side marker and position, then close the Bucky tray



- ix) Position the patient using JUST the floating table top to obtain radiograph of the pelvis
- x) Expose the patient using exposure factors of 75 kV, 18 mAs
- xi) Window the image
- xii) Correct the orientation

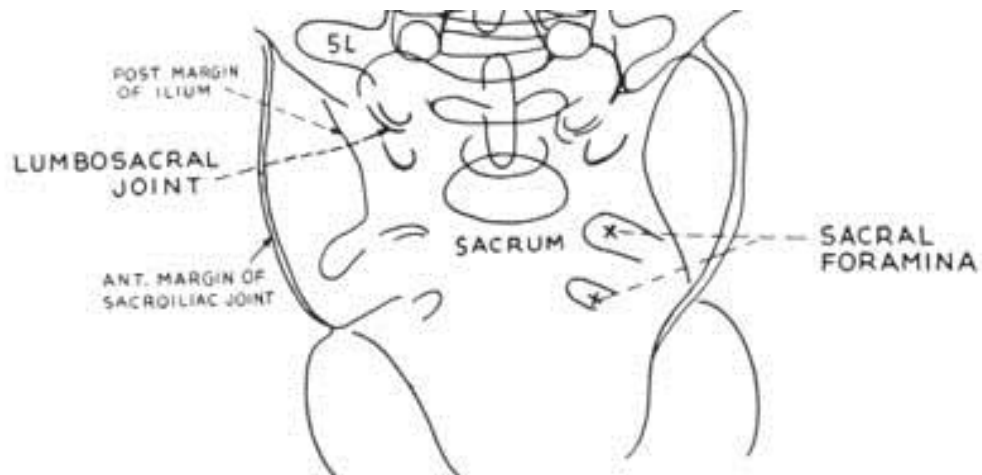
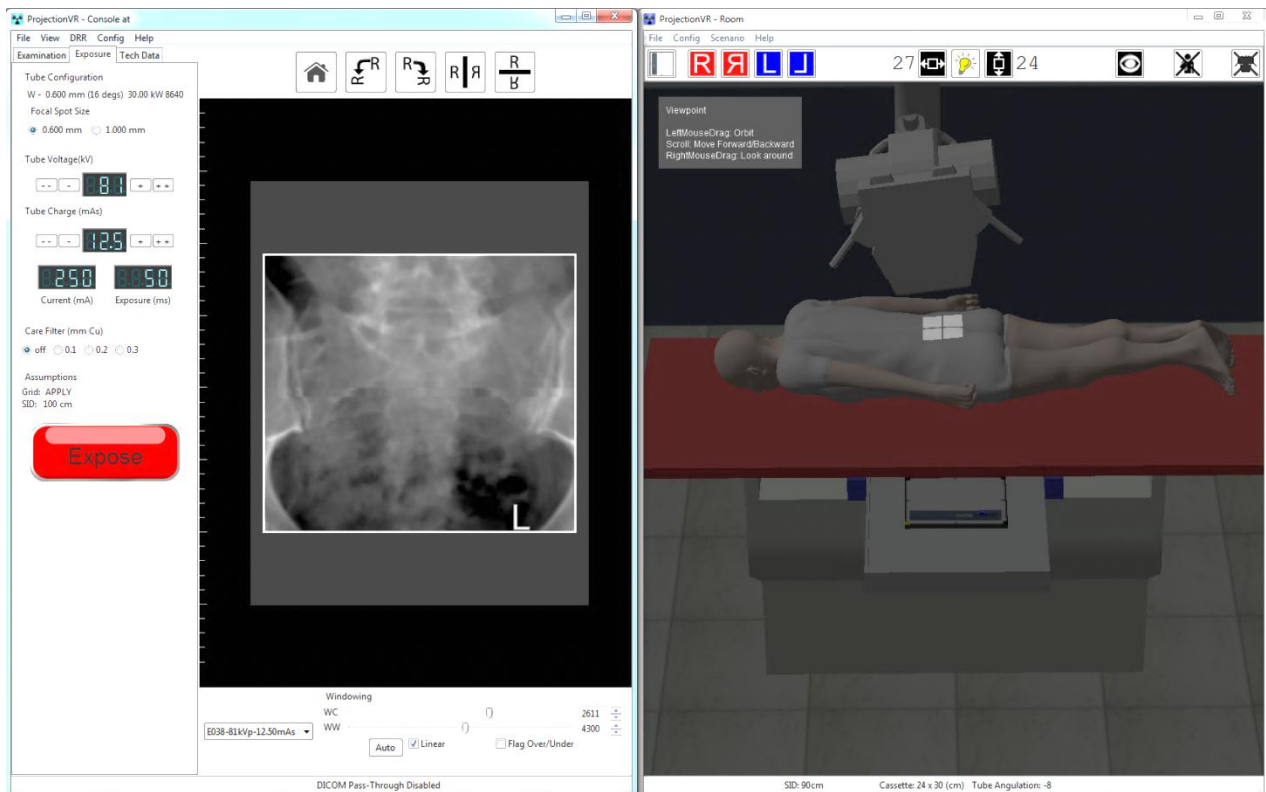


b) Review images



Meschan, I. 1951 *An Atlas of Normal Radiographic Anatomy* Saunders, London

- c) Extension activity. Continue on with the Study and position the patient Prone for Sacroiliac joints



Meschan, I. 1951 *An Atlas of Normal Radiographic Anatomy* Saunders, London

d) Questions

Fill in the table comparing the procedure to obtain these radiographs with those that you took with the receptor visible on the erect buck in the last Lab. What are the differences?

Procedural Steps

Table Bucky (Pelvis)	Table Top (Knee)

LAB 9 - Image criteria terminology & process

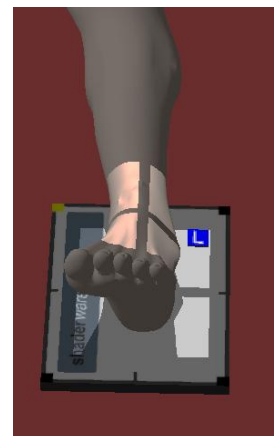
Outcomes

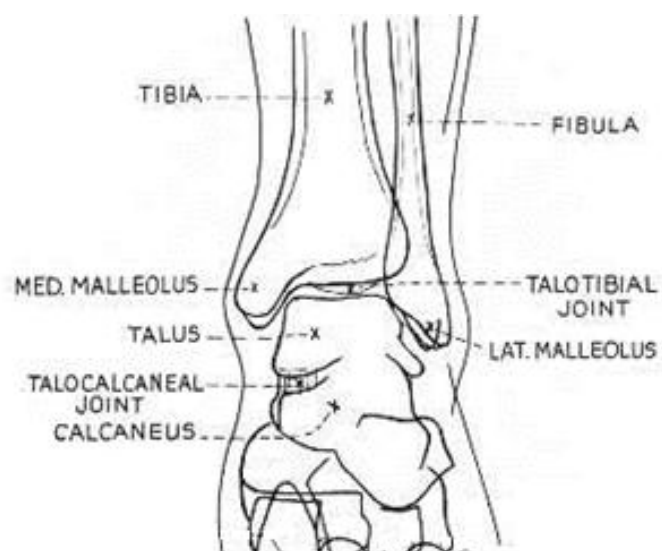
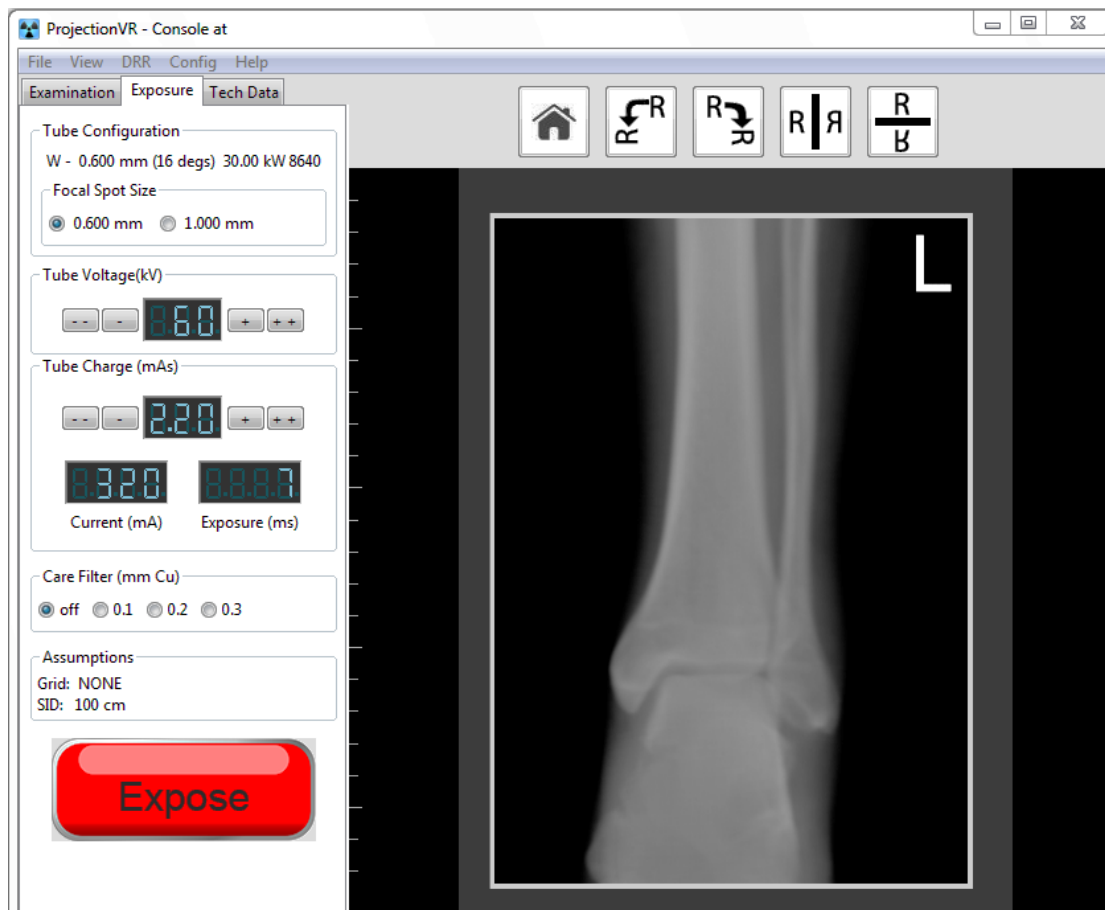
At the end of the Lab, students will be able to:

34. Compare CR and DR modes of radiography
35. Define the AABCS system of radiograph critique
36. List general points on a radiography criteria checklist (Adequacy)
37. Discover the fundamental importance of side markers and 'metadata'
38. Open a DICOM image in a viewer
39. Compare resultant radiographic image against explicit radiographic criteria

a) Ankle Study

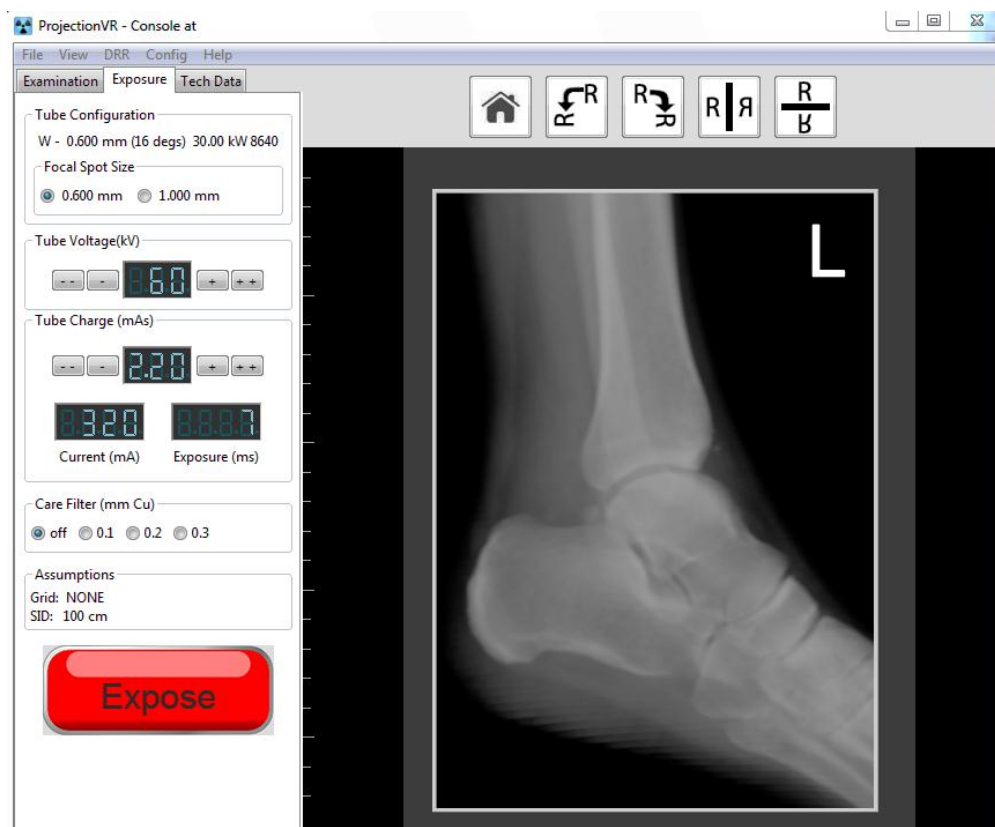
- i) On the Modality work list, select session 2, visit V0162, Homer Simpson in a Chair. *"Ski injury. Forced eversion of ankle. Swelling, bruising with fullness to side of Achilles. ?Syndesmotic Sprain ?#"*
- ii) Set the projection to be 'AP Ankle'
- iii) From the scenario menu select the receptor type to 'CR'
- iv) Choose the 18x24cm (10x8in) receptor and place it at the foot of the table on the table top.
- v) Pick the appropriate side marker and position it on what will be the Lateral aspect of the receptor
- vi) Admit the patient to the room and have them lie recumbent on the x-ray table.
- vii) Raise the table to working height; check the SID is 100cm (40in)
- viii) Choose the correct pose and position the patient to obtain required projection of the correct anatomical area
- ix) Collimate to include the Ankle as shown in this diagram
- x) Expose the image using tube voltage of 60 kV and tube charge of 2.2 mAs
- xi) Review the Image using the Image Criteria Checklist

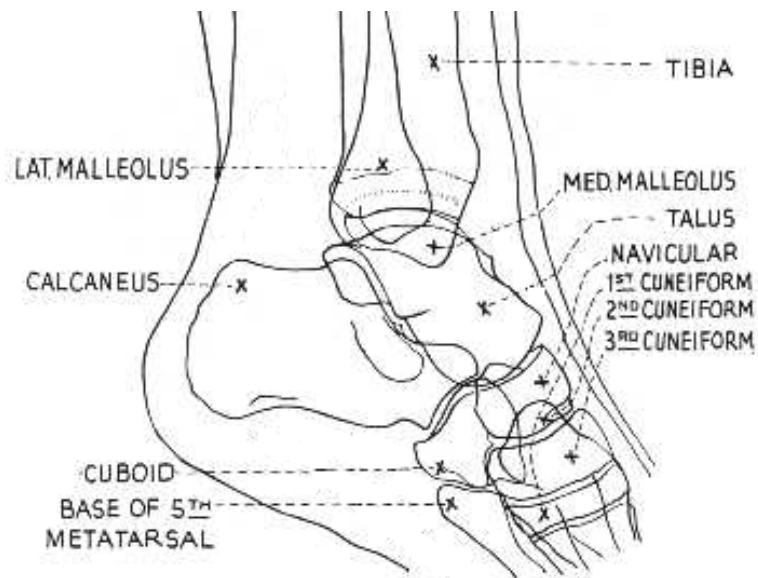




Meschan, I. 1951 *An Atlas of Normal Radiographic Anatomy* Saunders, London

- b) **Extension activity.** Repeat the steps for the Lateral projection, turning the patient slightly onto their left side





Meschan, I. 1951 *An Atlas of Normal Radiographic Anatomy* Saunders, London

- c) Open the DICOM image in a viewer and review again. Discuss radiographic critique

“Ski injury. Forced eversion of ankle. Swelling, bruising with fullness to side of Achilles. ?Syndesmotic Sprain ?#”

The AABCS Method of Radiographic Critique

Adequacy	Notes: This system is important, because in focusing on the interpretation the radiographer never loses sight of the reason the Study is being carried out. Clinical History must always be reviewed prior to using ABCS
Clinical History	
Alignment	
Bony cortex	
Cartilage	
Soft tissue	

Footnote: Shadernware Ltd recommend SanteViewer™ as a free DICOM viewer and ClearCanvas™ as a free PACS archival solution.

Image criteria for adequacy

<i>Item</i>	<i>Notes</i>
Choose Adequate Viewing Conditions	The ambient light level affects the ability to subtle differences between dark shades. The monitor must be capable of presenting an image with adequate brightness and resolution. The viewer must have the minimum tool set.
Demographic checks	Hospital Name, Hospital Number, Date, Time Patient Name, DOB, Hospital Number
Anatomy	Does the anatomical area tally with that requested
Marker s and legends	Minimum of R or L (never both). An arrow for which way is up, times if a series of images has been taken, pre and post an event/intervention, mobile , if carried out away from the department, comparison if a normal limb has been irradiated, bone age...
Projection	Does the central ray pass through the anatomy as indicated (AP, Lateral, etc.). The central ray should pass through the centre of the area of interest (see Protection).
Patient Position	The area of interest must all be within the collimation. Is patient general position correct and correctly identified in the metadata? Is any specific position correctly achieved? Are any anomalies annotated e.g. Decubitus
Structures Shown	Relevant joints, structures and superimposing structures should be visualised in the acceptable standard required
Collimation	There should be 4 visible collimation marks on the radiograph at all times.
Image Quality	All 4 radiographic contrasts should be visible on the image without noise degradation. The Exposure Index must be higher than the agreed maximum for that Study – with no flagged areas. Check for artefacts, unsharpness, distortion and scatter.
Protection	The Exposure Index must be lower than the agreed maximum for that Study. Recorded dose measurements must be below the local Diagnostic Reference Level (DRL). Shielding must be correctly applied or a reason for its omission documented

“Dogs Always Make Perfect Pets Showing Considerable IQ, Pups Can’t Handle ABC’s”

d) Questions

What generally is the correct way to 'hang' a radiograph?

Does this/these image(s) 'pass' using the criteria?

Can radiographers issue a written comment on the radiograph?

What can be the result if side markers are not present?

What data is commonly held with the radiographic image in a DICOM object?

Which is easier to operate with CR or DR? Why?

Radiographic Science One

This chapter contains four Labs that develop the scientific underpinning of radiographic practice. The basic concepts are introduced.

LAB 10 - Magnification

Aims of Lab

- Demonstrate magnification and introduce the object-image:source-image ratio
- Practice more complex receptor handling techniques

LAB 11 - Distortion one

Aims of Lab

- Demonstrate distortions and errors due to incorrect use of projection
- Practice more complex projections

LAB 12 - Distortion two

Aims of Lab

- Demonstrate how position alters projection, i.e. PA position with caudal angulation is analogous to AP position with cranial angulation
- Discuss reasons for choice of patient position and projection
- Practice more complex projections

LAB 13 - SID (Inverse square law)

Aims of Lab

- Demonstrate the effect of change in distance between source and image plane on x-ray intensity

LAB 10 - Magnification

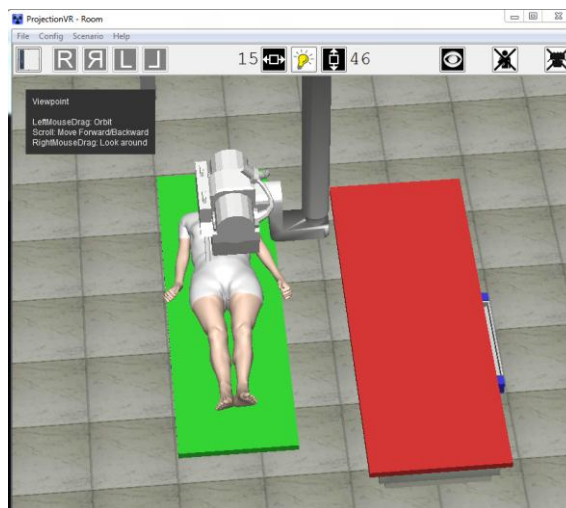
Outcomes

At the end of the Lab, students will be able to:

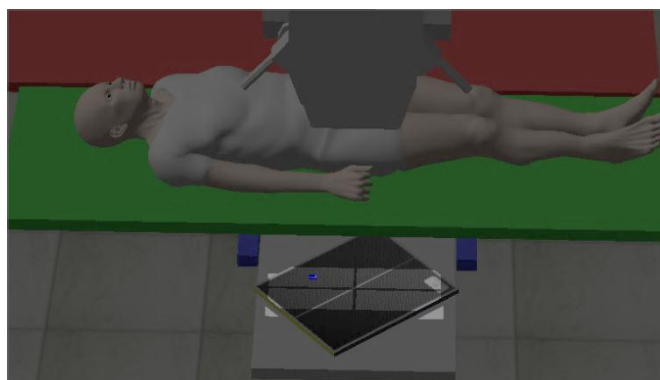
40. Change receptor orientation
41. Position the patient to minimise magnification of the area under investigation
42. Estimate changes in SID to combat or use magnification

a) AP Femur

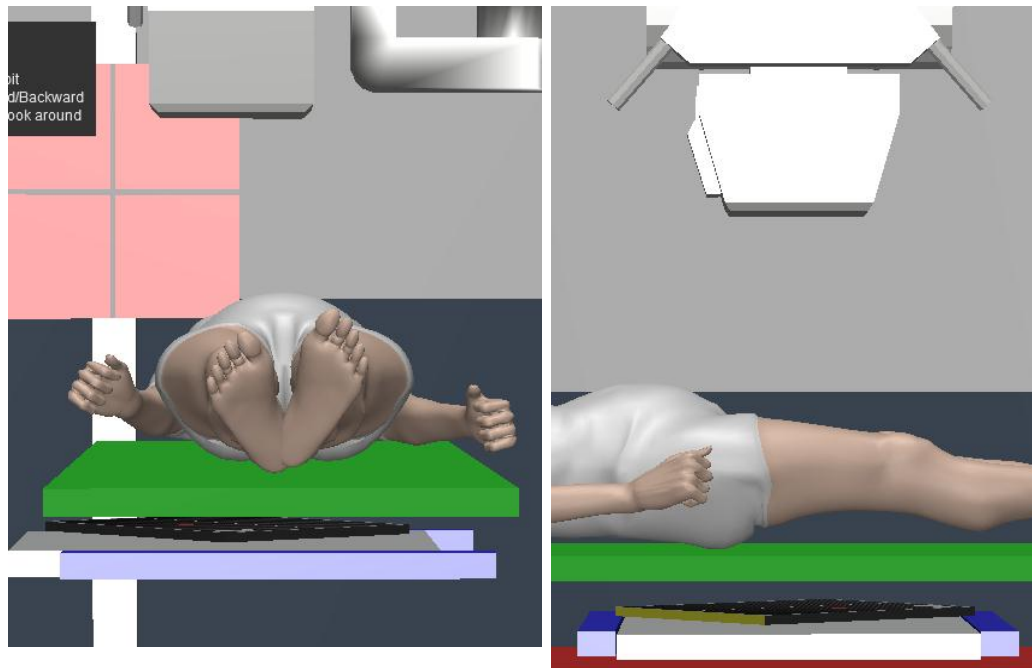
- i) In the Modality work list, select Session 7, Visit V0146, Selma Bouvier for a Rt Femur exam. "RTC. Frontal collision. Right mid shaft thigh deformity. ?# Femur ?# Hip ?# Pelvis"
- ii) Select 'Femur: AP (Distal Anode)' as the projection.
- iii) Move the trolley and rotate it in the room (Rt click and scroll green top). Bring tube across (S key)



- iv) Select 35x43cm 8:1 Parallel (17x14in) receptor and place it on the trolley receptor tray. Add a side marker toward the left lateral aspect of the patient and Check the SID is 100cm (40in).

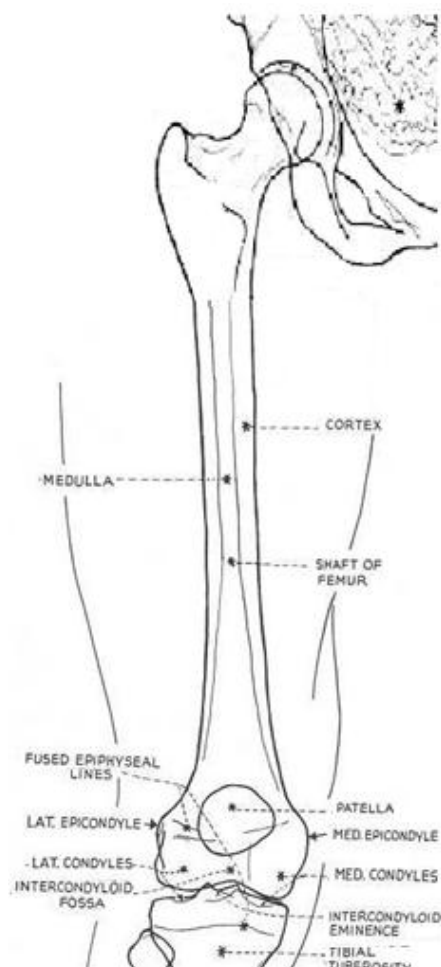


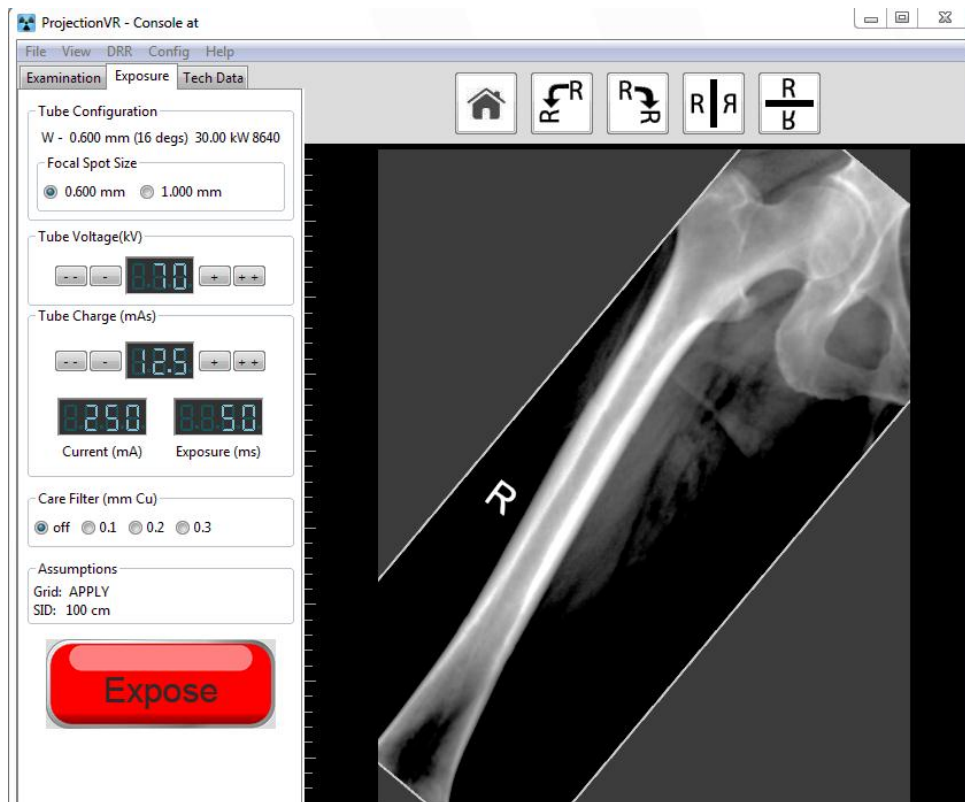
- v) Use sightlines to the trolley tray to line up the x-ray beam, patient and receptor.



- vi) Collimate to include the region shown in the diagram

- vii) Expose and Review the Image using the Image Criteria Checklist

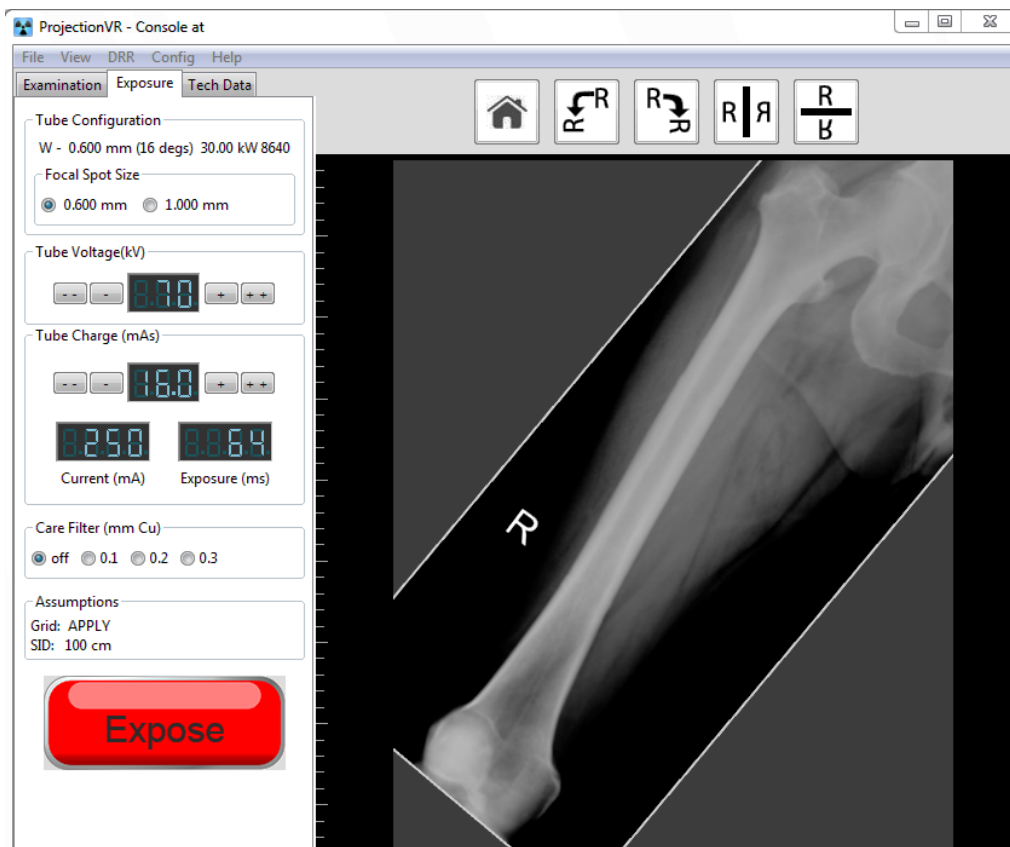
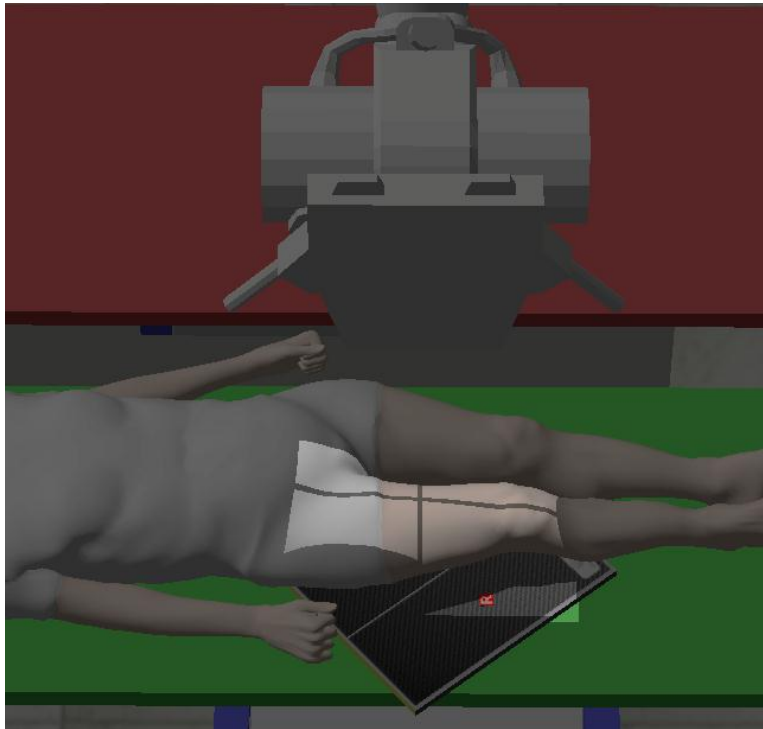




b) If you cannot fit the femur on, repeat the exposure - change the SID to 120cm and increase the Tube Charge to 16mAs



c) If you cannot fit the Femur on this receptor, repeat the exposure - take the receptor out of Bucky and position on the trolley top under the femur, still using 120cm SID.



d) Questions

How does the SID affect the image size?

How does receptor position (table Bucky, table top) affect image size?

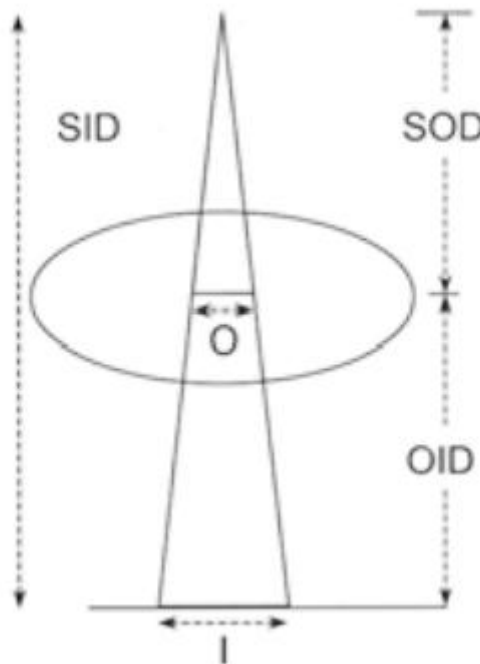
Is it safe to try and image a femur on one 35 x 43 receptor?

e) Explanation

X-rays travel in straight lines. Magnification occurs because the x-ray beam diverges from a point source (S) to the image plane (I) through the object (O). Magnification factor (M) is the size of the image at I compared to its real size and O ($M=I/O$). Due to the maths of triangles, M also = SID/SOD .

In the first change, SID was increased from 100 to 120cm. OID remained constant, so M decreased.

In the second change, OID was reduced. SOD remained the same, so M decreased.




LAB 11 - Distortion one

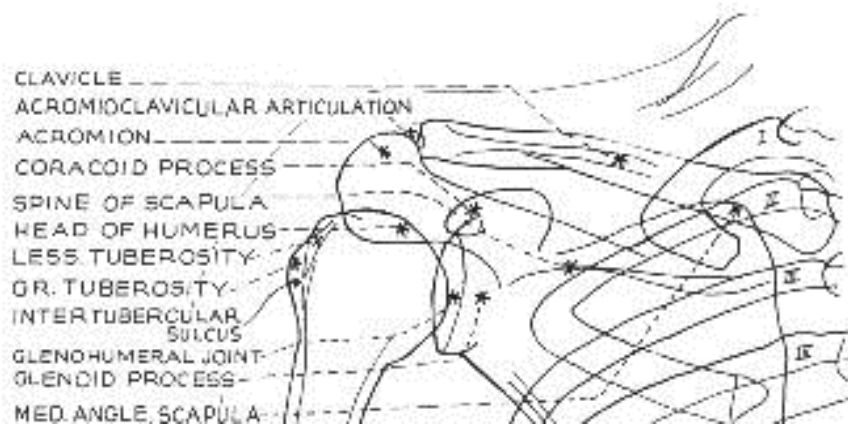
Outcomes

At the end of the Lab, students will be able to:

43. Use tube angulation to obtain projections without complex overlying anatomy and the minimum of distortion
44. Be aware that radiographic anatomy is different to the real anatomy due to perspective distortion ('key-stoning') and differential magnification ('barrel distortion')
45. Practice radiographic projection using the technique of 'off-centring'

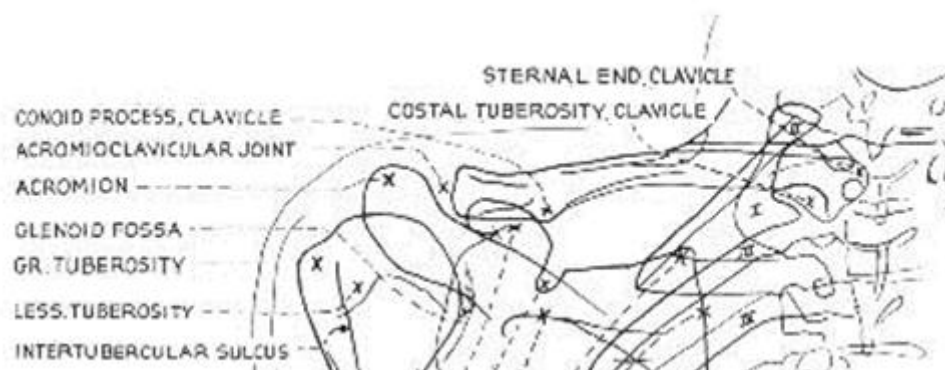
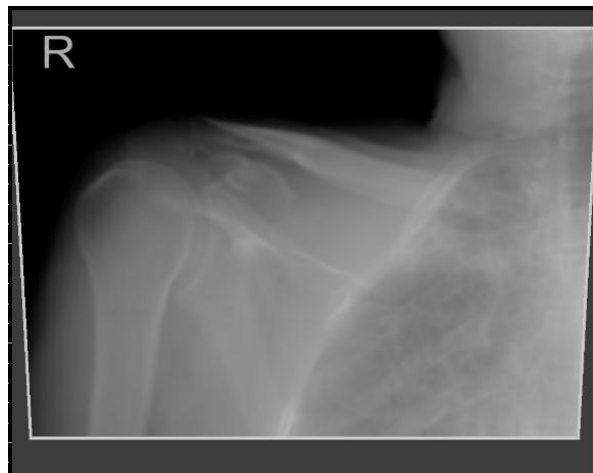
a) Two projections of the clavicle

- i) In the Modality Worklist, select session 1, visit V0277, Homer Simpson for Rt Clavicle Study. "Decorator fell from step-ladders. Pain over clavicle ?# Clavicle". Set Clavicle: AP' as the projection.
- ii) Set patient/gantry relationship to 'Transverse'
- iii) Select a 24 x 30cm (12 x 10in) receptor, and place it in the erect Bucky. Rotate it to landscape orientation.
- iv) Select the 'R' side-marker and place it on the receptor to appear on the lateral aspect of the patient. Rotate it to be legible
- v) Check the SID and as necessary move the x-ray tube to 100cm (40in). Use the Scenario menu to save time.
- vi) Collimate to just within the receptor boundaries using the LBD
- vii) Admit the patient into the x-ray room 
- viii) Position patient, receptor, chest stand and tube to include right clavicle as shown in the diagram overleaf.
- ix) Expose the patient and review the result.



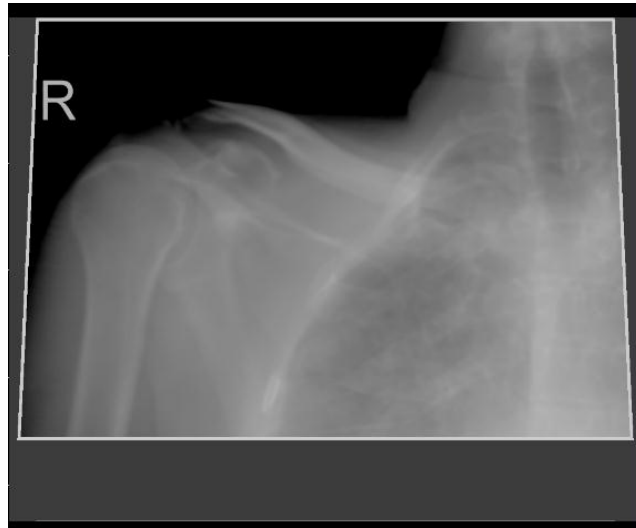
Meschan, I. 1951 *An Atlas of Normal Radiographic Anatomy* Saunders, London

- b) Repeat exposure, selecting Study/projection Rt. Clavicle: AP Half-Axial' with 20 degree cranial angulation



Meschan, I. 1951 *An Atlas of Normal Radiographic Anatomy* Saunders, London

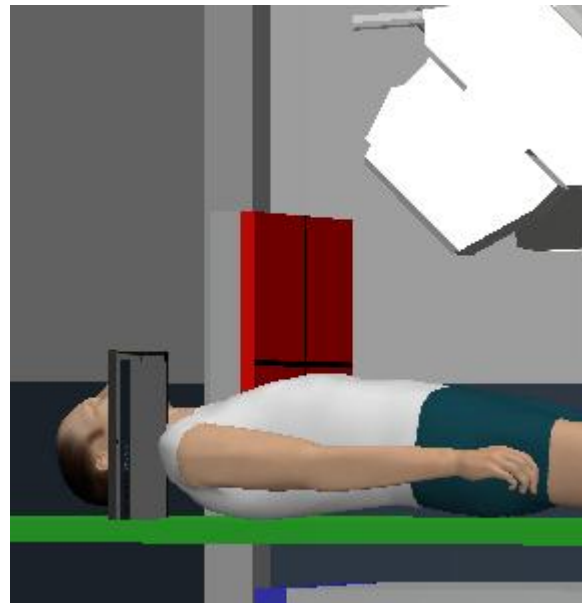
- c) Turn the patient to face the receptor and modify the technique to produce a PA Half axial projection



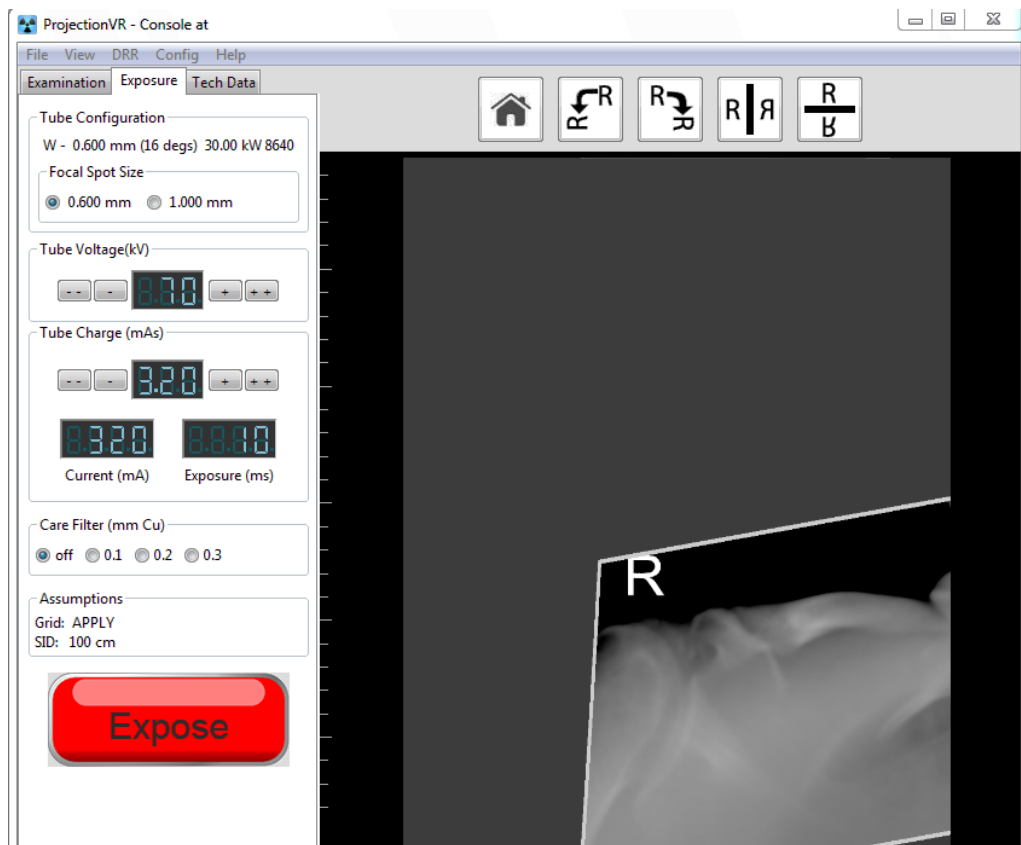
d) Extension activity

Williams describes an infero-superior projection of the clavicle (Carver and Carver (2006, p82). A similar projection was outlined by Clark (1949, p49)

- i) Select session 1, visit V0278 Ned Flanders on a Trolley for Clavicle XR Rt. "Rugby referee. Caught between tackling players. Deformity and tenderness over Rt Clavicle. Unable to weightbear Rt Leg. ?# Clavicle ?# Tib & Fib"



- ii) This Study does not use a scatter rejection grid. Reduce the tube voltage to 70 kV and tube charge to 3.2 mAs.



e) Questions

What is different about the angulation of the tube between AP and PA half axial projections?

What were the differences in side marker between the two radiographs?

Which is likely to produce less distortion of the clavicle, Williams (2006) technique or the previous techniques? Which is a true axial?

LAB 12 - Distortion two

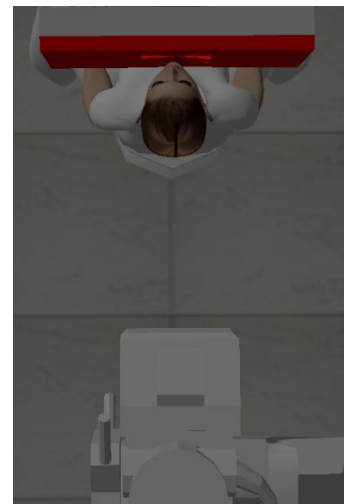
Outcomes

At the end of the Lab, students will be able to:

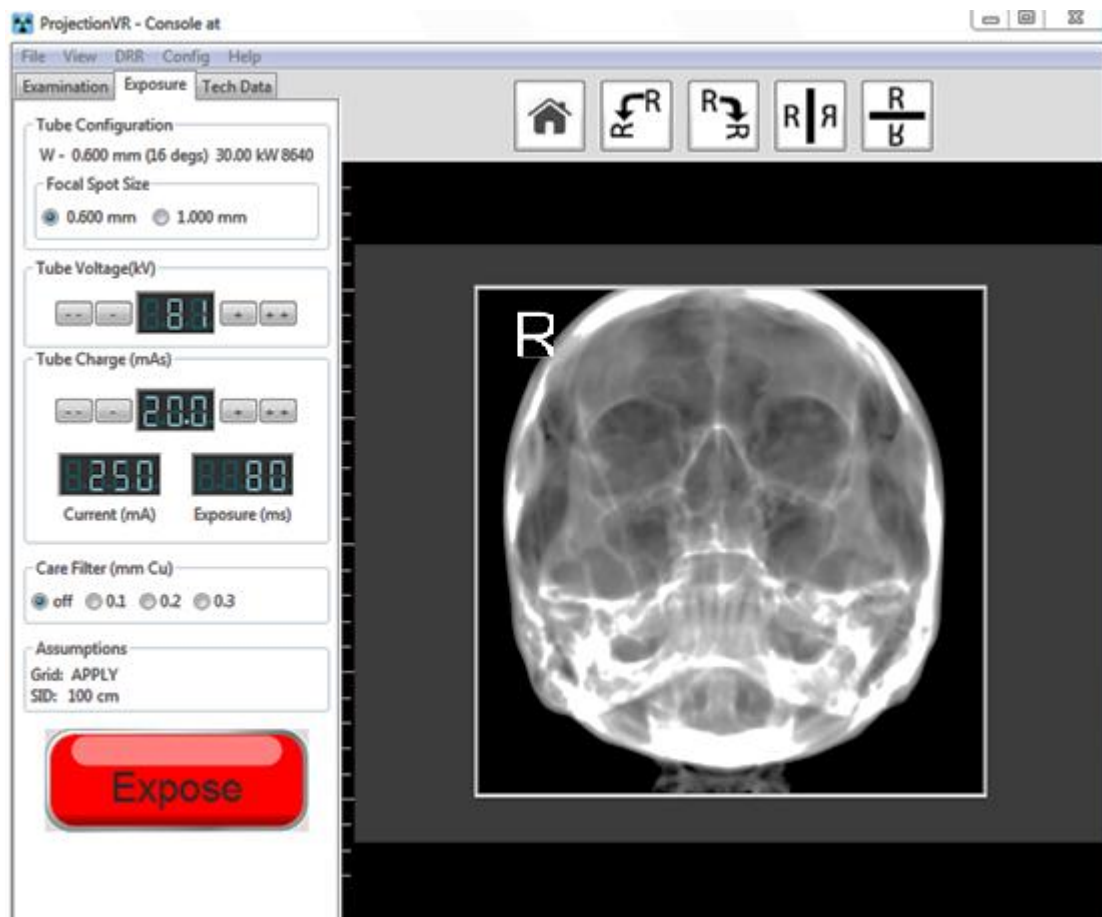
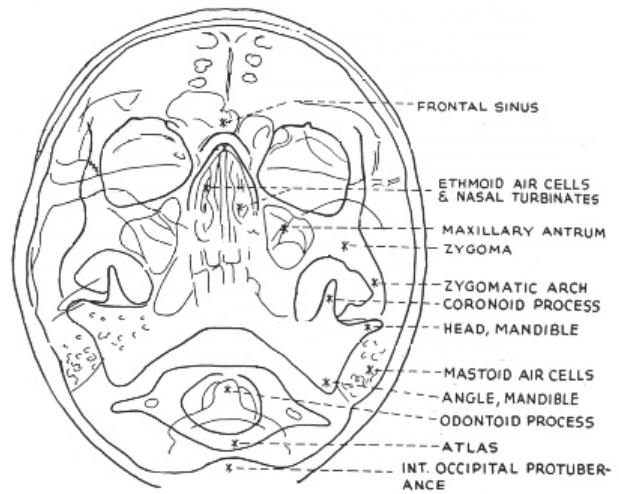
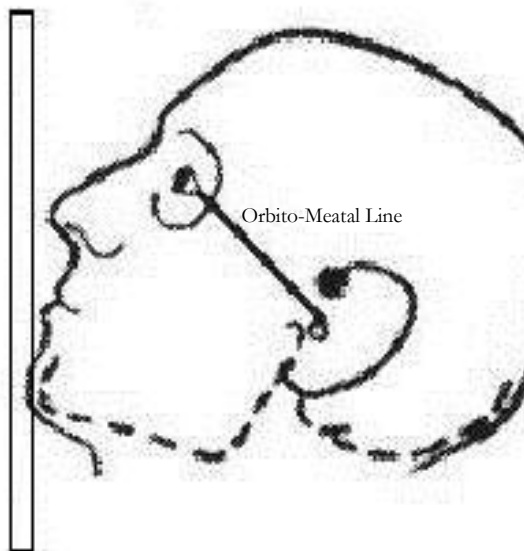
46. Use tube angulation to obtain projections with the minimum of distortion
47. Understand that angulation of the patient and angulation of the central ray do NOT give the same results (in a general room).
48. Practice radiographic projection 'off-centring' the Bucky

a) Facial Bones

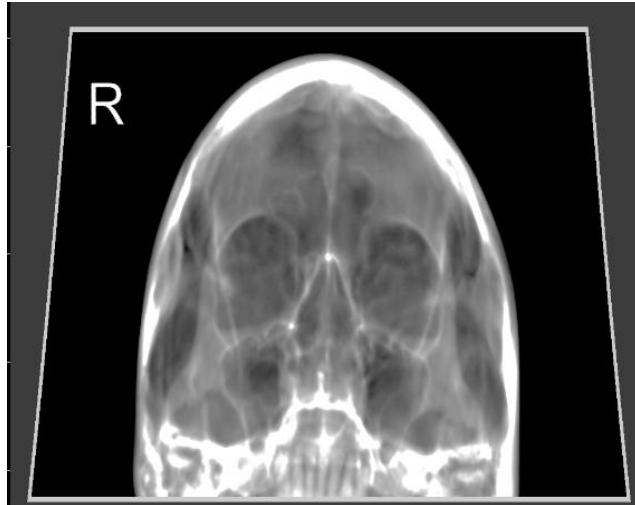
- i) In the Modality Worklist, select Session 1, Visit V0132, Edna Flanders in a Chair for Facial Bones. "Assault: profuse epistaxis from right nostril only. ?Fracture Left Maxilla"
- ii) Select a 24 x 30cm (12 x 10in) receptor, and place it in the erect Bucky.
- iii) Select the inverted 'R' side-marker and place it on the receptor to appear on the Rt lateral aspect of the patient.
- iv) Check the SID and as necessary move the x-ray tube to 100cm (40in)
- v) Collimate to just within the receptor
- vi) Admit the patient into the x-ray room
- vii) Position the patient facing the Bucky



- viii) Position the patient to obtain the OM projection by raising the chin (as in the diagram over the page)
- ix) Expose the patient and review the result.



- b) Repeat the exposure as a projection but this time with the patient Anatomical, facing the Bucky (Orbito-Meatal Line parallel to the floor) and the central ray angled down 45 degrees.



c) Questions

What shapes are the collimation areas on the two images?

Which is more diagnostic? Why?

Why would it be difficult to use the first technique?

What TWO things do you have to remember when angling the tube against a Bucky?

LAB 13 - SID

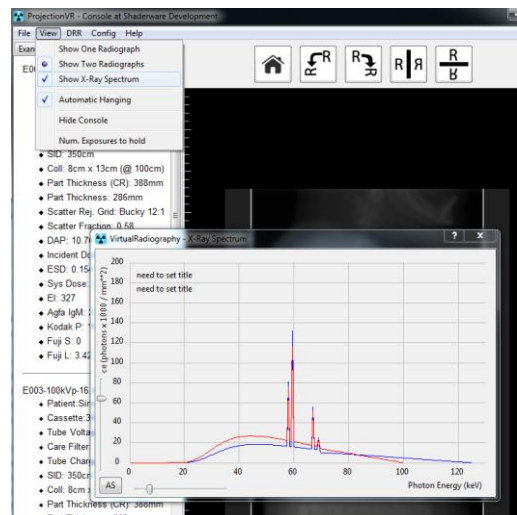
Outcomes

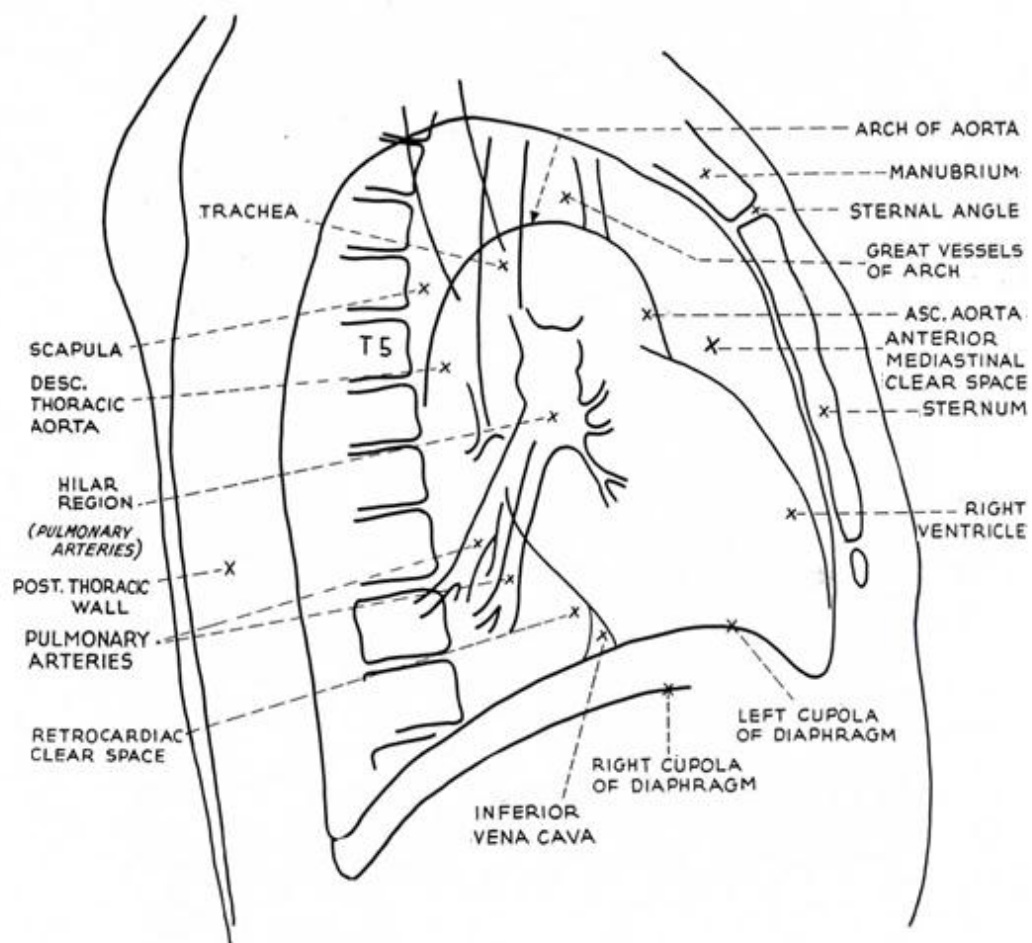
At the end of the Lab, students will be able to:

49. Define Dose Area Product (DAP)
50. Define Entrance Surface Dose (ESD)
51. Define System Dose (SysD)
52. Define Exposure Index (EI)
53. State the basic effect of SID on DAP, ESD, SysD and EI

a) SID

- i) On the 'Modality Work List...' Select Session 1, Visit V0098, Marj Simpson for a Chest Exam. "Screening pre-employment CXR - dive instructor. ?Normal"
- ii) Select Projection as 'Left Lateral'
- iii) In the x-ray room, select the 35x43cm (17 x 14in) receptor. Place it in the erect Bucky and apply a left side-marker.
- iv) Select a large Source Image Distance (SID) of 350cm (use the scroll wheel for fine tuning)
- v) Collimate to the size of the receptor
- vi) Admit the patient by selecting the 'patient' icon. Stand them in front of the erect bucky
- vii) Pose the patient with their arms in the air, and facing to the right, left side against the erect bucky. The central ray (CR) should pass through the mid-axillary line at the level of T7
- viii) Expose the patient using tube voltage of 125 kV and tube charge of 12.5 mAs
- ix) On the Console menu, select View Xray spectrum and review result
- x) Click on Tech Data Tab. Record DAP, SID, DAP, ESD, SysD and EI in the table.
- xi) Reduce the SID by 50cm and repeat





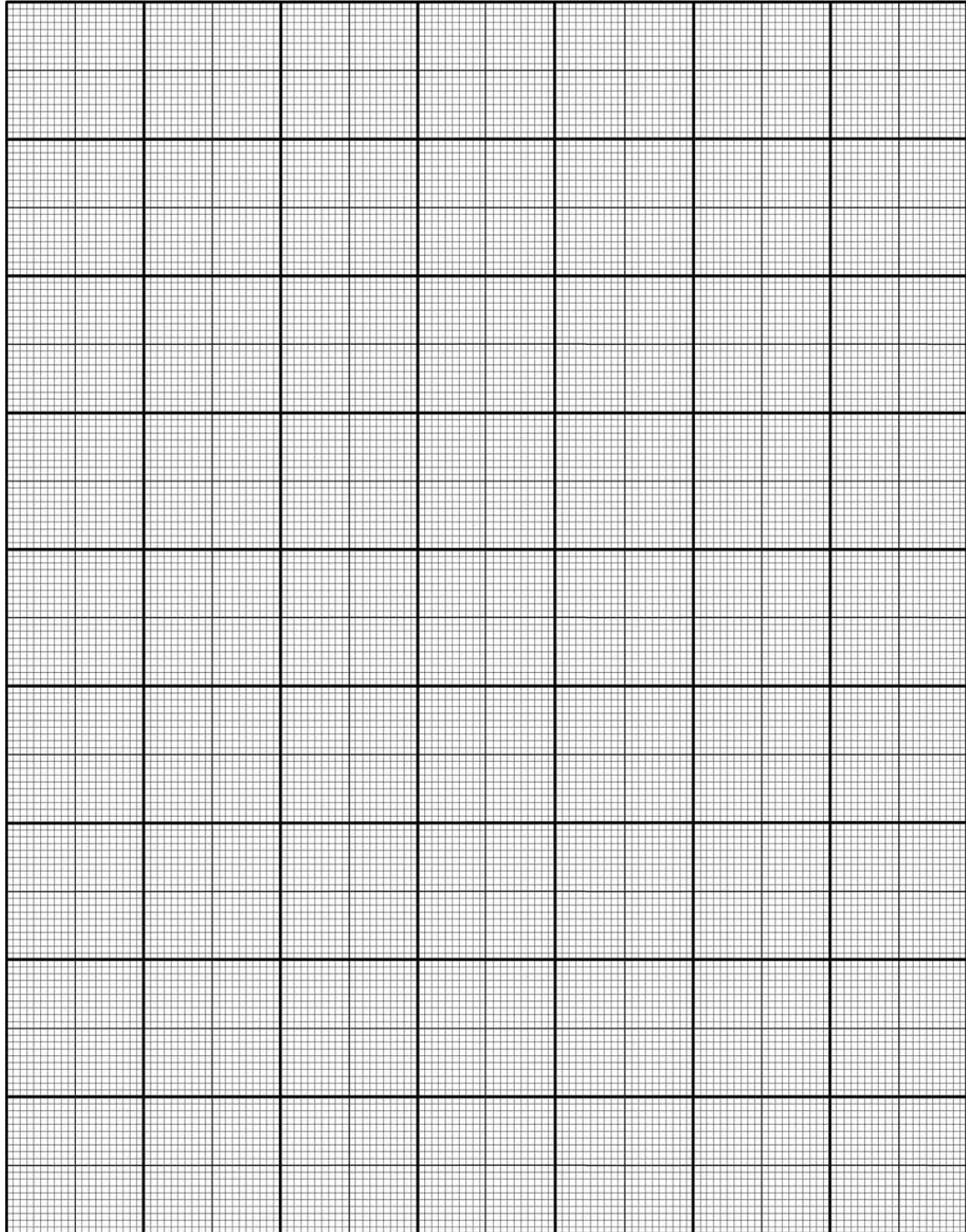
Meschan, I. 1951, p399 *An Atlas of Normal Radiographic Anatomy* Saunders, London

b) Results

Tube Voltage	Tube Charge	Collimation Area @100cm	SID	DAP	ESD	SysD	EI
kV	mAs	cm x cm	cm	cGy.cm2	mGy	μGy	
125	12.5	9 x 12	350				
125	12.5	9 x 12	300				
125	12.5	9 x 12	250				
125	12.5	9 x 12	200				
125	12.5	9 x 12	150				
125	12.5	9 x 12	100				

Plot points on the graph paper to show the resultant radiation dose measured at certain distances from the source. Title this graph 'Radiation Dose Vs Distance'. Use the entrance surface dose (ESD) on the Y-axis and source image distance (SID) values on the X-axis.

c) Graph

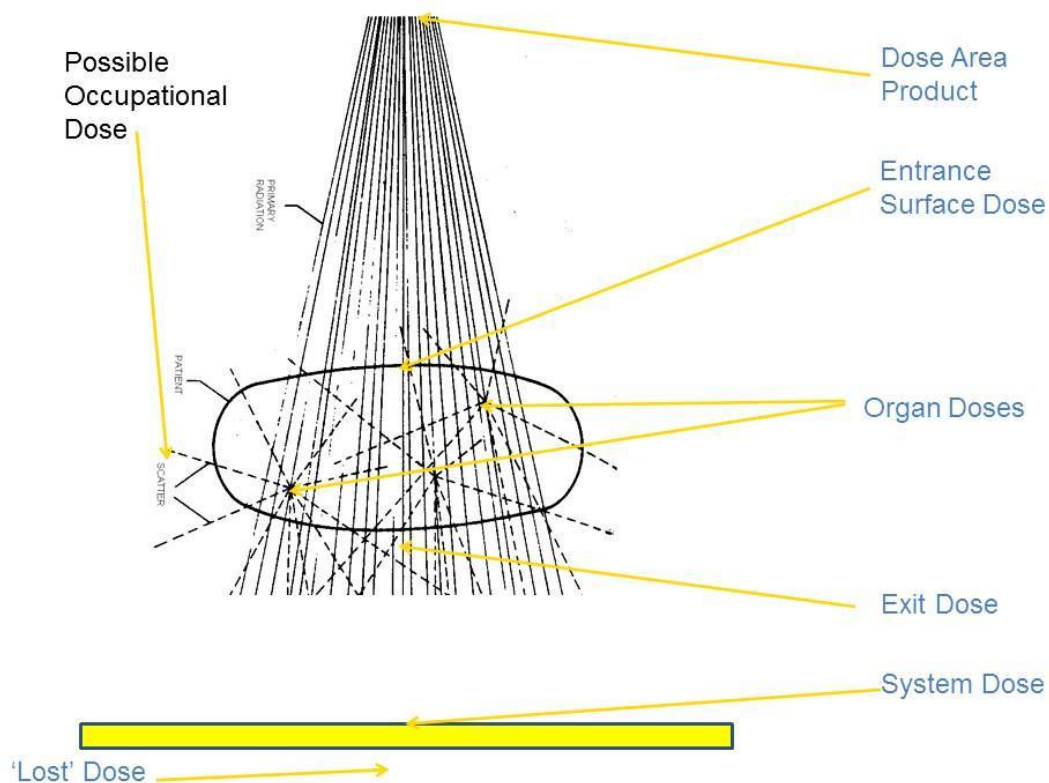


- d) **Extension activity.** Add a second Y-axis to the graph and plot the co-ordinates for system dose (SysD) at certain distances.

e) **Explanation:**

The entrance surface dose (ESD) is the radiation dose measured at the point on the patient surface where the central ray passes through. It includes any backscatter from the patient.

The System Dose (SysD) is the average radiation dose on the imaging receptor, expressed in (μGy). Systems report an Exposure Index (EI), which is related to this value.



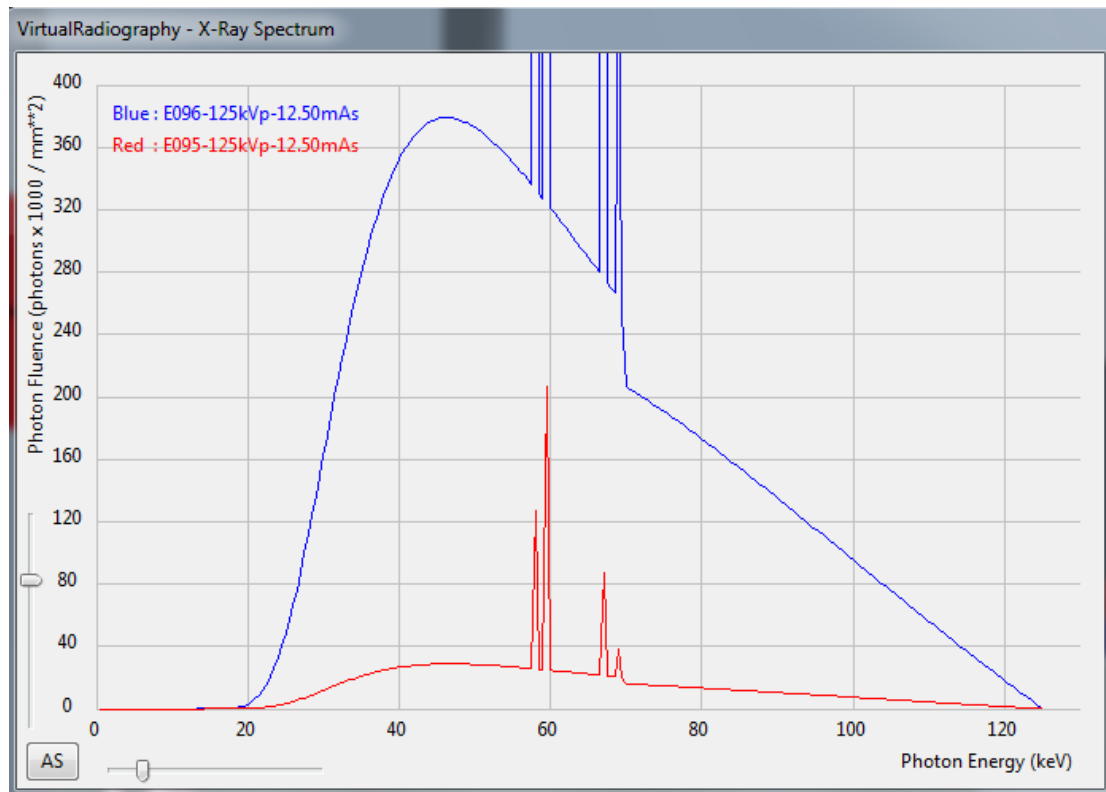
The different uses of the word 'Dose' in diagnostic radiography and where they are measured

Your graph will show an increase in both ESD and SysD as the SID decreases. This is true despite there being the same total amount of x-radiation generated (as the tube voltage and charge remained the same.)

As the distance between the source and the receptor is decreased, the same amount of radiation is concentrated in a smaller area. This means intensity is increased (Intensity being defined as the amount of something in a given area or volume.)

f) Visualising the X-Ray beam

The x-ray beams can be visualised as a distribution of all the x-ray photons arranged by photon energy.



The area under the graph is related to the total energy in the beam (per unit area), therefore the total potential dose. The extreme right hand end of the distribution indicates the most energetic photons present in the beam (this is controlled by the Tube voltage), The extreme left hand edge of the distribution indicates the least energetic photons present in the beam (this is affected by the Care filter setting).

g) Questions

What type of relationship is there between distance from source and ESD?

- a) linear b) inverse linear c) inverse square

Is there a difference in shape between the ESD vs SID curve and the SysD vs SID curve?

If so - describe it.

Which is the best indicator of 'patient dose' in this case?

a) DAP, b) ESD, c) SysD, d) EI

What difference can you see in the images produced?

Make notes:

What questions would you like to ask?

h) Extension activity

Repeat the experiment, but this time, try to compensate for the increasing intensity of the x-ray beam as the distance decreases. You can do this by decreasing the amount of radiation generated. The tube charge can be reduced to achieve this. *Start with it set at 25 and reduce to maintain the SID to as close to 3.00μGy as possible.*

The collimation also needs to be altered; otherwise the anatomy to be demonstrated is missed; increase the collimated area to cover the entire receptor for each distance set.

Tube Voltage	Tube Charge	Collimation Area @100cm	SID	DAP	ESD	RAK	EI
kV	mAs	cm x cm	cm	cGy.cm2	mGy	μGy	
125	12.5	9 x 12	350				
125			300				
125			250				
125			200				
125			150				
125			100				

i) Questions

Which is the best indicator of 'patient dose' in this case?

- a) DAP, b) ESD, c) SysD, d) EI

What settings would give the lowest patient radiation dose, therefore the lowest risk?

Radiographic Science Two

This chapter contains three Labs that provide opportunities for the student to work through some fundamental science concepts.

LAB 14 – Effect of Tube Charge on X-ray quantity and quality

Aims of Lab

- To measure the effect of changing tube charge on radiation doses
- To chart the effect of tube charge change on ESD, DAP, SysD, EI and Latitude
- To demonstrate the visual differences (if any) resulting on changes of Tube Charge.

LAB 15 - Effect of Tube Charge on X-ray penetration

Aims of Lab

- To measure the effect of changing tube charge on x-ray penetration
- To contrast the term x-ray intensity with the term x-ray penetration

LAB 16 - Effect of Tube Voltage on X-ray quantity and quality

Aims of Lab

- To measure the effect of changing tube voltage on radiation doses
- To chart the effect of tube voltage change on ESD, DAP, SysD, EI and Latitude
- To demonstrate the visual differences (if any) resulting on changes of Tube Voltage.


LAB 14 - Tube Charge

Outcomes

At the end of the Lab, students will be able to:

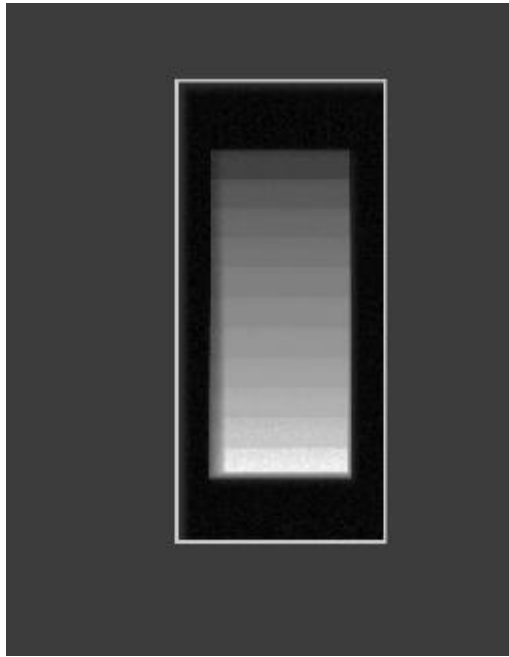
54. Define Tube Charge (mAs)
55. State the basic effect of changing Tube Charge on DAP, ESD, RAK, EI and Latitude
56. Describe the effect of changing tube charge on a) patient dose and b) image appearances
57. Recognise 'too little' and 'too much' irradiation on an x-ray receptor

a) Tube Charge (mAs)

- i) On the console, select the 'Study Tab' - Select 'Modality Work List...' Session 1, Visit V0183 'Stepwedge' from the list.
- ii) To complete the Study set up, select Quality Assurance (QA) test as the projection.
- iii) Change receptor type to CR in the scenario menu
- iv) In the x-ray room, select a 24 x 30cm (10 x 8in) receptor size. Place it on the table top.
- v) Admit the test object by selecting the 'patient' icon . Position the receptor with the stepwedge in the middle.
- vi) Raise the table to working height; check the SID is 100cm (40in)
- vii) Collimate to a field size with a 2.5cm (1in) border around the test object using the LBD (9 x 20cm)
- viii) Select the 'expose' tab on the console. Change the Tube Voltage to 60kV and the Tube Charge to 0.1 milliAmpere x seconds (0.1mAs)
- ix) Expose the stepwedge and record the results in the table. Replace the receptor and repeat to complete the table.



b) Image



Aluminium stepwedge

c) Results

Tube Voltage kV	Tube Charge mAs	SID cm	DAP cGy.cm2	ESD mGy	SysD μGy	LgM or EI	Latitude	Cancer Risk	Diagnostic Accuracy	Image Quality
60	0.1	100								
60	1	100								
60	10	100								
60	100	100								

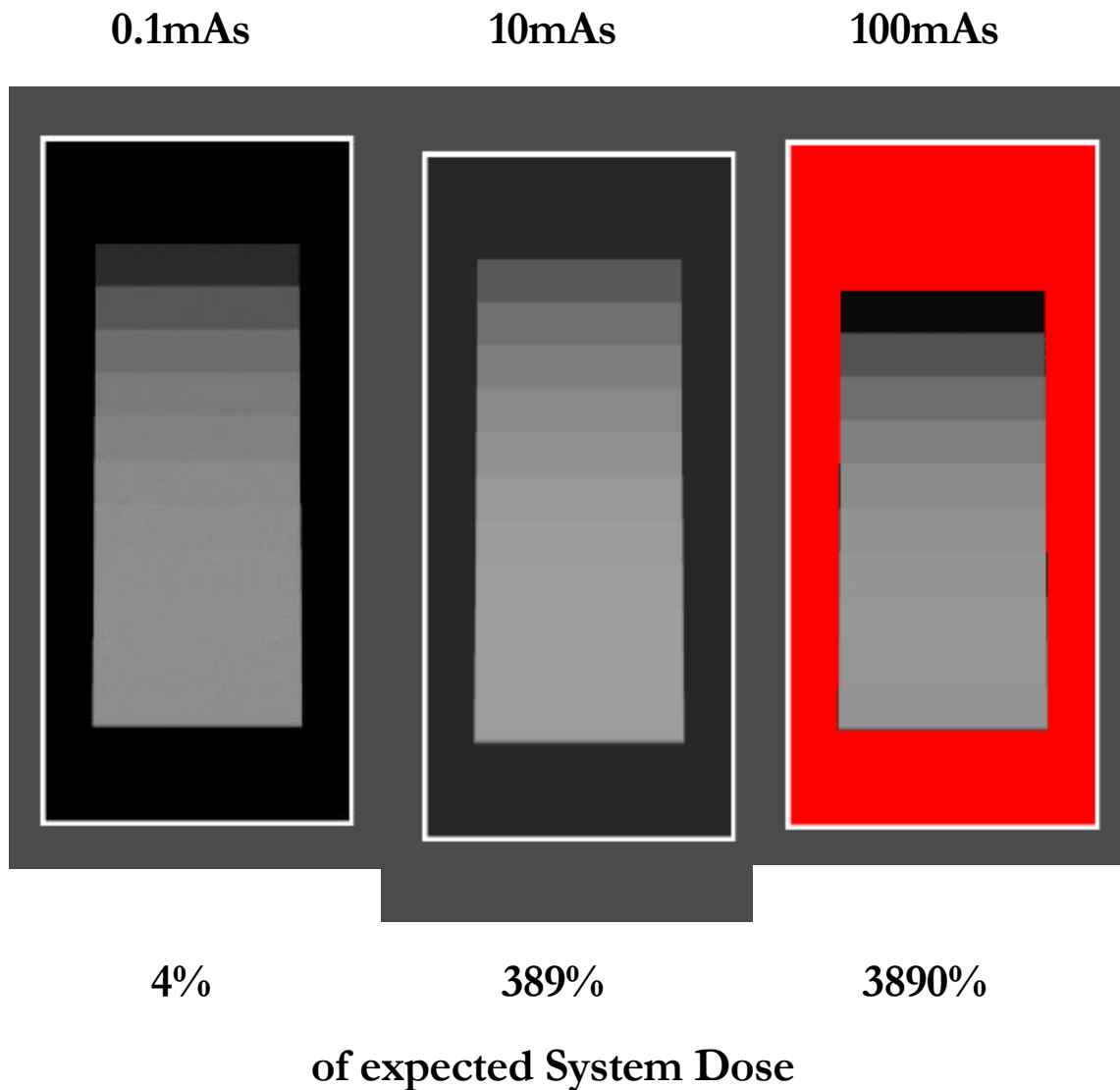
d) Explanation

The tube charge is a direct measure of the number of electrons crossing the tube during the exposure. Electrons colliding in the target generate x-rays. Tube charge therefore directly affects the x-ray photon numbers (intensity=number per unit area).

The receptor has a wide operating range, but there are limits. If the x-ray intensity is too low then no signal will be recorded (this can be flagged as green in this simulation). If x-ray intensity is too great, the receptor sites will be saturated and report the maximum value (this is flagged as red in this simulation). Receptor manufacturers have a 'recommended intensity'.

The system was able to produce very similar results with tube charges that varied ten-fold (1 and 10 mAs). The appearance of the two comparable images is similar and the Latitude (a measure of the greyscale within the image) is also comparable.

Radiographers will sometimes be unable to estimate the required x-ray intensity and the system often provides diagnostic images despite radiographer error. However, as can be seen from the DAP and ESD values, the patient dose is also directly proportional to tube charge settings (all other factors fixed). Radiographers are responsible for patient safety!



3mAs would have been perfect! 100%

The CR manufacturer recommends an LgM of 2.00

The DR receptor manufacturer recommends an EI of 250

The 'graininess' in the first image is called noise. It is noticeable when there is too little radiation to form an image without amplification. The red in the last image is called 'saturation'. The red areas are where the readings were 'maxed out'. It happens when there is too much radiation; when the radiation overwhelms the receptor.

Which receptor is more sensitive?

LAB 15 - X-ray Beam Penetration


Outcomes

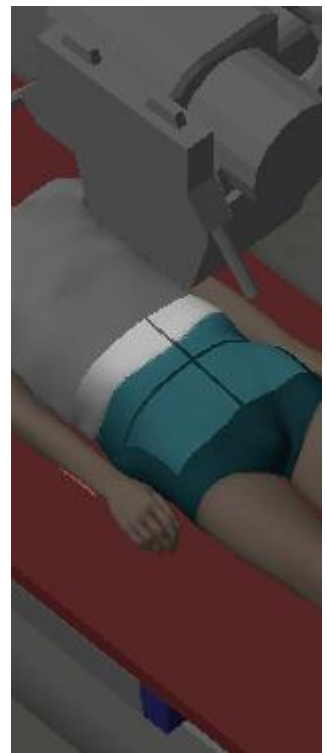
At the end of the Lab, students will be able to:

58. Define Tube Voltage (kV)
59. State the basic effect of changing Tube Charge on penetration of the x-ray beam
60. Describe the effect of changing part thickness/electron density on image appearances
61. Recognise too little and too much penetration of the irradiated object

a) X-ray Beam Penetration

(skip to step seven if you have just completed 14 [change to DR])

- i) On the console, select the 'Study Tab' - Select 'Modality Work List...' Session 3, Visit V0051 'Ned Flanders from the list. "Aches and pains in the lumbar region and thighs. Accompanying muscle weakness, fatigue and hypocalcaemia ?Osteomalacia"
- ii) To complete the Study set up, select AP Pelvis as the projection.
- iii) In the x-ray room, select a 35 x 43 (14 x 17in) receptor size. Place it in the Table Bucky.
- iv) Admit the Patient by selecting the 'patient' icon . Position them supine on the table.
- v) Raise the table to working height; check the SID is 100cm (40in)
- vi) Collimate to the receptor size and position the patient for a pelvis
- vii) Expose the patient using the default tube voltage setting of 75kV with charge of 18 mAs and record the results in the table.
- viii) Select the 'expose' tab on the console. Change the Tube Voltage to 33kV and the Tube Charge to 180mAs and expose again. Note these results on the table also.



b) Images



c) Results

Tube Voltage kV	Tube Charge mAs	SID cm	DAP cGy.cm2	ESD mGy	SysD μGy	EI	Latitude	Cancer Risk	Diagnostic Accuracy	Image Quality
75	18	100								
33	180	100								

d) Explanation

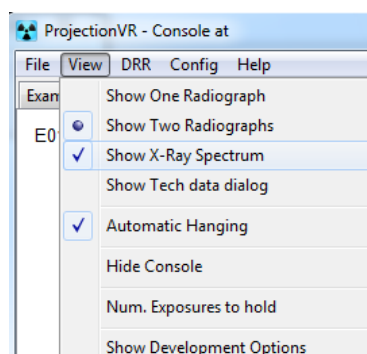
The x-ray intensity is similar incident on the patient, as shown by similar Dose area Products (DAP) and entrance surface doses (ESD).

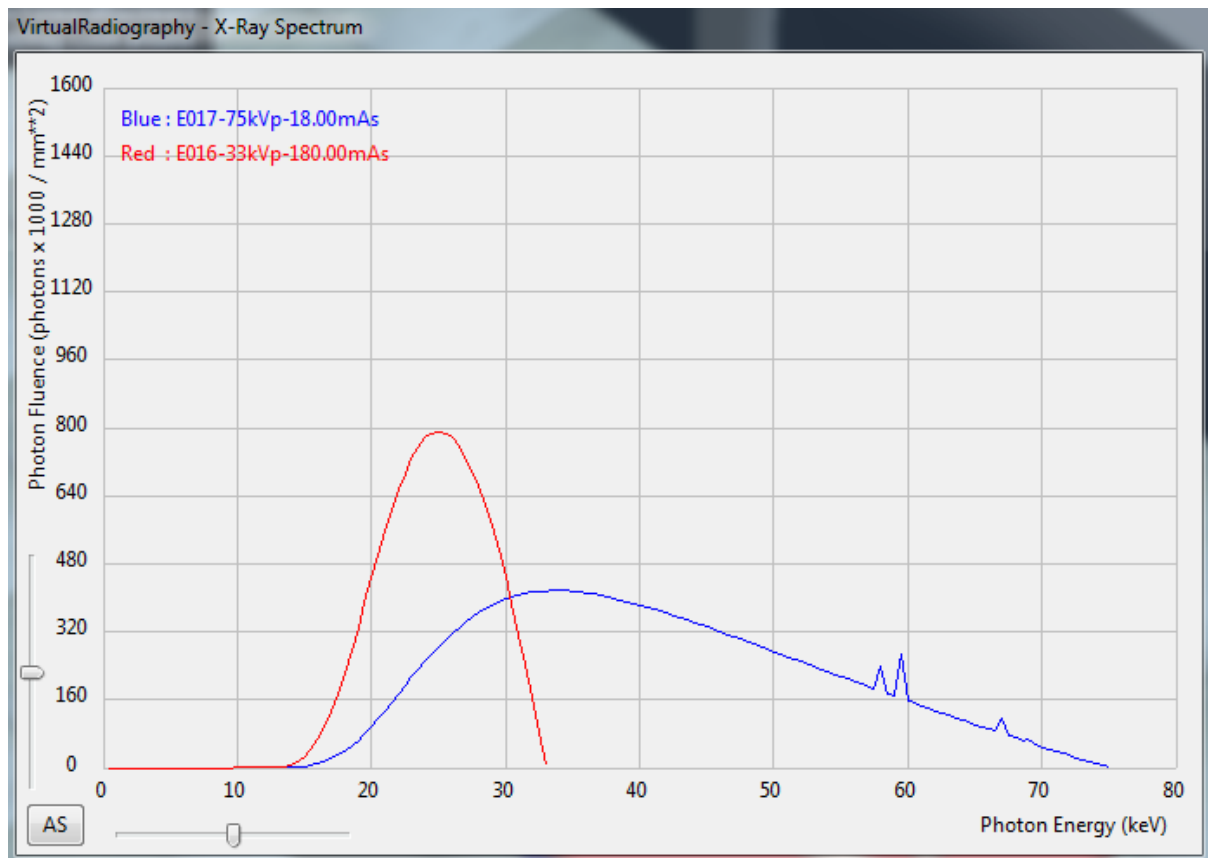
With a low tube voltage (33,000 volts) the electrons crossing the x-ray tube are slow (7.5 million miles per hour). With 75,000 volts, the electrons are faster (12 million miles per hour). The maximum energy of the x-ray photons in a beam depends on the speed of the fastest electron crossing the tube that generated it.

Low tube voltage cannot generate high energy x-rays. Low energy x-rays cannot pass through the thick body part no matter how many there are. They do not have high penetration. The graininess is electronic noise showing no photons have reached the receptor. The low energy beam is very dangerous to the patient, as the energy does not escape them.

e) Extension activity

Select the x-ray spectrum window from the View menu of the console:





The graph shown compares the x-ray photon energies of two beams, the blue one is set at tube voltage of 75 kV and tube charge of 18mAs. The red one is set at 33 kV and 180mAs. The red beam has a lot of photons at a low energy, However, the maximum photon energy is much lower than the blue beam maximum. The maximum photon energy is related to the penetrating power of the beam.


LAB 16 - Tube Voltage

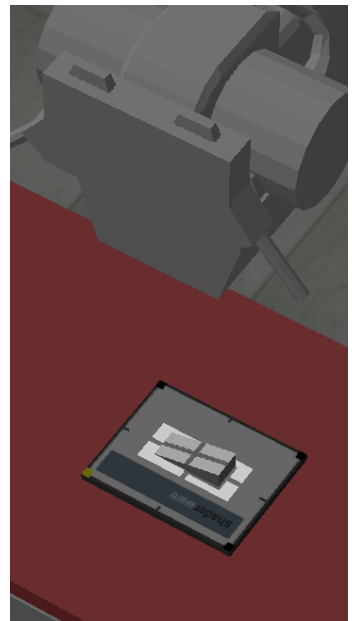
Outcomes

At the end of the Lab, students will be able to:

62. State the basic effect of changing Tube Voltage on DAP, ESD, RAK, EI and Latitude
63. Describe the effect of changing Tube Voltage on a) patient dose and b) image appearances
64. Recognise too little and too much contrast on an x-ray receptor

a) Tube Voltage (kV) (skip to step seven if you have just completed 14)

- i) On the console, select the 'Study Tab' - Select 'Modality Work List...' Session 1, Visit V0183 'Stepwedge' from the list.
- ii) To complete the Study set up, select Quality Assurance (QA) test as the projection.
- iii) In the x-ray room, select a 24 x 30cm (10 x 8in) receptor size. Place it on the table top.
- iv) Admit the test object by selecting the 'patient' icon . Position it on top of the receptor in the middle.
- v) Raise the table to working height; check the SID is 100cm (40in)
- vi) Collimate to a field size with a 2.5cm (1in) border around the test object using the LBD (9 x 20cm)
- vii) Select the 'expose' tab on the console. Change the Tube Voltage to 46kV and the Tube Charge to 5mAs
- viii) Expose the stepwedge and record the results in the table. Repeat to complete the table, Raising the tube voltage 15% each time.

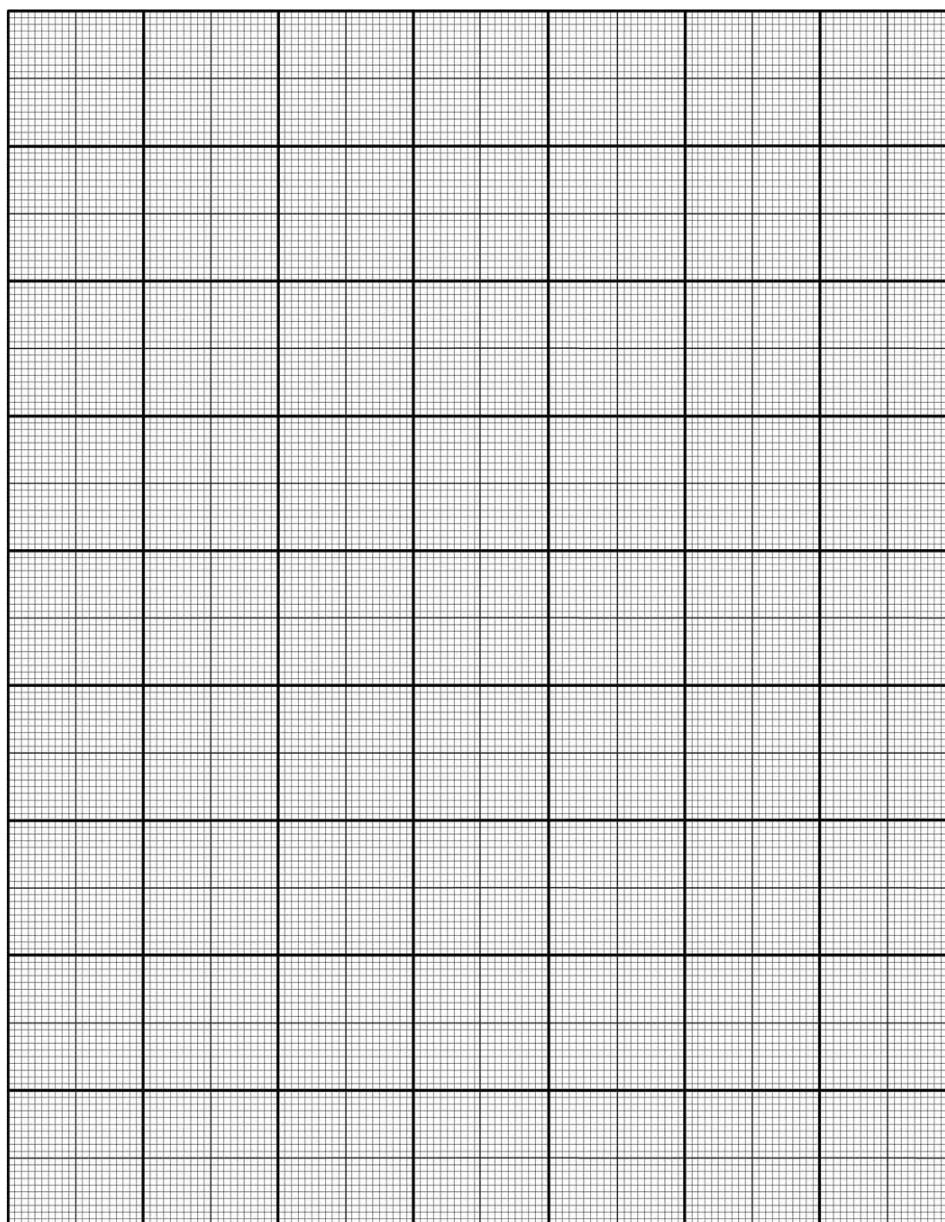


b) Results

Tube Voltage kV	Tube Charge mAs	SID cm	DAP cGy.cm ²	ESD mGy	SysD μGy	EI	Latitude	Cancer Risk	Diagnostic Accuracy	Image Quality
46	5	100								
54	5	100								
62	5	100								
70	5	100								
81	5	100								

c) Graph

Use the graph paper to plot Tube Voltage against System Dose



d) Explanation

It used to be said that increasing the tube voltage by 15% had a similar effect on the receptor as doubling the tube charge. It can be seen from your results that it is still true that a small increase in tube voltage has a large effect on system dose and exposure index.

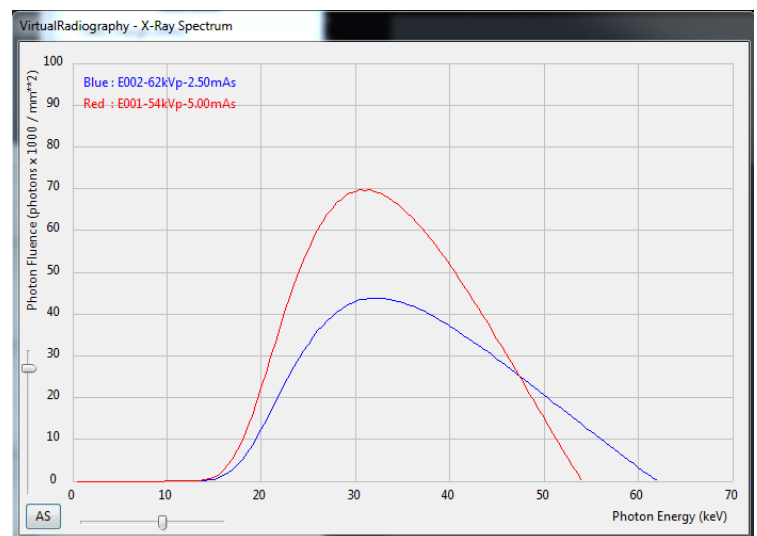
Changes to tube voltage have a much smaller effect on entrance surface dose. Combining these findings, many have suggested that using higher tube voltages can allow reductions in tube charge and therefore reductions in patient dose.

e) Extension activity: Select the x-ray spectrum window (see lab 15)

Tube Voltage	Tube Charge	SID	DAP	ESD	RAK	EI	Latitude	Cancer Risk	Diagnostic Accuracy	Image Quality
kV	mAs	cm	cGy.cm2	mGy	μGy					
62	2.5	100								

f) Explanation

This exposure provides similar SysD and EI to the receptor as the 54kV 5mAs exposure, but delivers half the ESD to the patient. The graphs show the area under the curve is similar, but it is distributed differently. Although there are less photons, more of the 62kV beam will penetrate the patient.



However, this is only half the story. Your findings also demonstrate a relationship between increasing tube voltage and decreasing latitude.

Contrast is controlled in part by the tube voltage. Lower tube voltage produces a high degree of contrast over a short scale. High tube voltage selection produces lower degrees of contrast, but over a longer scale. Increasing tube voltage will reduce the observer's ability to identify two objects of subtly different electron densities. Latitude is a measure related to contrast.

It follows that increasing tube voltage can only be used to save radiation dose where it is safe to do so. These situations are *where subtle findings will not be missed* and reduced patient dose is critical. There is an optimal tube voltage for each given part thickness and clinical indication. It is the radiographer's role to select this on a patient by patient basis. Also, different receptor materials will have different optimal x-ray energies so do not be surprised to see differing local protocols in practice.

Radiographic Science Three

This chapter contains three Labs that present opportunities for the student to work through some more fundamental science concepts.

LAB 17 - Effect of irradiated part thickness on the image

Aims of Lab

- To demonstrate the effect of part thickness on scatter/primary ratio
- To demonstrate the effect of part thickness on image quality

LAB 18 - Effect of beam restriction on the image

Aims of Lab

- To demonstrate the effect of beam restriction (collimation) on scatter production
- To demonstrate the effect of beam restriction on image quality

LAB 19 - Scatter rejection using air-gaps

Aims of Lab

- To demonstrate the effect of increased OID on the rejection of scatter
- To measure the effect on Entrance Surface Dose of using anti-scatter devices

LAB 20 - Use and pitfalls of scatter rejection grids

Aims of Lab

- To demonstrate the effect of scatter rejection devices on image quality
- To measure the effect on Entrance Surface Dose of scatter rejection devices
- Understand the limitations to beam angulation inherent in use of scatter rejection devices.

LAB 17 - Effect of irradiated part volume on the image

Outcomes

At the end of the Lab, students will be able to:

65. Describe the effect of increasing part thickness on scatter/primary ratio
66. Estimate the proportion of incident photons produced by scatter
67. Identify the effects on image quality due to high scatter/primary ratio

a) Ankle Study

- i) On the console, select Session 3, Visit v0161. Homer Simpson "Footballer, inversion injury. Unable to continue. Unable to weight bear. Swelling and effusion. Tender over lateral malleolus and fibula head. ?Fibula #"
 - ii) Set study to be 'Ankle XR Lt' with the patient position as 'Recumbent' and set the projection to be 'AP'.
 - iii) Choose the 24x30cm (10x8in) receptor and place it at the foot of the table on the table top.
 - iv) Pick the appropriate side marker and position it on what will be the Lateral aspect of the receptor.
 - v) Raise the table to working height; check the SID is 100cm (40in)
 - vi) Position the patient to obtain required projection of the correct anatomical area
 - vii) Pose the patient (selecting the correct dataset)
 - viii) Collimate to include the Ankle
 - ix) Complete the table overleaf from the 'Tech Data' tab results
- b) Repeat the steps six-eight for the study 'Lt Knee' - AP projection (leave the receptor on the table-top)
- c) Now add a Hip study, and repeat the steps six-eight for 'Lt Hip' -AP projection (remember to select the full body model; leave the receptor on the table top)



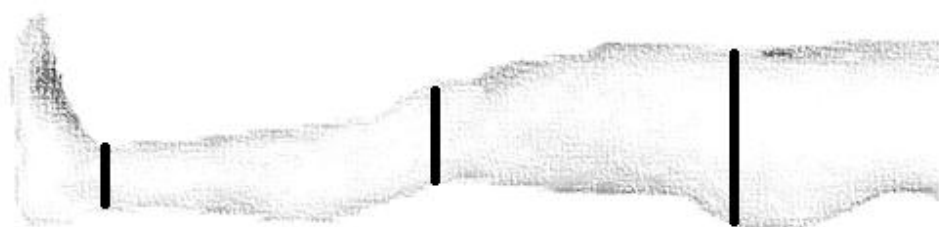
d) Results

Projection	Tube Voltage kV	Tube Charge mAs	SID cm	Part thickness mm	DAP cGy.cm2	ESD mGy	SysD μGy	Scatter fraction %
Lt Ankle AP	60	10	100					
Lt Knee AP	60	10	100					
Lt Hip AP	60	10	100					

What difference can you see in the images produced?

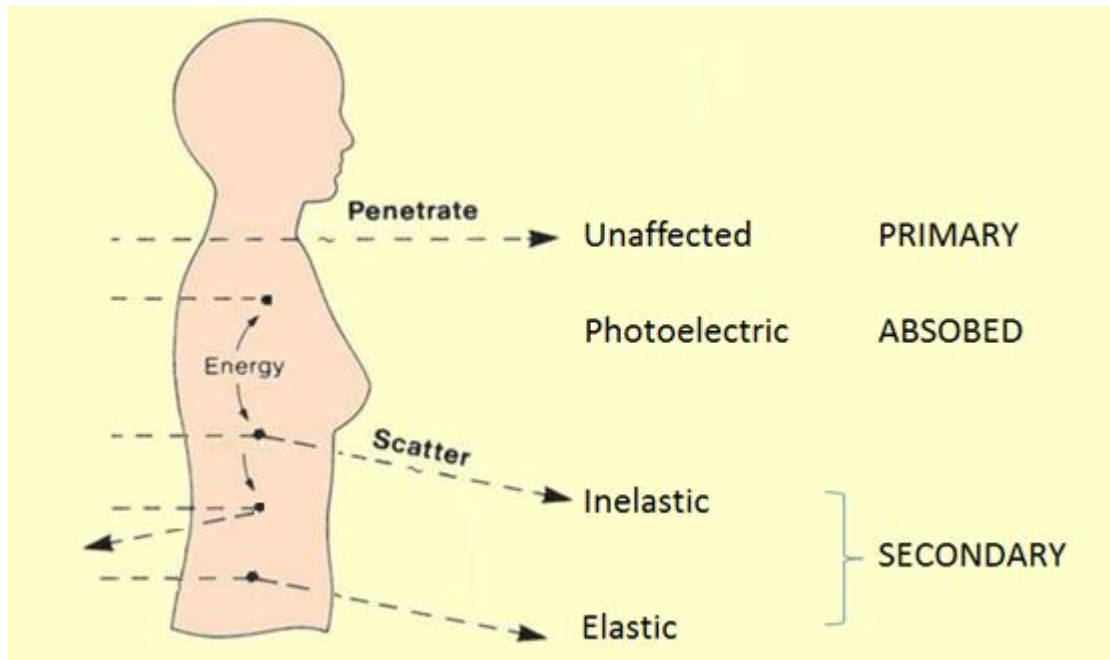
a) Extension Activity (calculator required!)

Multiply the System Dose by the scatter fraction (as a decimal) and complete the 'scatter dose to receptor' column. Subtract this useless part of the receptor dose and complete the 'primary dose to receptor' column with the results:



Thickness mm			
System Dose μGy			
% Scatter			
Scatter μGy			
Primary μGy			

You can see the useful 'signal' is dramatically reduced as the part thickness increases. This is why it gets 'swamped' by the 'fog' of useless scattered photons. Image quality reduces as can be seen in the images. All but the Ankle are un-diagnostic.



There are three outcomes possible for any photon entering matter, i) useful primary beam carrying information, ii) absorbed leading to potential harm, or ii) secondary 'fog' leading to poor image quality and possible harm.

LAB 18 - Effect of beam restriction on the image

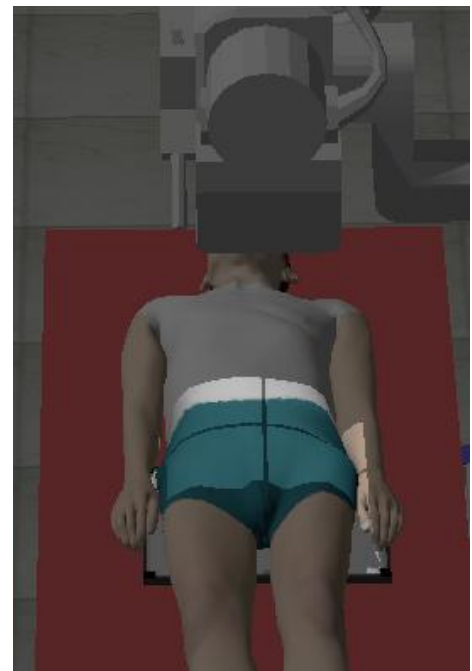
Outcomes

At the end of the Lab, students will be able to:

- 68. Describe the effect of restricting the beam on scatter/primary ratio
- 69. Choose appropriate collimation for optimum image quality

a) Pelvis Study

- i) On the console, select Session 3, Visit v051. Ned Flanders “Aches and pains in the lumbar region and thighs. Accompanying muscle weakness, fatigue and hypocalcaemia. ?Osteomalacia”
- ii) Set study to be ‘Pelvis’ with the patient position as ‘Recumbent’ and set the projection to be ‘AP’.
- iii) Choose the 35x43cm (17x14in) receptor and place it on the table top. Rotate it to landscape
- iv) Pick the appropriate side marker and position it on what will be the Lateral aspect of the receptor
- v) Admit the patient to the room.
- vi) Raise the table to working height; check the SID is 100cm (40in)
- vii) Position the patient to obtain required projection of the correct anatomical area
- viii) Open the collimation to 35x43cm (14x17in)
- ix) Expose the patient using tube voltage of 65kV and tube charge of 18mAs
- x) Complete the table overleaf from the ‘Tech Data’ tab results



- b) Collimate to 25x33 cm (10x13in) repeat exposure record data
- c) Collimate to 15x23 cm (6x9in) repeat exposure record data
- d) Collimate to 5x13 cm (2x5in) repeat exposure record data

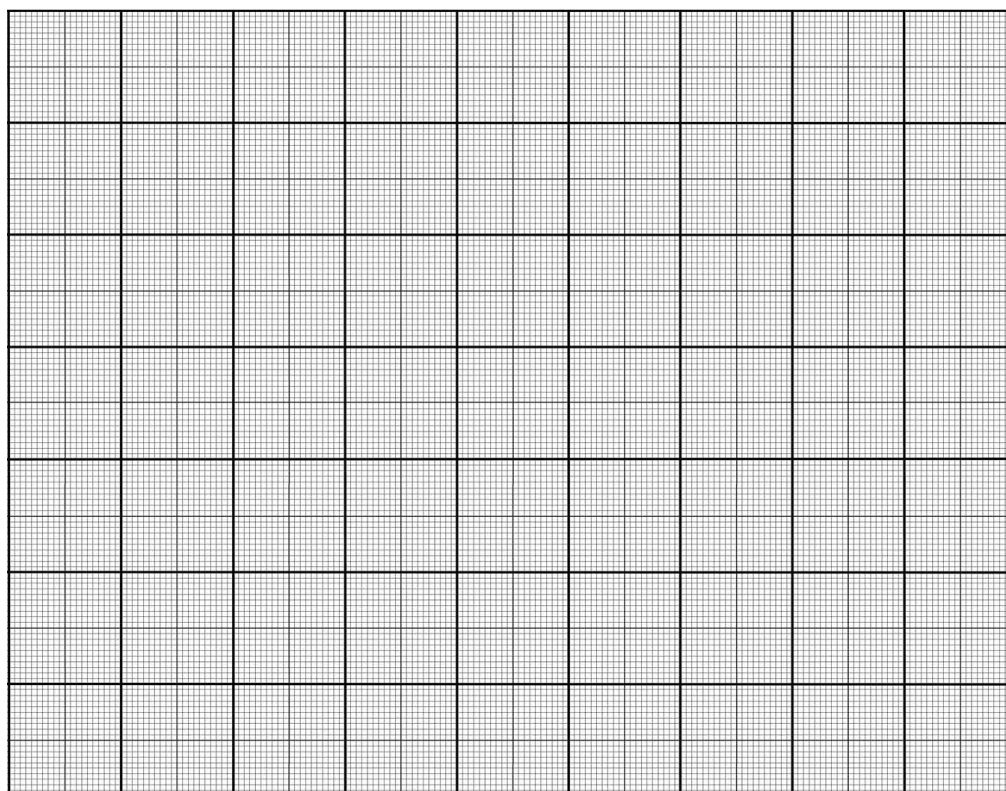
e) Results

Collimation cm	Tube Voltage kV	Tube Charge mAs	SID cm	Part thickness (CR) mm	DAP cGy.cm ²	ESD mGy	SysD μGy	Scatter fraction %	Image Quality
35x43	65	20	100						
25x33	65	20	100						
15x23	65	20	100						
5x13	65	20	100						

What difference can you see in the images produced?

f) Graph

Use the graph paper to plot Beam Area against Scatter Fraction



g) Explanation:

You can see that as the area of irradiation decreases, the % scatter decreases. However, altering collimation areas larger than about 15x15cm (6x6in) has little effect.

Knowledge of this effect is used to reduce the scatter/primary ratio in 'fan beam' systems such as CT, DEXA, and others by utilising a very small simultaneous irradiation area, and then moving this across the area to be imaged.

LAB 19 - Scatter rejection using air-gaps

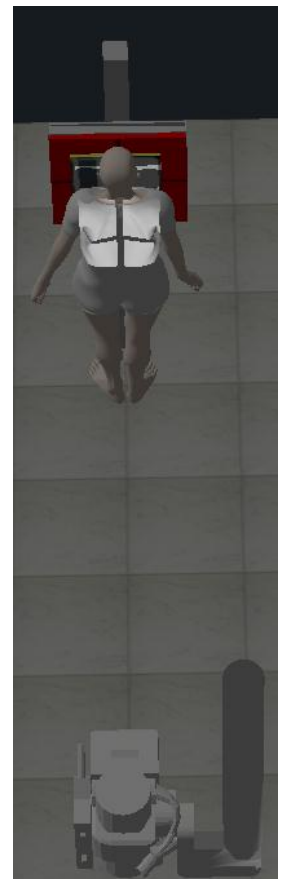
Outcomes

At the end of the Lab, students will be able to:

70. Describe the effect of increasing OID on scatter/primary ratio.
71. Choose appropriate OID for scatter rejection where appropriate.
72. Identify the disadvantages of air-gaps regarding magnification and patient immobilisation; also positioning x-ray tubes and tube ratings.

a) Chest Study

- i) On the console, select Session 1, Visit v0110. Marj Simpson "Haemoptysis. Night sweats, fatigue, poor appetite. ?Pulmonary TB"
 - ii) Set study to be 'Chest' with the patient position as 'Erect' and set the projection to be 'PA'.
 - iii) Choose the 35x43cm (17x14in) receptor and place it on the erect chest stand surface.
 - iv) Pick the appropriate side marker and position it on what will be the Lateral aspect of the receptor
 - v) Admit the patient to the room.
 - vi) Move the tube to an SID of 300cm (120in)
 - vii) Position the patient to obtain required projection of the correct anatomical area
 - viii) Collimate to the receptor
 - ix) Expose the patient using Tube Voltage of 109kV and Tube Charge of 5 mAs
 - x) Complete the table overleaf from the 'Tech Data' tab results
- b) Now move the patient so there is an approximate 50cm (20in) gap between the receptor and their anterior aspect (one floor tile). Repeat exposure.



c) Results

Collimation cm@100	Tube Voltage kV	Tube Charge mAs	SID cm	Part thickness mm	DAP cGy.cm2	ESD mGy	SysD μGy	Scatter fraction %	Image Quality
12x14	109	5	300						
12x14	109	5	300						

What difference can you see in the images produced?

Make notes:

What questions would you like to ask?

d) Explanation

Scattered photons do not travel from the x-ray tube focus to the receptor, they have been deflected. If there is a large enough gap between the patient and the receptor, the angle of scatter will divert many of the scattered photons so they miss the receptor entirely. Therefore the scatter to primary ratio can be reduced by using a so called 'airgap'.

The entrance surface dose is only slightly increased by an air-gap, so this is a low dose way of rejecting scatter. However, to minimise magnification and other problems a large SID must be used.

Large SID's require large tube charges (mAs) to compensate for the dispersion due to the inverse square law. Creating a large number of electrons can put a strain on the Tube filament; the other alternative, a long exposure time, may induce movement blur.

LAB 20 - Use and pitfalls of scatter rejection grids

Outcomes

At the end of the Lab, students will be able to:

73. State the basic effect of using a scatter rejection grid on DAP, ESD, SysD, EI and Latitude
 74. Show awareness of the effect of scatter rejection grids on scatter to primary ratio
 75. Describe the limitations of beam angulation due to scatter rejection grids
 76. Choose when to use appropriate scatter rejection techniques
- a) Chest Study (if just completed lab 19, skip instructions and repeat exposure with receptor in Erect Bucky and NO airgap)
- i) On the console, select Session 1, Visit v0110. Marj Simpson “Haemoptysis. Night sweats, fatigue, poor appetite. ?Pulmonary TB”
 - ii) Set study to be ‘Chest’ with the patient position as ‘Erect’ and set the projection to be ‘PA’.
 - iii) Choose the 35x43cm (17x14in) receptor and place it in the erect Bucky. IMPORTANT don’t chose the 8:1 scatter rejection grid!
 - iv) Pick the appropriate side marker and position it on what will be the Lateral aspect of the receptor
 - v) Admit the patient to the room.
 - vi) Move the tube to an SID of 300cm (120in)
 - vii) Position the patient to obtain required projection of the correct anatomical area
 - viii) Collimate to the receptor
 - ix) Expose the patient using Tube Voltage of 109kV and Tube Charge of 5 mAs
 - x) Complete the table from the ‘Tech Data’ tab and compare to lab 19

Collimation cm@100	Tube Voltage kV	Tube Charge mAs	SID cm	Part thickness mm	DAP cGy.cm2	ESD mGy	SysD μGy	Scatter fraction %	Image Quality
12x14	109	5	300						

b) Hip Study

i) On the console, select session 11, visit V0142. Penny Simpson "Fall. Shortened and externally rotated L leg. ?# Left Hip"

ii) Set study to be 'Hip' with the patient position as 'Recumbent' and set the projection to be 'Lateral Half Axial'.

iii) Choose the 24x30cm (12x10in) receptor and place it on the erect chest stand surface.

iv) Pick the appropriate side marker and position it on the receptor

v) Admit the patient to the room.

vi) Move the tube to an SID of 115cm (46in)

vii) Position the patient to obtain required projection. Collimate to the area of interest

viii) Expose the patient to tube voltage of 75kV and tube charge of 40 mAs

ix) Complete the table overleaf from the 'Tech Data' tab results

c) Now repeat exposure with receptor in bucky

d) Now repeat exposure with 24x30cm 8:1 grid receptor

e) Now repeat exposure with 35x43cm 8:1 grid receptor



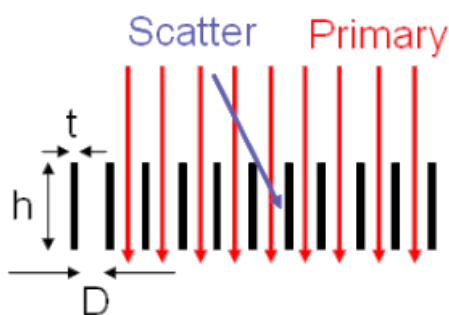
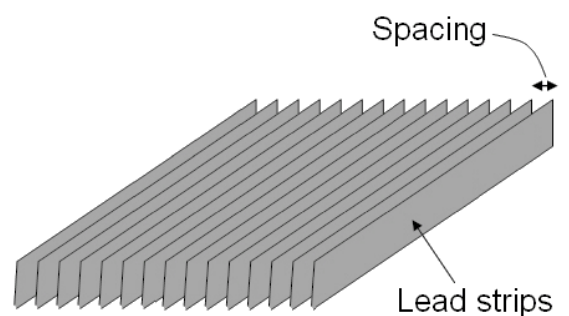
f) Results

Scatter rejection method	Tube Voltage kV	Tube Charge mAs	SID cm	Part thickness mm	DAP cGy.cm2	ESD mGy	SysD μ Gy	Scatter fraction %
None	75	40	115					
8:1 carbon fibre grid	75	40	115					
8:1 aluminium grid	75	40	115					
12:1 Bucky grid	75	40	115					

What difference can you see in the images produced?

g) Explanation

Scatter rejection grids are used between the patient and the receptor. They consist of fine strips of attenuators, such as lead, separated by spaces filled with translucent material.



Grids all work by rejecting any photon that is not traveling perpendicular to the grid plane.

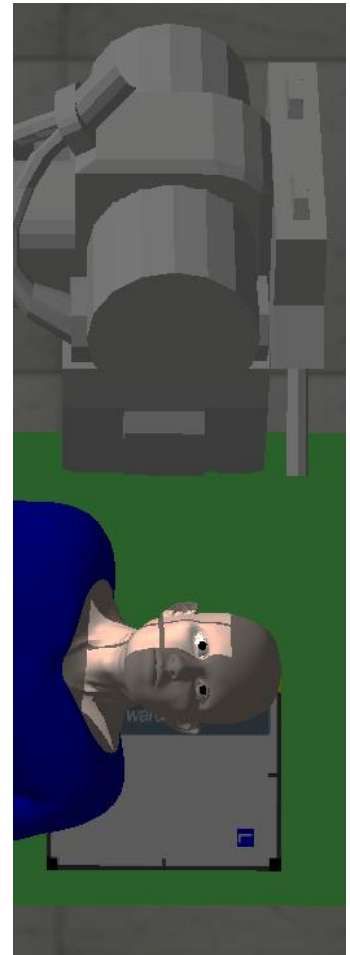
Different grids have different properties dependent on the measurements: height (h) & thickness (t) of the attenuator strips, distance between these strips (D), and the type of spacer material used.

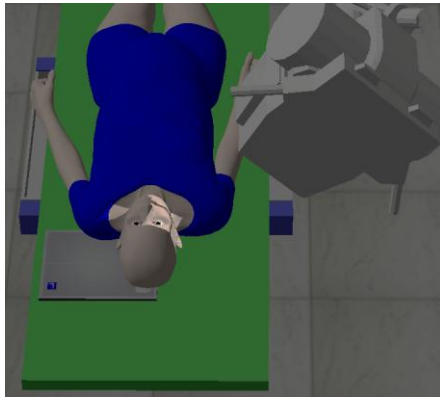
Differences in these specifications explain your results:

- The 8:1 grids have strips that are eight times as high (h) as the distance between them (D). This is known as the grid ratio, $h:D$. the Bucky uses a 12:1 grid which is more effective.
- The aluminium grid uses aluminium spacer material, as opposed to carbon fibre used in the Bucky and the carbon fibre grid. The carbon fibre is more translucent to primary radiation.
- Grid frequency is a measure of how many strips in a given distance (inch or cm). High frequency grids (70lines/cm) need to have very thin (t) strips. Low frequency grids are in the range 40-50lines/cm.
- Covers used to protect the grid can be made of many different materials. This will also affect the attenuation of the primary beam.

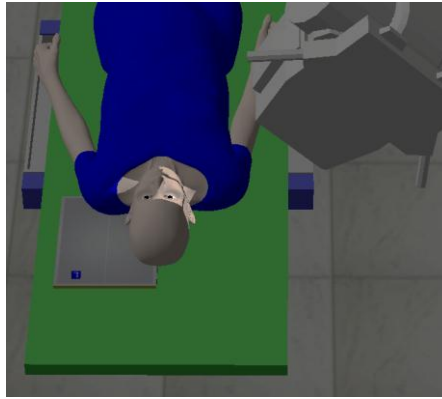
h) Extension Activity - Trauma oblique cervical spine radiographs

- i) On the console, select session 4, visit V0135. Homer Simpson
“Assault: beaten about the head with a bat: severe facial swelling.
Lost several teeth. Unconscious. ?Facial Fractures
?Fractured Mandible ?# C Spine”
 - ii) Set study to be ‘Cervical Spine’ with the patient
position as ‘Recumbent’ and set the projection to
be ‘AP Trauma Obliques (LPO) in Dorsal
Decubitus’.
 - iii) Admit the patient to the room.
 - iv) Choose the 24x30cm (12x10in) receptor and place
it on the trolley surface.
 - v) Orientate the receptor to portrait
 - vi) Pick the appropriate side marker (L) and position it
on the receptor to the left lateral aspect
 - vii) Angle the tube 45 degrees
 - viii) Move the tube to an SID of 100cm (40in)
 - ix) Position the patient to obtain required projection
and collimate to the area of interest
 - x) Expose the patient using a tube voltage of 70 kV
and a tube charge of 6.3 mAs
 - xi) Compare the image acquired with that overleaf
and document in table
- i) Now repeat exposure with a grid receptor (increase tube charge to 16 mAs)
- i. Orientate the grid receptor to landscape (with the yellow edge to
the right and manufacturer label to the foot of the patient).
 - ii. Select ‘transverse’ as the patient/gantry relationship on the console
- j) Now repeat exposure with the grid receptor in portrait orientation



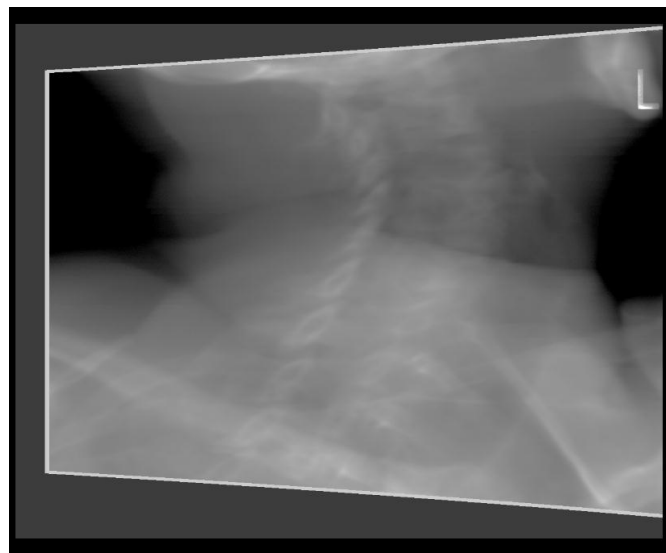


Exposure B



Exposure C

k) Results



Trauma Oblique (LPO) in dorsal decubitus.

l) Results

Scatter rejection method	Grid orientation	Tube Voltage kV	Tube Charge mAs	SID cm	Part thickness mm	DAP cGy.cm2	ESD mGy	SysD μ Gy	Scatter fraction %
None	-	70	6.3	100					
8:1 aluminium grid	Portrait	70	16	100					
8:1 aluminium grid	Landscape	70	16	100					

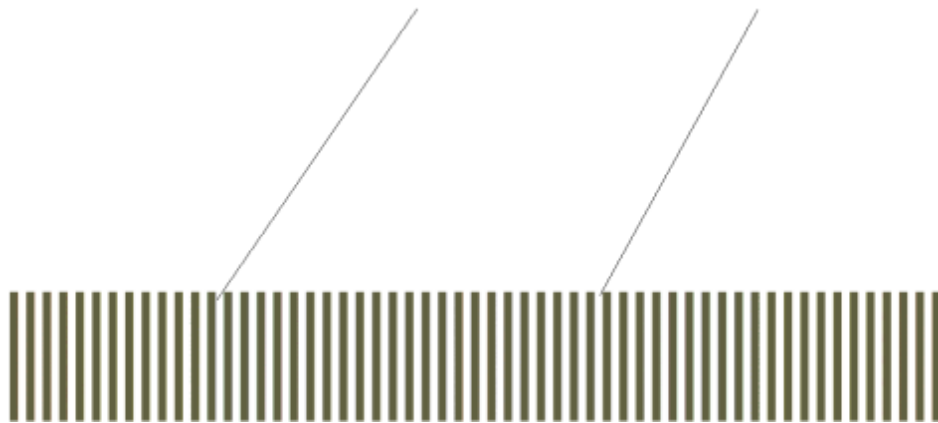
m) Explanation

Normally, the scatter rejection grid lines run parallel to the long side of the receptor (this should be clearly marked). In a table Bucky they are always parallel to the long table side; in an erect Bucky they are vertical. The grid orientation is therefore critical to success.

In this case, when the grid is in portrait mode, the x-ray beam is angled ACROSS the long side of the receptor. This means the primary beam is also rejected by the grid as well as the scatter.

When the grid is in landscape mode the primary beam is angled ALONG the long side of the receptor and is allowed through.

It is dangerous to angle against a grid because small angles matter, but the image quality improvement may be worth the risk. The radiographer must be VERY careful in setting up the exposure.



Patient Practice

This chapter contains three Labs that present patient specific cases to the student to work through.

LAB 21 - Supine abdomen radiography (AXR)

Aims of Lab

- See the process of interpreting and justifying radiographic requests
- Gaining confidence in patient positioning and radiographic projection
- Experience making judgements against a radiograph assessment criteria
- Translate anatomy/pathology knowledge to radiographs

LAB 22 - Supine chest radiography (CXR)

Aims of Lab

- See the process of interpreting and justifying emergency radiographic requests
- Gaining confidence in patient positioning and radiographic projection
- experience making judgements against a radiograph assessment criteria
- Translate anatomy/pathology knowledge to radiographs

LAB 23 - Formative assessment

Aims of Lab

- Test student learning
- Give students feedback
- Evaluate workbook outcomes

LAB 21 –Supine abdomen radiography (AXR)

Outcomes

At the end of the Lab, students will be able to:

77. List indications for a plain supine abdomen Study
78. Follow an efficient procedure throughout
79. Position a patient and choose a projection to ensure area of interest is included in the radiograph
80. Critique the resultant radiograph against a given criteria to judge acceptability and write a comment on findings

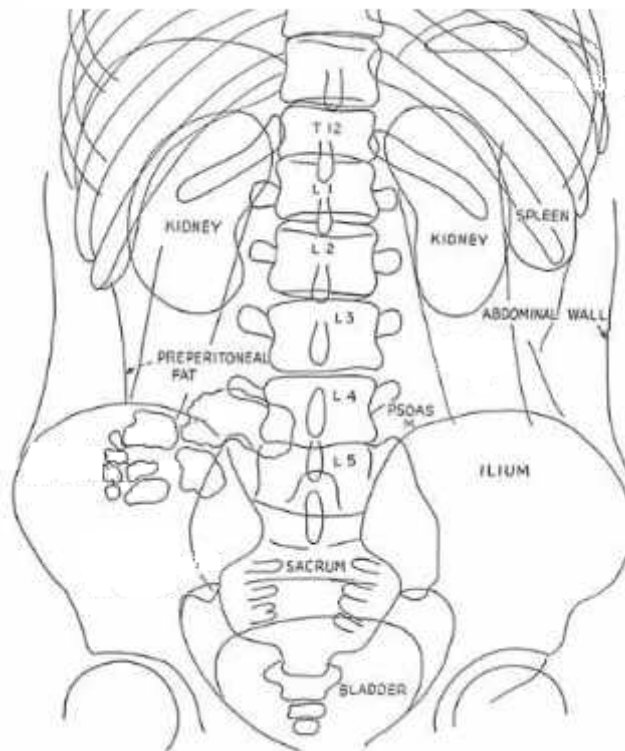
Review Session 1, Visit V0120

Standard Indications for imaging

- Bowel gas patterns in obstruction, intussusceptions, volvulus,
- Investigation of biliary and renal lithiasis
- Control or preliminary films for contrast studies
- ? Aortic Aneurysm when sclerotic and with calcifications

Question

Do you proceed?



Meschan, I. 1951 *An Atlas of Normal Radiographic Anatomy* Saunders, London

Radiographic Criteria:

“Dogs Always Make Perfect Pets Showing Considerable IQ, Pups Can’t Handle ABC’s”

1. **Collimation:** Borders only top and bottom (to ensure abdominal margins visible)
2. **Area included:** from T11/12 to Symphysis Pubis.
3. **Projection/Position:** No rotation; Judge symmetry from iliac wings, obturator foramina (if visible), ischial spine and outer lower rib margins.
4. **No Movement:** No respiratory movement. Judge from sharp rendition of ribs and gas margins.
5. **Density and Contrast:** Judge from visualisation of psoas muscle, lumbar transverse processes and ribs.

Radiographers Comment

Signed:

Date:

Don't forget to complete the paperwork!

Review Session 1, Visit V0168

Question

Do you proceed?

Radiographers Comment

Signed:

Date:

Don't forget to complete the paperwork!

LAB 22 –Supine chest radiography (CXR)

Outcomes

At the end of the Lab, students will be able to:

81. List indications for a supine CXR Study
82. Position a patient and choose a projection
83. Critique the resultant radiograph against a given criteria to judge acceptability and write a comment on findings
84. Consider pathology and its possible impact on exposure factor selection

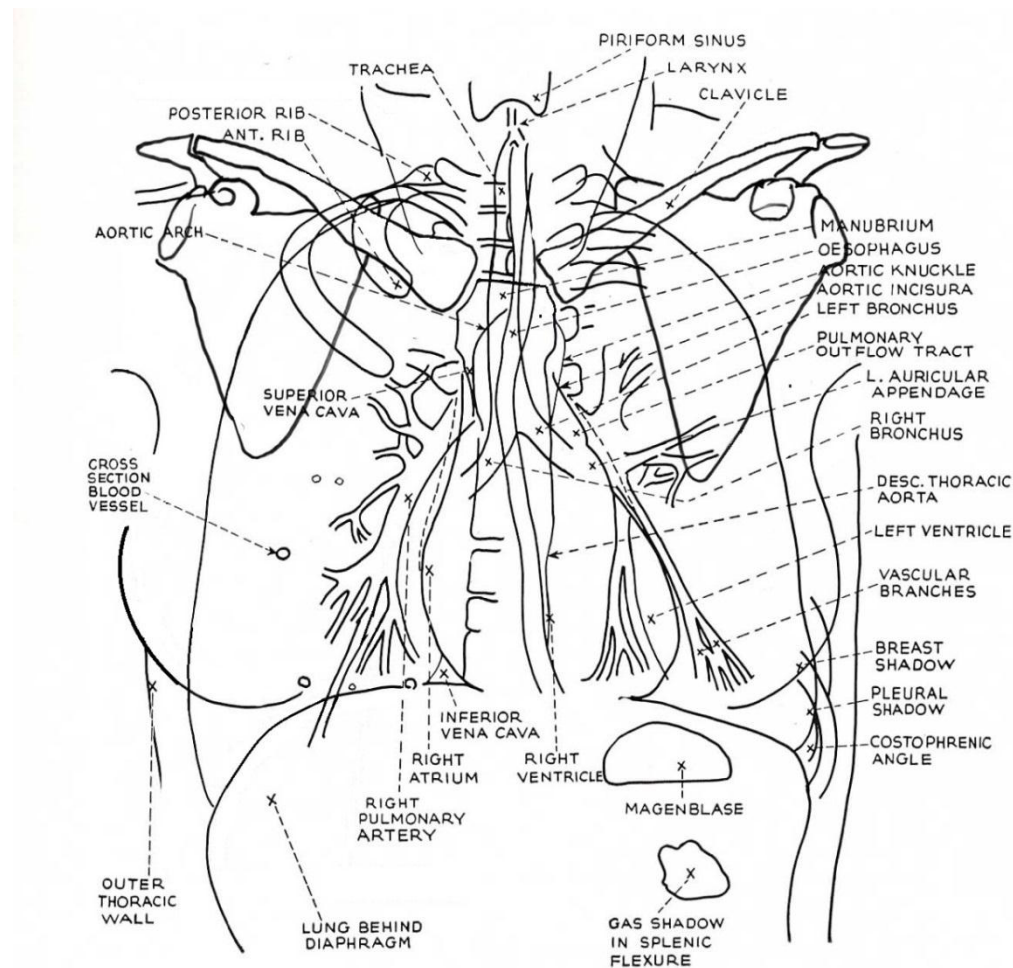
Review the Session 18, Visit V0180

Standard Indications for imaging

- Chest pain ?MI (Assessment of heart size & pulmonary oedema)
- Chest pain
- Acute aortic dissection
- Pulmonary embolus
- Pericarditis
- Pericardial effusion
- Vascular disease
- Chest trauma (if ? pneumothorax)
- Pneumonia follow up (To confirm resolution (>10 days))
- Haemoptysis (+ lateral)
- ITU (Progress check)

Question

Do you proceed?



Meschan, I. 1951 *An Atlas of Normal Radiographic Anatomy* Saunders, London

Radiographic Criteria

“Dogs Always Make Perfect Pets Showing Considerable IQ, Pups Can’t Handle ABC’s”

1. **Collimation:** Borders on all 4 sides, within skin margins and close to apices and costophrenic angles - centred around T7
2. **Area included:** In full inspiration, both lungs from apices to costophrenic angles. Count 8-9 posterior ribs above diaphragm (normally 10 for erect patient). First rib upper border should be included.
3. **Projection/Position:** Three posterior ribs should be visible above the clavicles. No rotation; Judge Symmetry from equidistance of sternoclavicular joints and outer rib margins from spine
4. **No Movement:** no respiratory movement. Judge from sharp rendition of ribs, lung markings and gas margins.
5. **Density and Contrast:** Judge from faint visualisation of vertebral bodies through the heart shadow and air in the trachea down to T5.

Radiographers Comment

Signed:

Date:

Don't forget to complete the paperwork!

For more patient practice, choose Studies from any of the 20 sessions provided.

To improve your terminology, use a medical dictionary or go to

<http://www.shaderware.com/live/er.html>

LAB 23 - Formative assessment

Patient practice

Complete all the patient exams in session eight (8) in order and review the images, complete the table

Visit	Patient Name	Study	Clinical History	Reason for Study	Number exposures	Number rejects	Cummulative DAP
17	Homer Simpson	Leg (Lt)	Shin pain and swelling accompanied by nonspecific symptoms, including chills, fever, and malaise. Recent Inguinal Hernia Repair	?Osteomyelitis			
23	Marj Simpson	Pelvis	Pain over pelvis, accompanied by fatigue and anaemia - no trauma	?Ewing's Sarcoma			
37	Patricia Bouvier	Knee (Lt)	Pain and limited range of motion at knee. Local swelling.	?Giant Cell Tumour			
61	Patty Swisher	ACJoint (Lt)	Painful Lt shoulder joint	?Degenerative Changes In AC Joint			
64	Marj Simpson	Sacroiliac Joints	Sciatic pain, tenderness over Rt SI joint. Increasing on straight leg raise test	?SI Joint Lesion			
67	Homer Simpson	Hip (Lt)	Hip Pain. History of Asthma - on steroids	?Avascular Necrosis			
106	Marj Simpson	CXR	Cough, fatigue, fever	?Pneumonia			
154	Ned Flanders	Knee (Lt)	Knee effusion with inability to bear weight or flex to 90 degrees. Patient distressed. No clear history due to mental incapacity.	?# ?Infection			

Extension Activity

Complete all the patient studies in session twelve (12) and complete the table

Visit	Patient Name	Study	Clinical History	Reason for Study	Number exposures	Number rejects	Cummulative DAP
12	Homer Simpson	Lumbar spine	Acute back pain with sciatica +ve SLR	?Disk Herniation			
27	Marj Simpson	Clavicle (Rt)	Hard, fixed, non-painful lump of long standing	?Osteoma Of Clavicle			
29	Homer Simpson	Knee (Lt)	Dull pain above knee, increases at night, limping.	?Giant Cell Tumour			
47	Homer Simpson	Hip (Lt) & Pelvis	Pain in the hip for the past four months	?Fibrosarcoma			
143	Penny Simpson	Pelvis	Fall after dizzy spell. Tender bruising, swelling and crepitus of pubis.	?# Pelvis			
148	Marj Simpson	Shoulder (Lt)	Weightlifter. Feeling that It shoulder has gone in and out of joint	?Subluxation Of Glenohumeral Jt. ?# Glenoid			
158	Selma Bouvier	Knee (Lt)	Fall from height. Patient complaining of pain in knee. Haemarthrosis.	?# Femoral Condyles			
165	Ned Flanders	Femur (Lt)	Fallen from ladder onto greenhouse, multiple superficial lacerations to hands and arms. Suspected glass splinter in deep wound on posterior thigh	?FB			

1) Alphabet Soup - Find the pairs with the same meaning:

- A) Semi-Erect
- B) Expose
- C) Cranial
- D) Central Ray passing through dorsal then ventral surfaces respectively
- E) SID
- F) 'To the tail'
- G) Magenblase
- H) Tube charge
- I) PA
- J) Supine
- K) Cephalic
- L) Orthogonal
- M) 12 x 10
- N) Central ray passing from 'front' to 'back' respectively
- O) FFD
- P) Dorsal Decubitus
- Q) Irradiate
- R) mAs
- S) Perpendicular
- T) Gas in Stomach
- U) Caudad
- V) AP
- W) Lateral
- X) Mediolateral
- Y) 24 x 30
- Z) Fowlers

2) Where does the Detent fix the ceiling suspended x-ray tube?

3) What is the LBD and what does it control?

- 4) What are the standard receptor sizes?
- 5) Why do we need to see four collimation edges on a radiograph?
- 6) What does DAP stand for?
- 7) Name two factors that can be altered to reduce magnification on a radiograph
- 8) What will the addition of an anti-scatter grid do to patient dose if EI is maintained?
- 9) How does SID affect EI?
- 10) How does tube charge affect ESD?
- 11) Generally, how should a patient appear on a radiograph correctly 'hung' for viewing?