Optimizing Dose in the Interventional Suite:

Do you really need that image quality?

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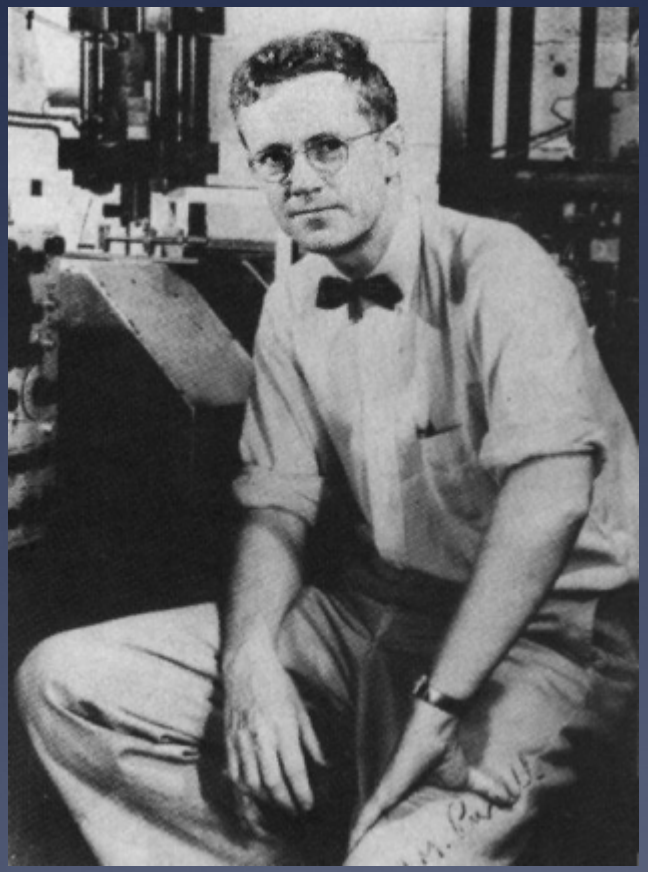
Financial Disclosure

Educational Consultant for Bard Access Systems

Personal Disclosure

What can I teach a room full of physicists?



http://theinvisibleagent.wordpress.com/tag/physics/

Two Perspectives

Physicist

$$CNR^2(f) = \frac{C^2(f)MTF^2(f)}{NPS(f)} = C^2(f)SNR^2(f)$$

Interventional Radiologist

Two Perspectives

Physicist

$$CNR^2(f) = \frac{C^2(f)MTF^2(f)}{NPS(f)} = C^2(f)SNR^2(f)$$

Interventional Radiologist

Learning Objectives

- Appreciation of the clinical perspective
  - Need for operator education
- Simple techniques to optimize dose
- Discuss the question: “Do I really need all that image quality?”

Wide Range of Dose

Table 3

Adult Effective Doses for Various Interventional Radiology Procedures

Examination	Average Effective Dose (mSv)*	Values Reported in Literature (mSv)
Head and/or neck angiography	5	0.8–19.6
Coronary angiography (diagnostic)	7	2.0–15.8
Coronary percutaneous transluminal angioplasty, stent placement, or radiofrequency ablation	15	6.9–57
Thoracic angiography of pulmonary artery or aorta	5	4.1–9.0
Abdominal angiography or aortography	12	4.0–48.0
Transjugular intrahepatic portosystemic shunt placement	70	20–180
Pelvic vein embolization	60	44–78

* Values can vary markedly on the basis of the skill of the operator and the difficulty of the procedure.

Mettler et al. Radiology 2008

Exam Protocol

Patient Info:
Name: Sex:: M ID:

Patient Position: HFS 23-Sep-11 10:57:02

1	DSA		FIXED	LOW DOSE	BODY 3		16s	3F/s	23-Sep-11 12:16:29			
A	73kV	398mA	50.3ms	0.0CL small	0.1Cu 48cm	2000.0µGym²	68.1mGy	1RAO	1CRA	47F		
2	DSA		FIXED	LOW DOSE	BODY 3		13s	3F/s	23-Sep-11 12:30:09			
A	80kV	362mA	50.3ms	0.1CL small	0.1Cu 42cm	1052.9µGym²	60.6mGy	24RAO	1CRA	40F		
3	DSA		FIXED	LOW DOSE	BODY 3		8s	3F/s	23-Sep-11 12:48:06			
A	78kV	371mA	50.3ms	0.3CL small	0.1Cu 42cm	546.8µGym²	33.5mGy	24RAO	1CRA	23F		
4	DSA		FIXED	LOW DOSE	BODY 3		8s	3F/s	23-Sep-11 12:57:50			
A	75kV	716mA	49.9ms	0.4CL large	0.1Cu 32cm	844.6µGym²	64.2mGy	24RAO	1CRA	25F		
5	DSA		FIXED	LOW DOSE	BODY 3		10s	3F/s	23-Sep-11 13:12:04			
A	77kV	379mA	50.3ms	0.5CL small	0.1Cu 42cm	790.7µGym²	40.8mGy	21RAO	1CRA	30F		
7	DSA		FIXED	LOW DOSE	BODY 3		10s	3F/s	23-Sep-11 13:23:52			
A	78kV	374mA	50.3ms	0.6CL small	0.1Cu 42cm	1004.6µGym²	46.2mGy	21RAO	1CRA	31F		
8	DSA		FIXED	LOW DOSE	BODY 3		5s	3F/s	23-Sep-11 13:30:41			
A	74kV	390mA	50.2ms	0.6CL small	0.1Cu 42cm	538.9µGym²	21.6mGy	21RAO	1CRA	16F		
9	DSA		FIXED	LOW DOSE	BODY 3		11s	3F/s	23-Sep-11 13:31:58			
A	77kV	377mA	50.3ms	0.7CL small	0.1Cu 42cm	1141.1µGym²	45.8mGy	21RAO	1CRA	32F		

Exam Protocol

Patient Info:
Name: Sex:: M ID:

---

10 DSA FIXED LOW DOSE BODY 3 9s 3F/s 23-Sep-11 13:36:56
A 76kV 384mA 50.3ms 0.7CL small 0.1Cu 42cm 650.6µGym² 39.5mGy 21RAO 1CRA 26F

Accumulated exposure data 23-Sep-11 14:01:41
Phys: YU Exposures: 9 Fluoro: 30.7min Total: 20486µGym² 1399mGy
A Fluoro: 30.7min 11916µGym² 978.8mGy Total: 20486µGym² 1399mGy

==========

What should we teach them?

1. Basic, simple techniques
2. Target the young physicians

Things you know

- Increase table height
- Add Barriers
- Exit the room for DSA runs
- Limit magnification

Increase the Table Height

Why?

Source to Skin Distance

- SSD: determined by table height
  the operator's height
- Skin dose decreases as SSD increases
- Therefore, maximize SSD within reason
  700 mm (27.6 inches)
  600 mm (23.6 inches): increase dose 17-29%
  Simple 10 cm (4 inch) maneuver

Wagner LK, Archer BR Cohen Am.JVIR 2000;11:25-33

20% Savings

Vary the technique

- Operator is in control
  - Vary:

    Frame Rates

    Gantry Position

    Protocol Used

    Collimation

Optimize

- Prior to the case
- During the case

Prior to the case

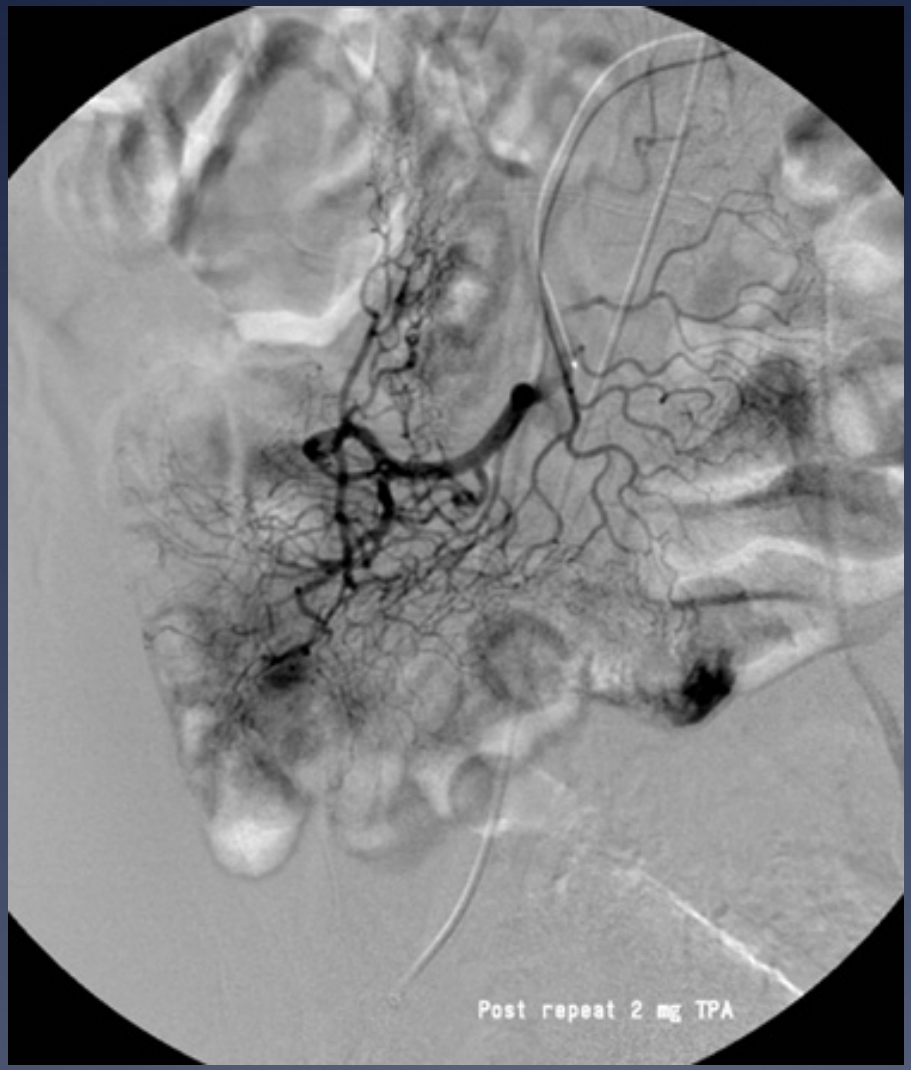
- Review old studies
  - CT
  - MRI
  - US
- Review prior Interventional Procedures
- Have a clear plan

During the case

- Ask: do I need great quality to…
  - Gain access to the celiac artery
  - Demonstrate IVC Filter Position
  - Insert a port
  - Drain an abscess
  - Perform cerebral angiography
  - Embolize a bleeding visceral artery

Use it if you need it

Use it if you need it

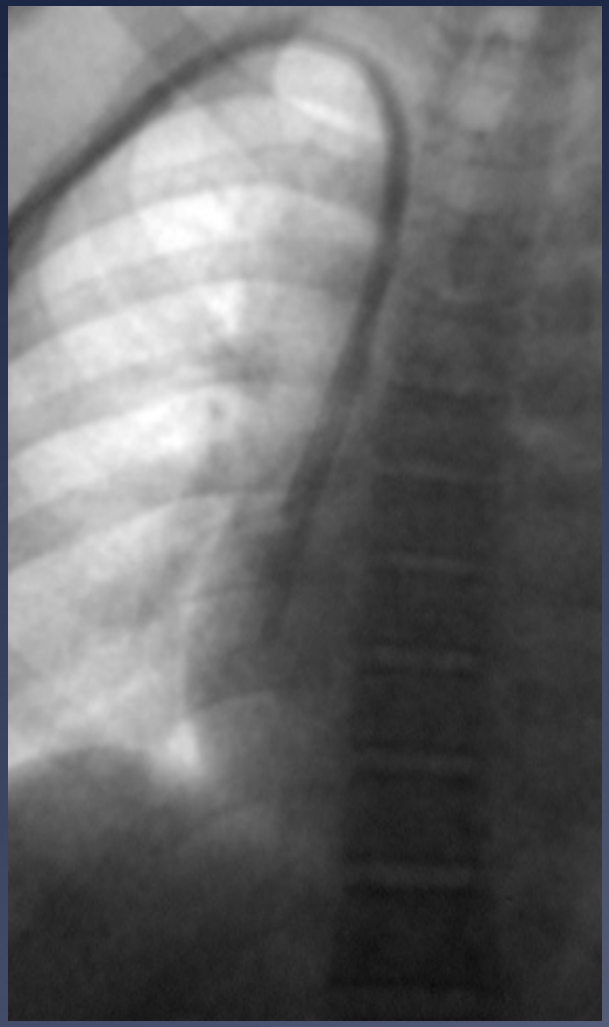


Consider alternatives if you don't

Save Fluoro

- LIH
- Fluoro Video Clips

Last Image Hold



Last Image Hold

Spot Radiograph

Slow the Frame Rate

- Fluoroscopic Frame Rate
- DSA acquisition Frame Rate

Pulsed Fluoroscopy

15 – 30 pps for critical procedures where precision required

7.5 pps used for many cases

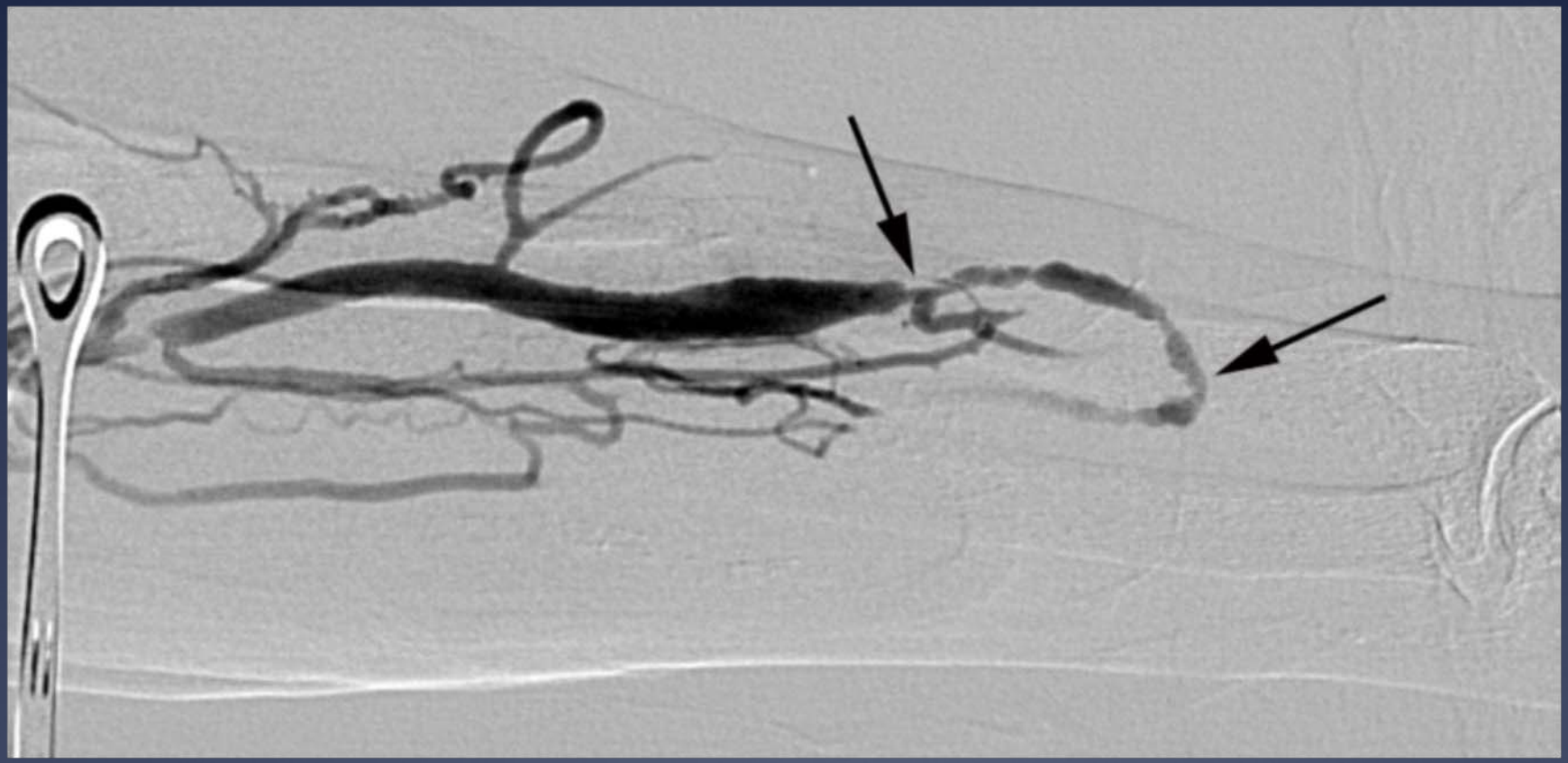
- Up to 70% dose savings compared with continuous fluoro *

3 pulses per second

- Used when dose savings are paramount or for simple procedures

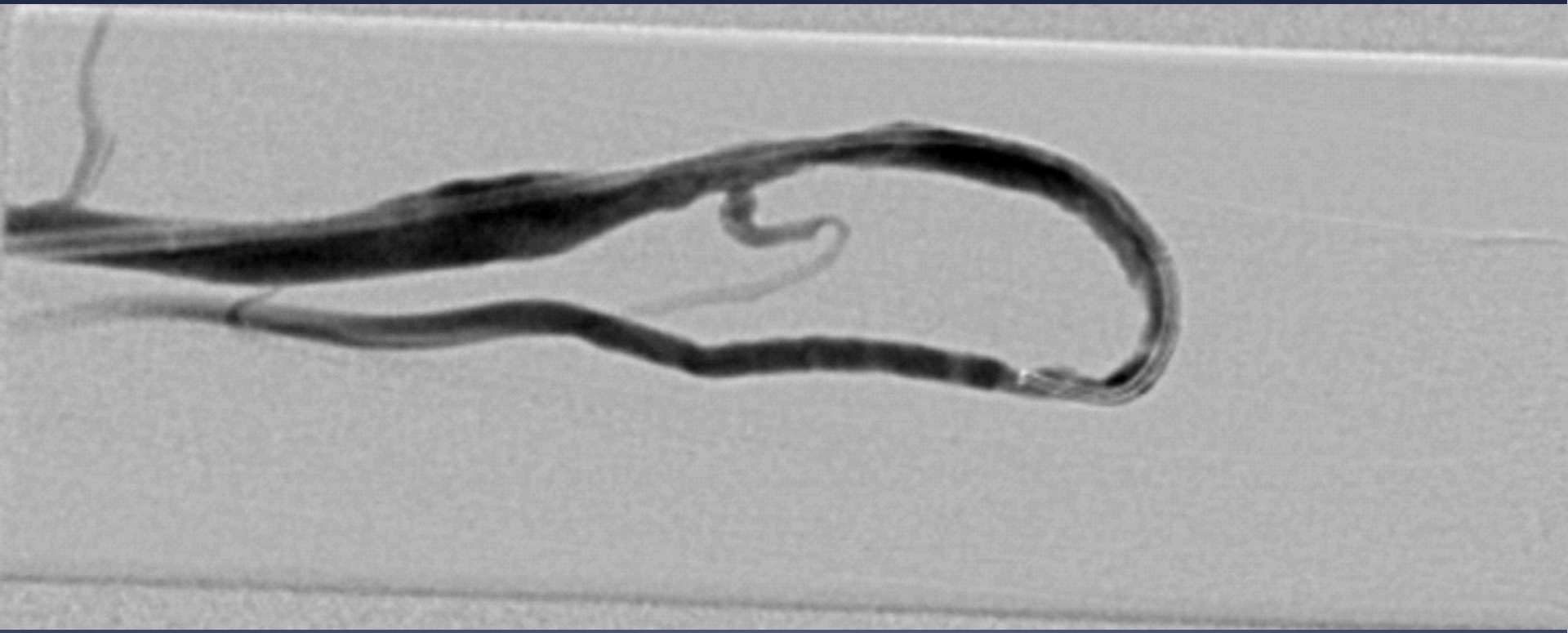
* Miller DL et al. Radiology 2002;225:329-336

75 yo male ESRD



Left Arm Fistula

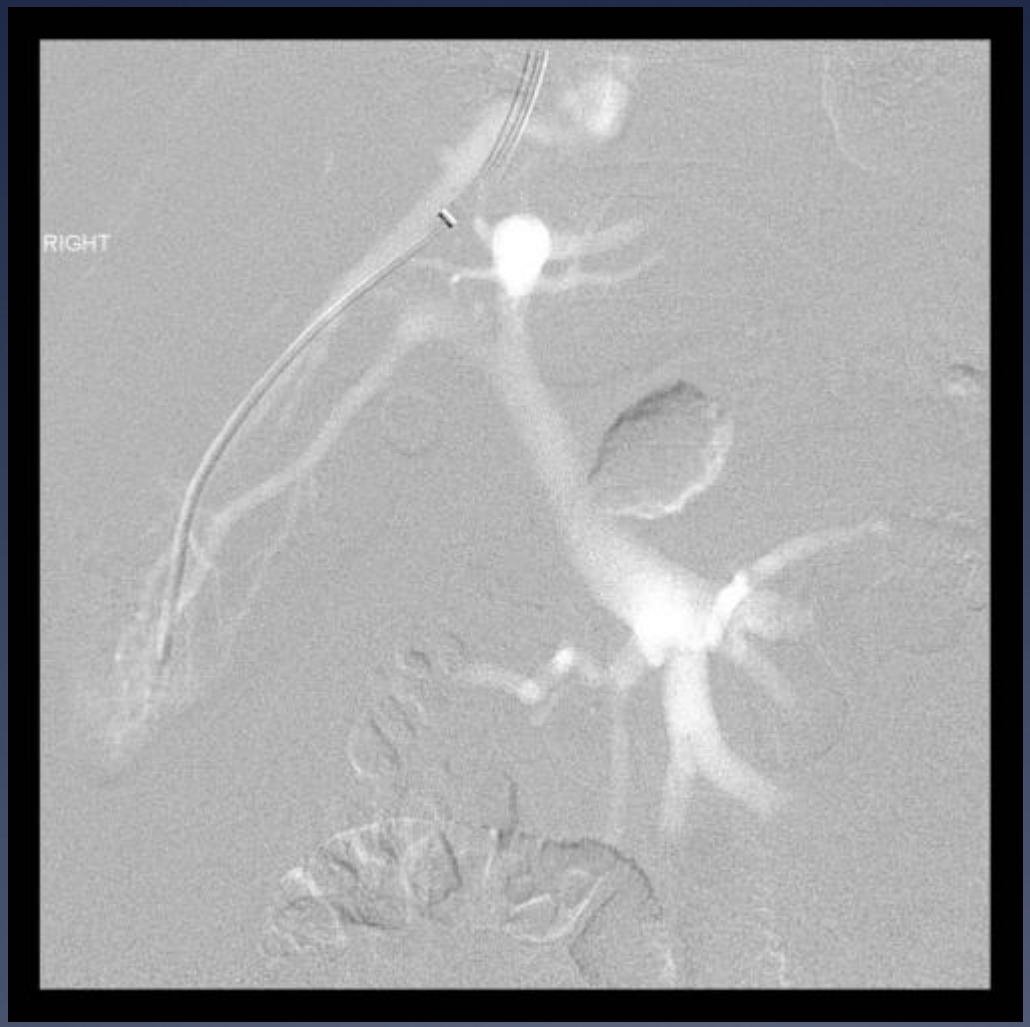
Following Angioplasty



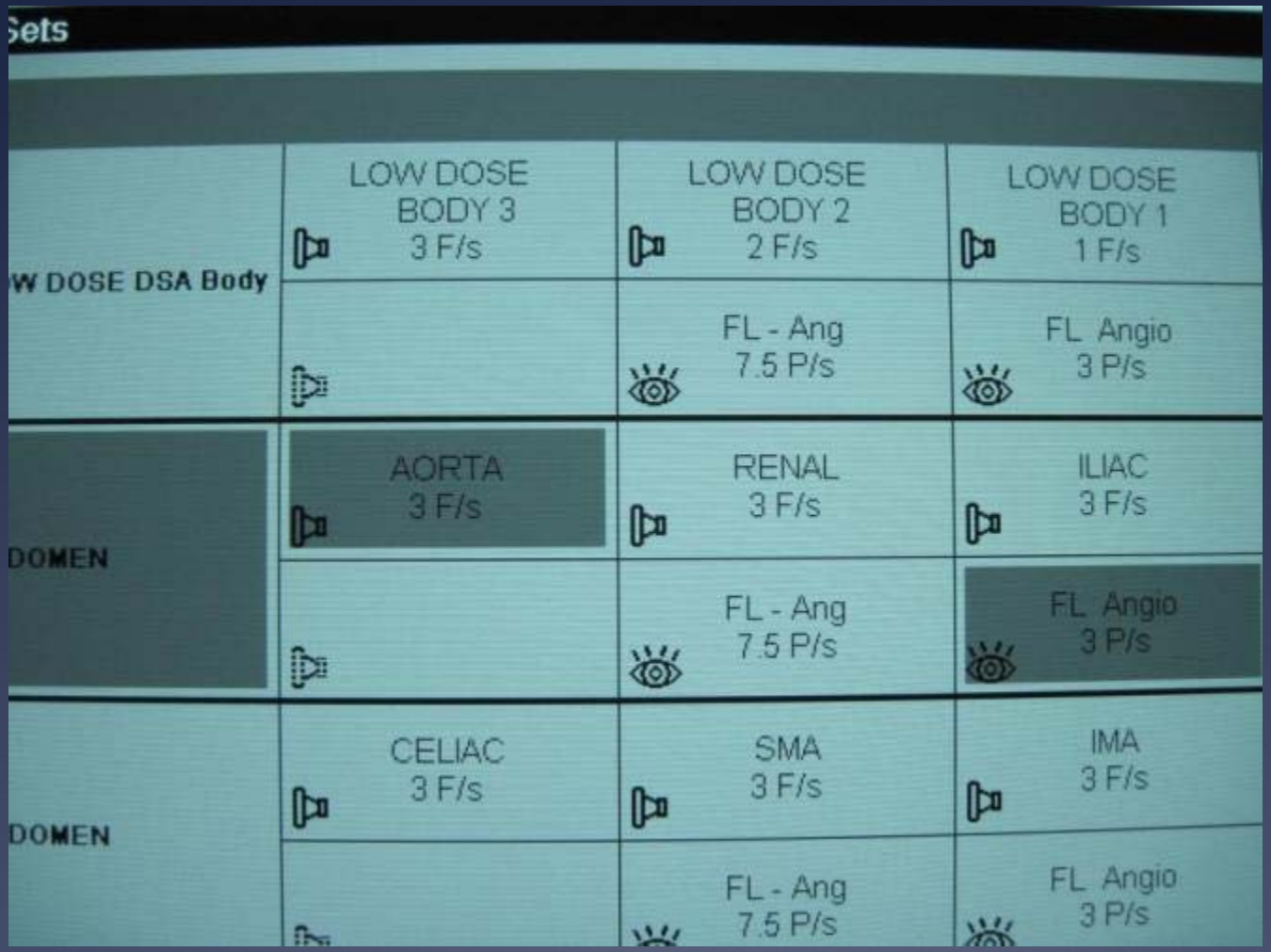
High Dose Procedures

- Embolization
- TIPS
- Renal/Visceral stent placements
- Cardiac RFA
- Coronary angioplasty/stent
- Biliary procedures

TIPS



Protocols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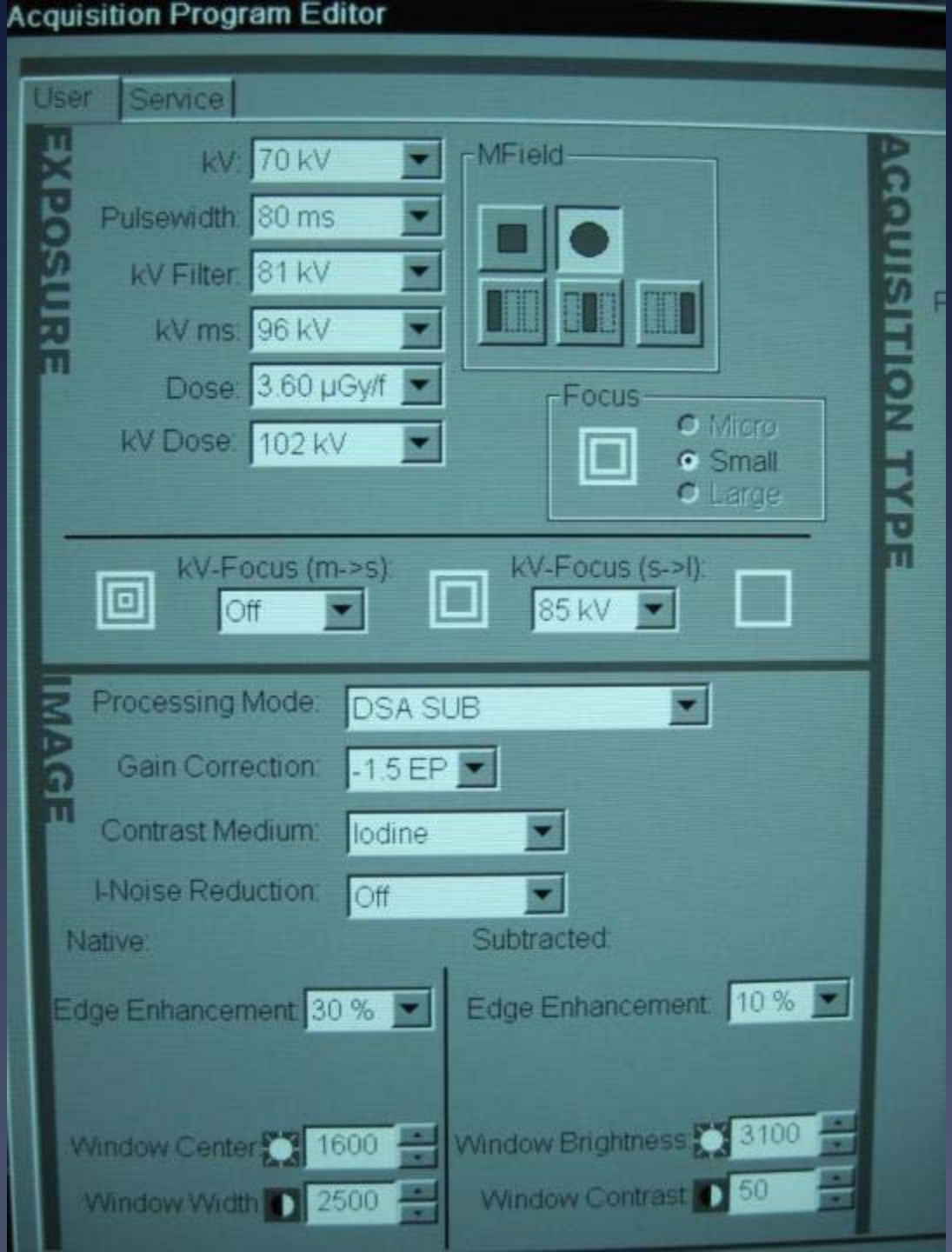
LOW DOSE BODY 3 3 F/s
LOW DOSE BODY 2 2 F/s
LOW DOSE BODY 1 1 F/s
FL - Ang 7.5 P/s
FL Angio 3 P/s
DOMEN
AORTA 3 F/s
RENAL 3 F/s
ILIAC 3 F/s
FL - Ang 7.5 P/s
FL Angio 3 P/s
DOMEN
CELIAC 3 F/s
SMA 3 F/s
IMA 3 F/s
FL - Ang 7.5 P/s
FL Angio 3 P/s


Acquisition Program Editor
User
Service
EXPOSURE
kV: 70 kV
Pulsewidth: 80 ms
kV Filter: 81 kV
kV ms: 96 kV
Dose: 3.60 µGy/f
kV Dose: 102 kV
MField
Focus
Micro
Small
Large
kV-Focus (m->s):
Off
kV-Focus (s->l):
85 kV
ACQUISITION TYPE
IMAGE
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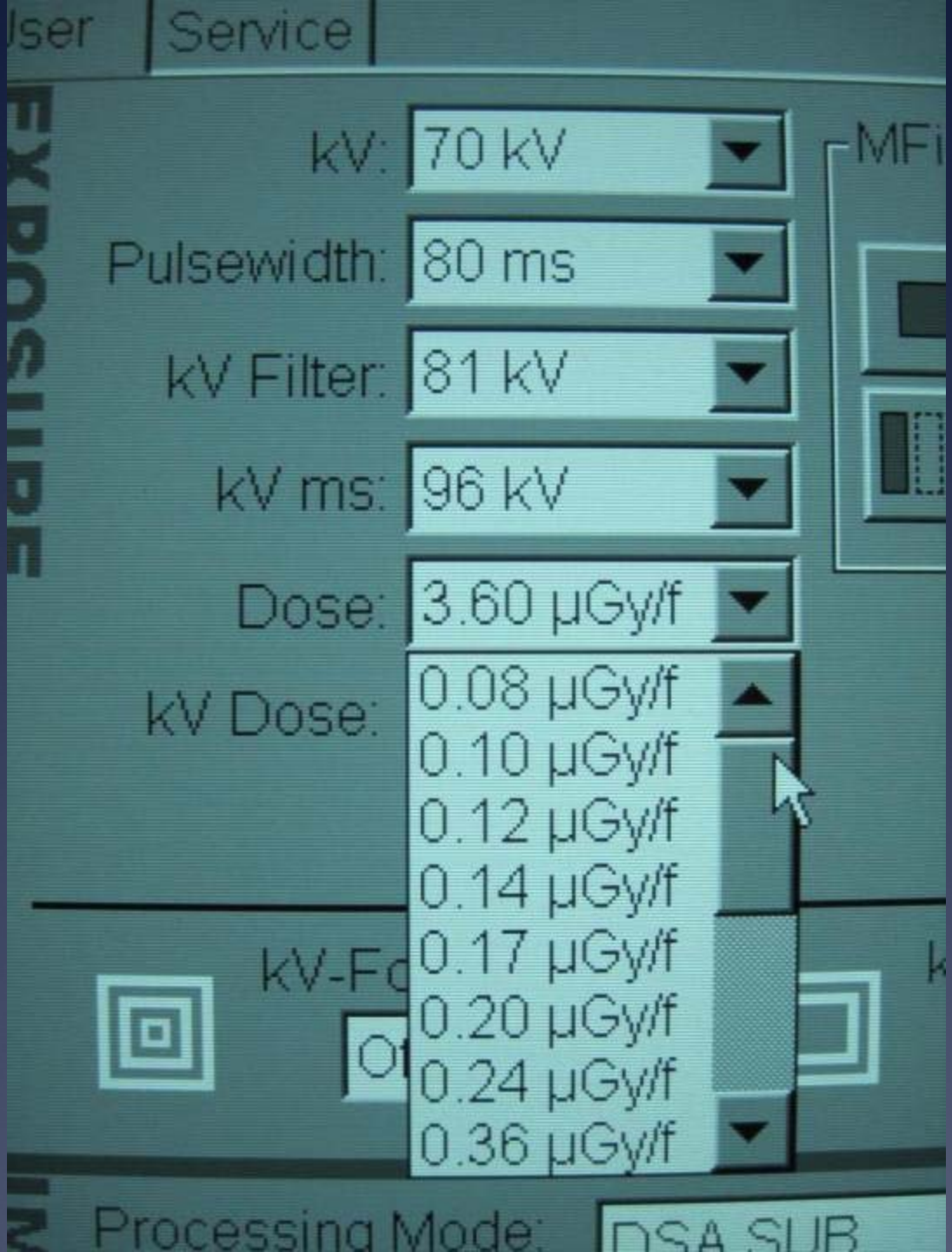
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Service
EXPOSURE
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kV Filter: 81 kV
kV ms: 96 kV
Dose: 3.60 µGy/f
kV Dose:
0.08 µGy/f
0.10 µGy/f
0.12 µGy/f
0.14 µGy/f
0.17 µGy/f
0.20 µGy/f
0.24 µGy/f
0.36 µGy/f
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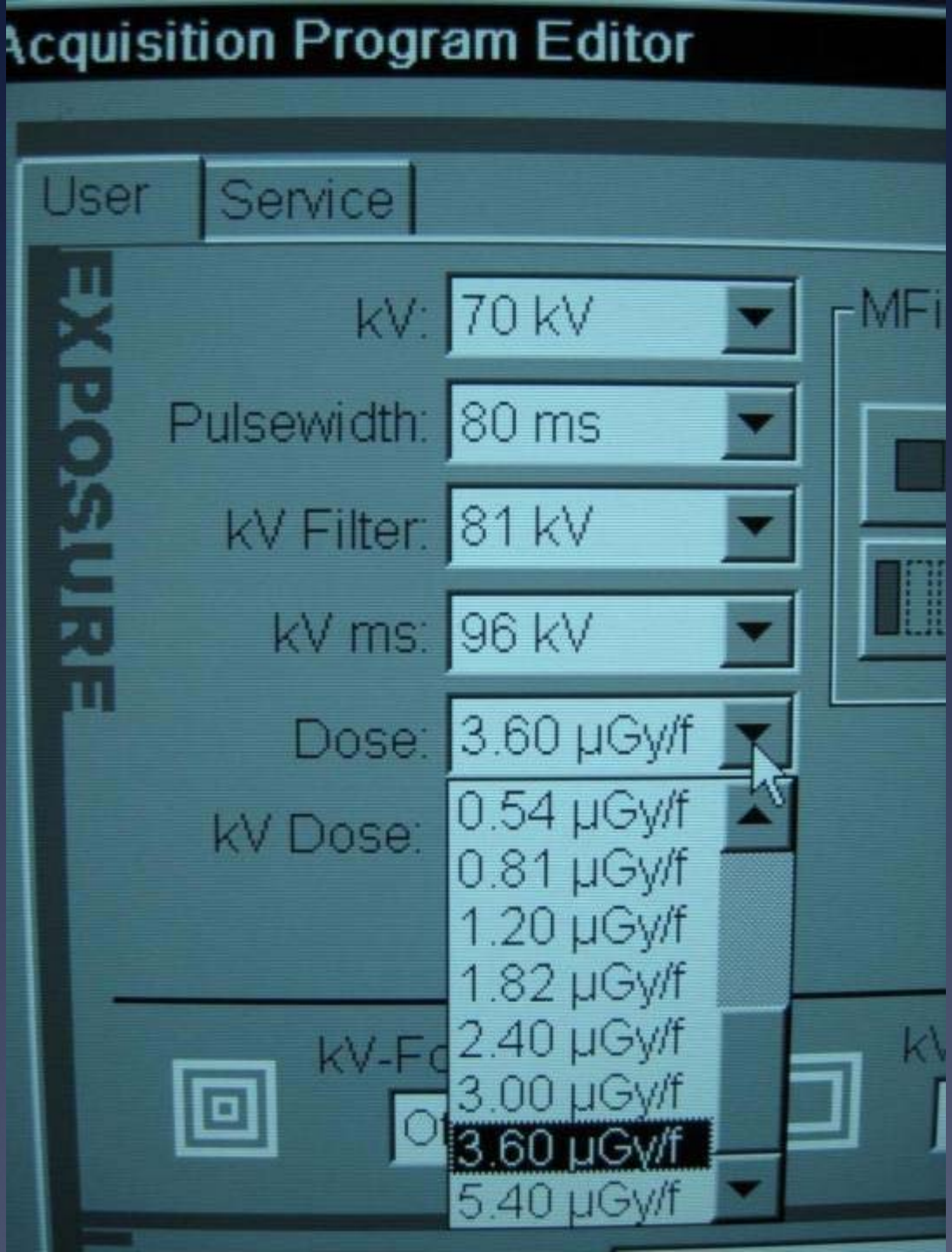
DSA SUB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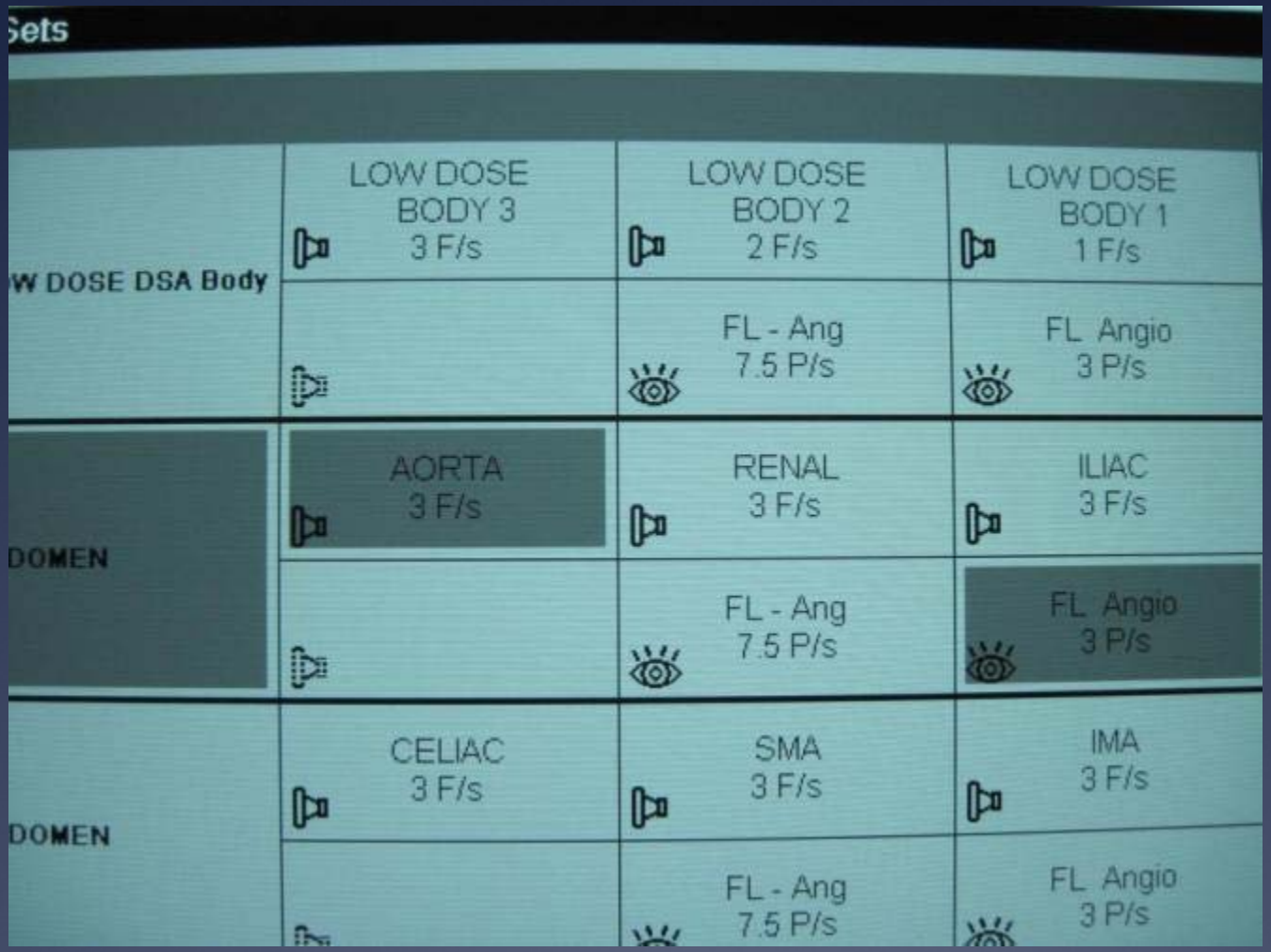
Dose:
3.60 µGy/f
kV Dose:
0.54 µGy/f
0.81 µGy/f
1.20 µGy/f
1.82 µGy/f
2.40 µGy/f
3.00 µGy/f
3.60 µGy/f
5.40 µGy/f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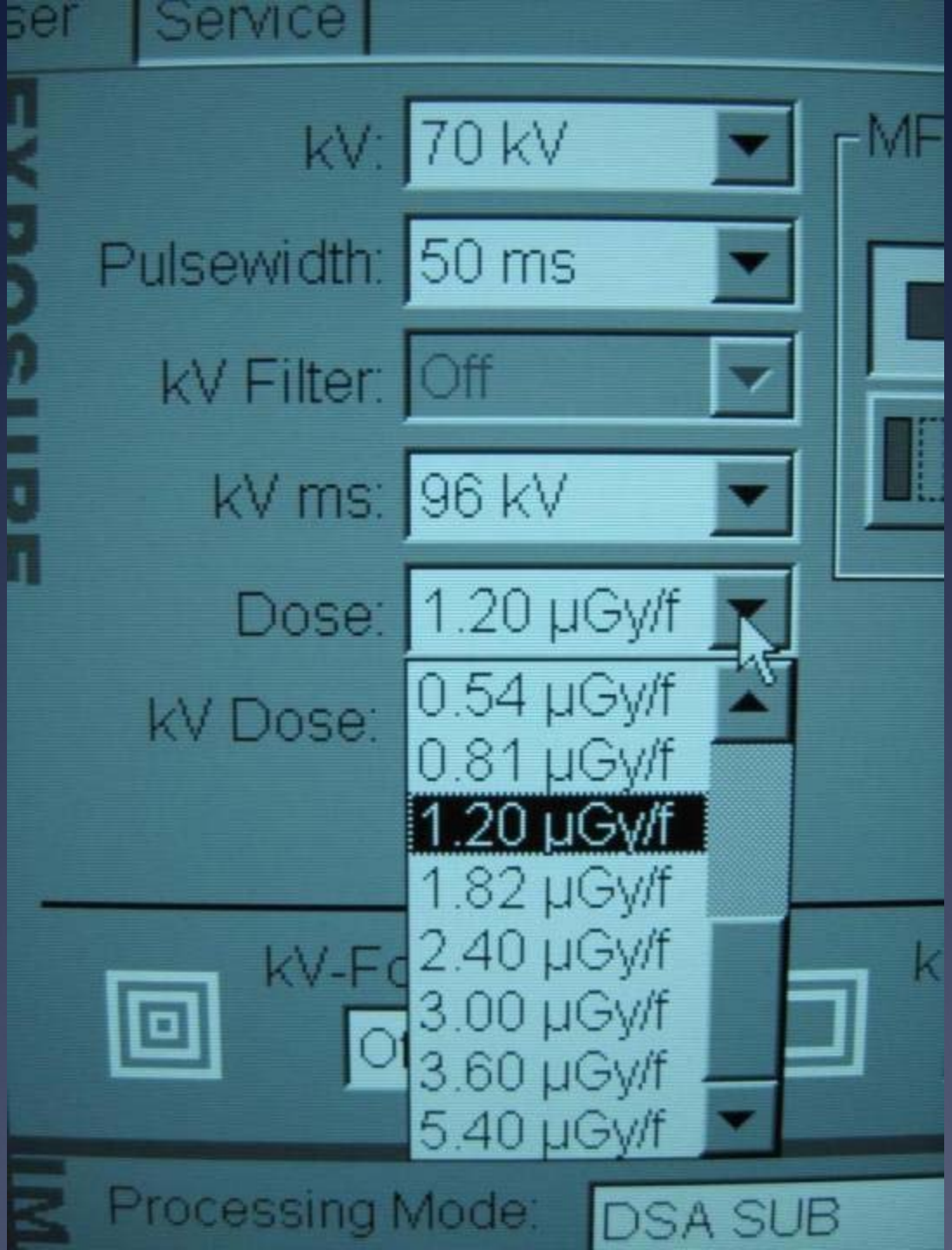
Service
kV: 70 kV
Pulsewidth: 50 ms
kV Filter: Off
kV ms: 96 kV
Dose: 1.20 µGy/f
kV Dose:
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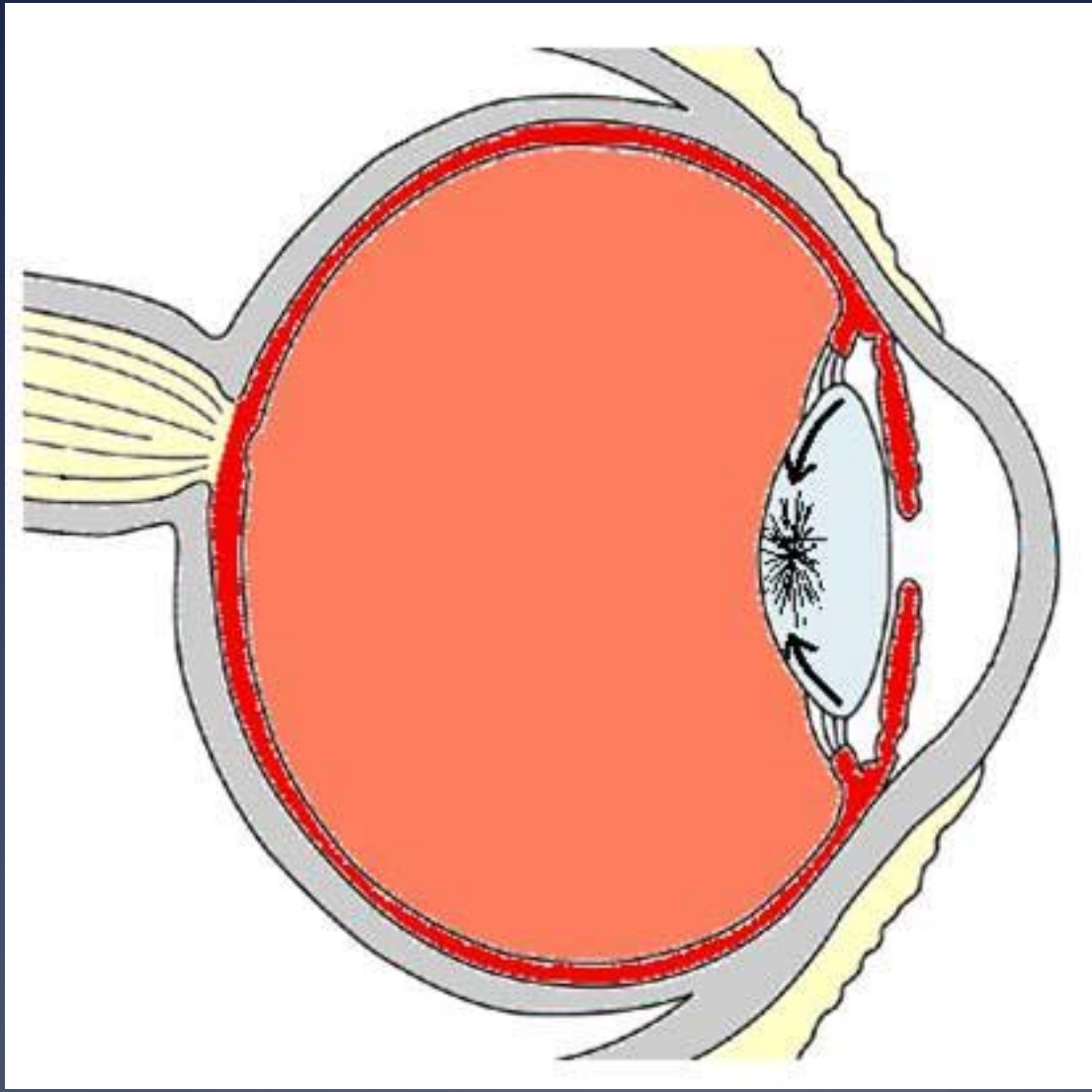
0.81 µGy/f
1.20 µGy/f
1.82 µGy/f
2.40 µGy/f
3.00 µGy/f
3.60 µGy/f
5.40 µGy/f
Processing Mode:
DSA SUB

Eyes: Protect Them!

Cataracts



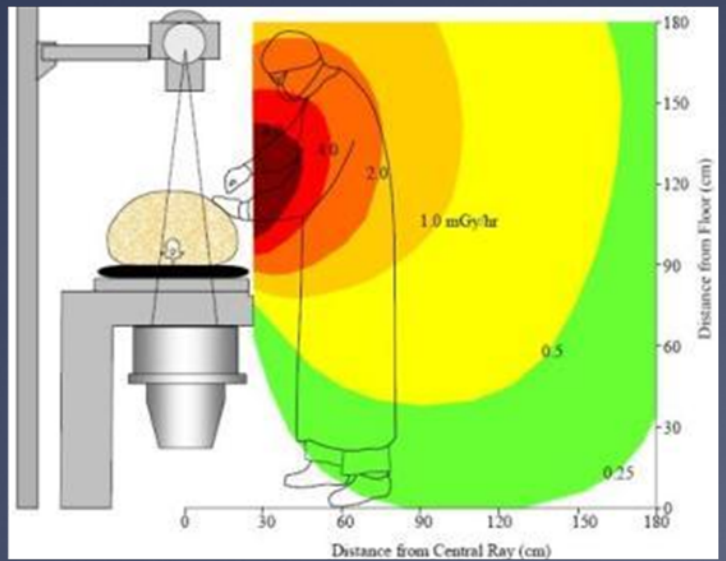
Ocular Guidelines

- Previously - Deterministic Effect:
  - 2 – 5 Gy for protracted exposure
- Early Studies
  - Short follow up
  - Lacked sufficient sensitivity
  - Few subjects with dose < few Gy

NCRP 168

Worse Case Scenario

- Source above table
- No Barrier Protection
- Dose to the eye 450 – 900 mSv/yr

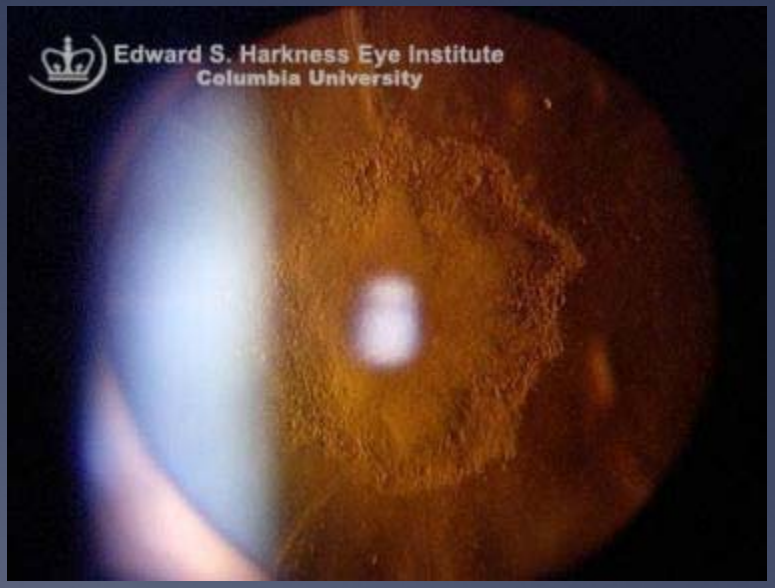


Vano Br J Radiol1998

Schueler et al. Radiographics 2006

Eye Protection

Typical workloads: dose to eye may exceed the threshold for cataracts after several years of work if radiation protection tools are not used.



Vano et al. Radiology 2008;248:945-953

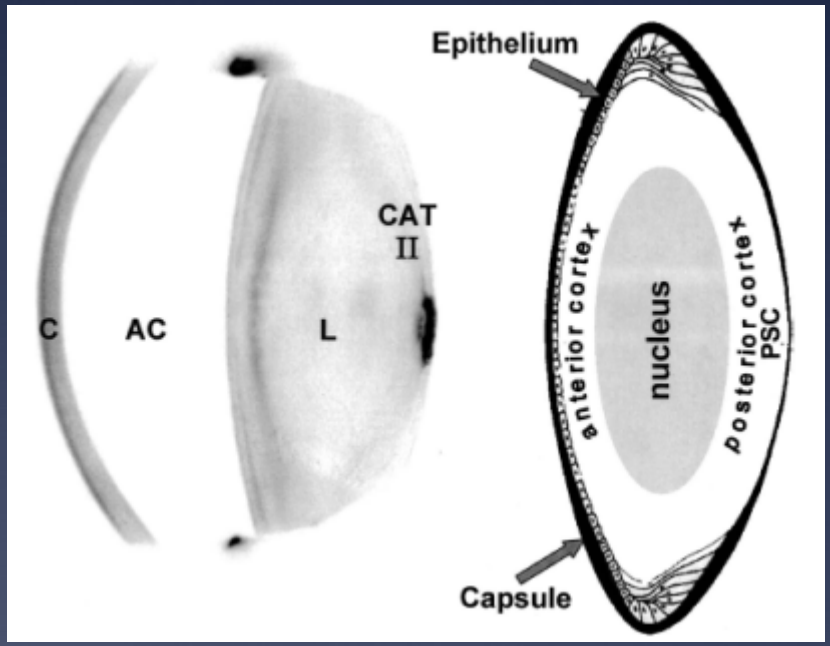
Newer Data

- Opacification of the lens at lower doses
- Based on
  - Patients: CT scans, radiation therapy
  - Atomic-bomb survivors
  - Residents of contaminated buildings
  - Chernobyl accident liquidators
  - Radiologic technologists

NCRP 168

Newer Data

- Chernobyl workers: < 1 Gy
- Rad Techs: risk increases linearly with no apparent threshold
- These challenge prior recommendations



NCRP 168
Worgul et al; Radiat Res 2007

ICRP

- Lens of the eye: threshold for tissue reaction in absorbed dose is now considered to be 0.5 Gy
- Occupational exposure:
  - Now recommend an equivalent dose limit of 20 mSv/yr (avg over 5 yrs)
  - Previously 150 mSv/yr
  - No single year > 50 mSv

www.ICRP.org – statement on tissue reaction.2011

Lens Exposure Cardiology

- Retrospective cumulative lens dose
- Avg: 22 years working/ 51 years old
- 25 mSv – 1600 mSv
- New Annual dose limit 20 mSv/yr
  - Exceeded by 60% of cardiologists

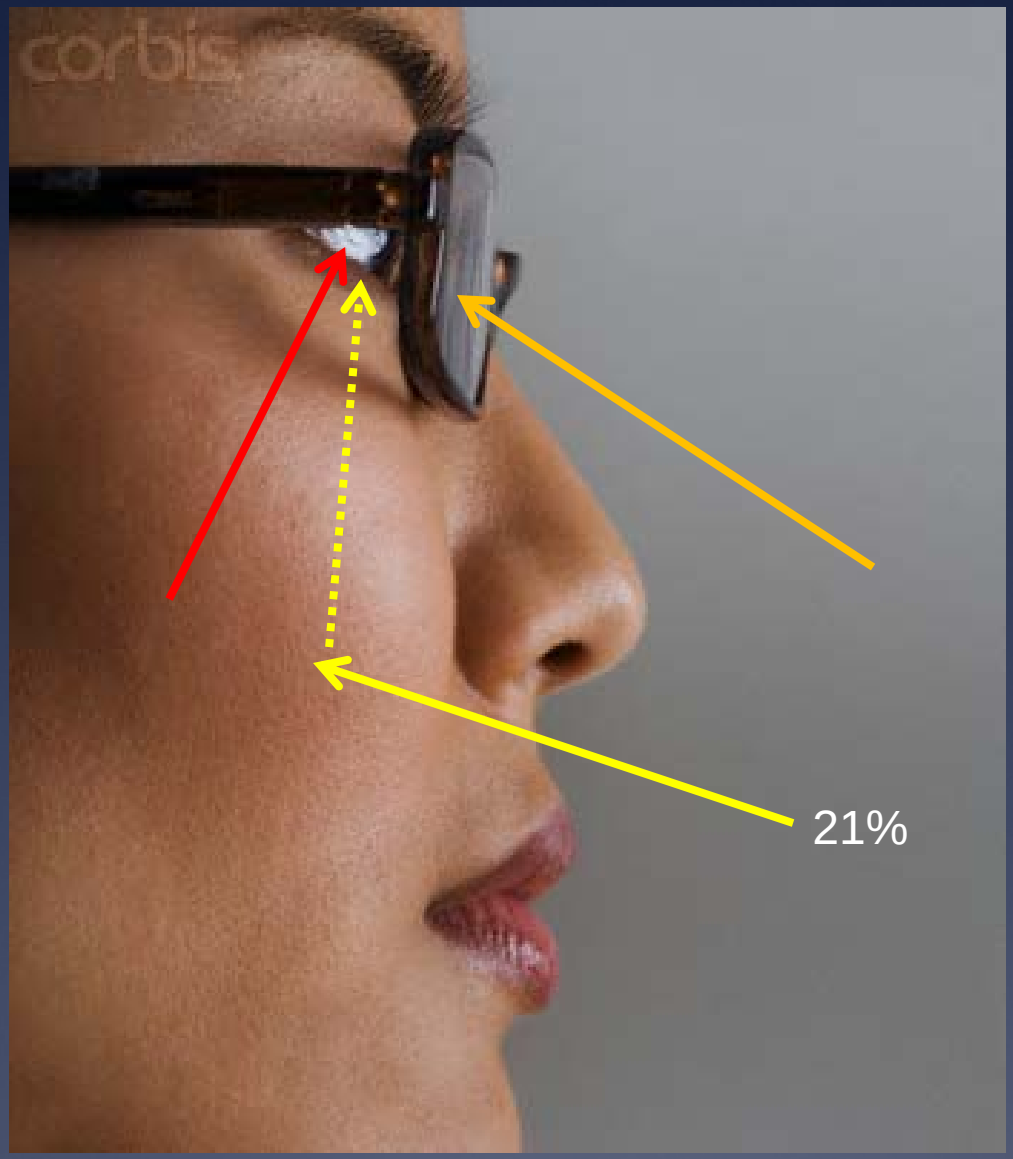
Jacob et al. Radiat Prot Dosimetry 2012

Lens Exposure Cardiology

- Several years + no protection may exceed ICRP lifetime dose threshold of 500 mSv
- Risk for developing radiation-induced cataracts

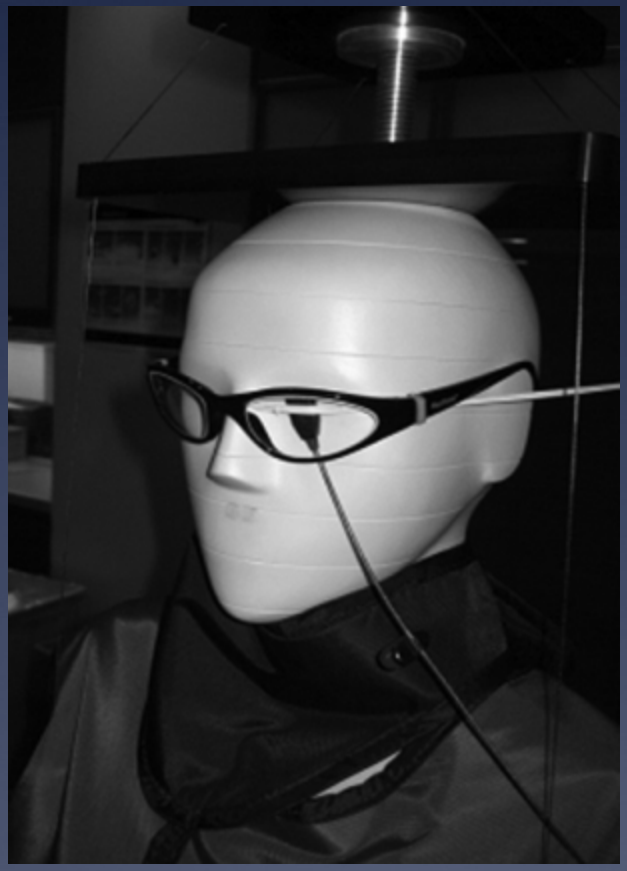
Jacob et al. Radiat Prot Dosimetry 2012

Eye Protection



Cousins et al. Radiol 1987;22:688-692

Operator Eye Protection



Thornton, Dauer et al.JVIR 2010

Comparing Strategies

- Leaded Glasses:
  reduced by a factor of 5 - 10
- Scatter Shielding Drapes:
  reduced by a factor of 5 - 25
- Both Together:
  reduced by a factor of > 25
- Suspended Shielded:
  Undetectable

Thornton, Dauer et al.JVIR 2010

CT Suite

15 yo with post-op abscess

CT Abdomen and Pelvis

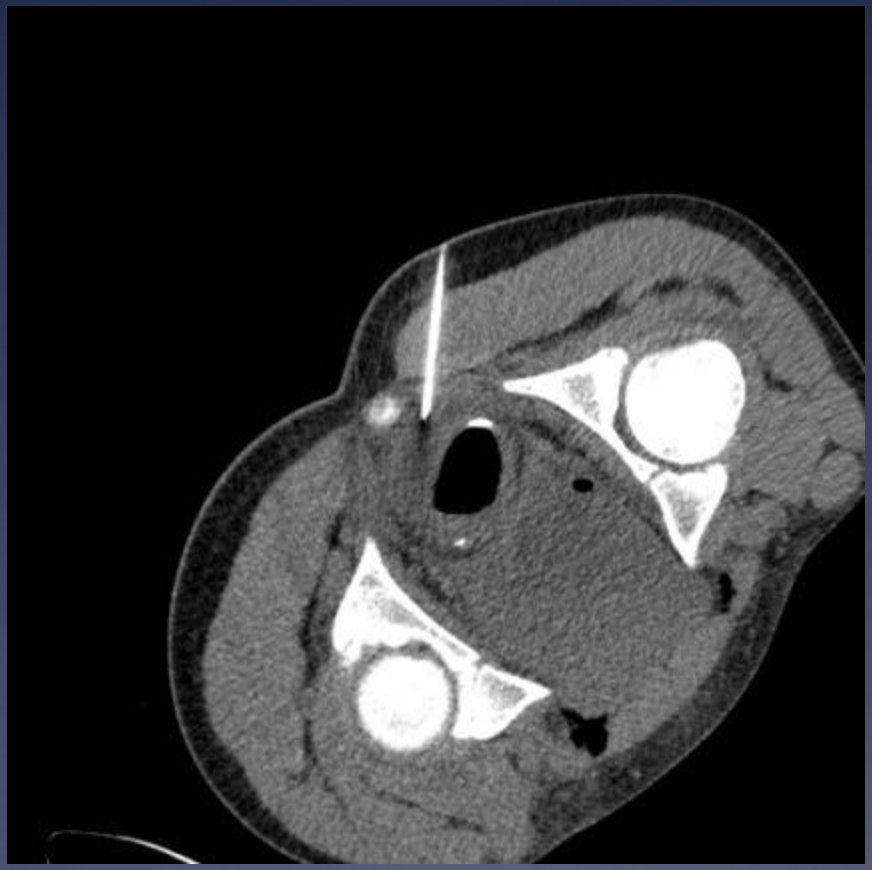
14-Dec-2011 14:19

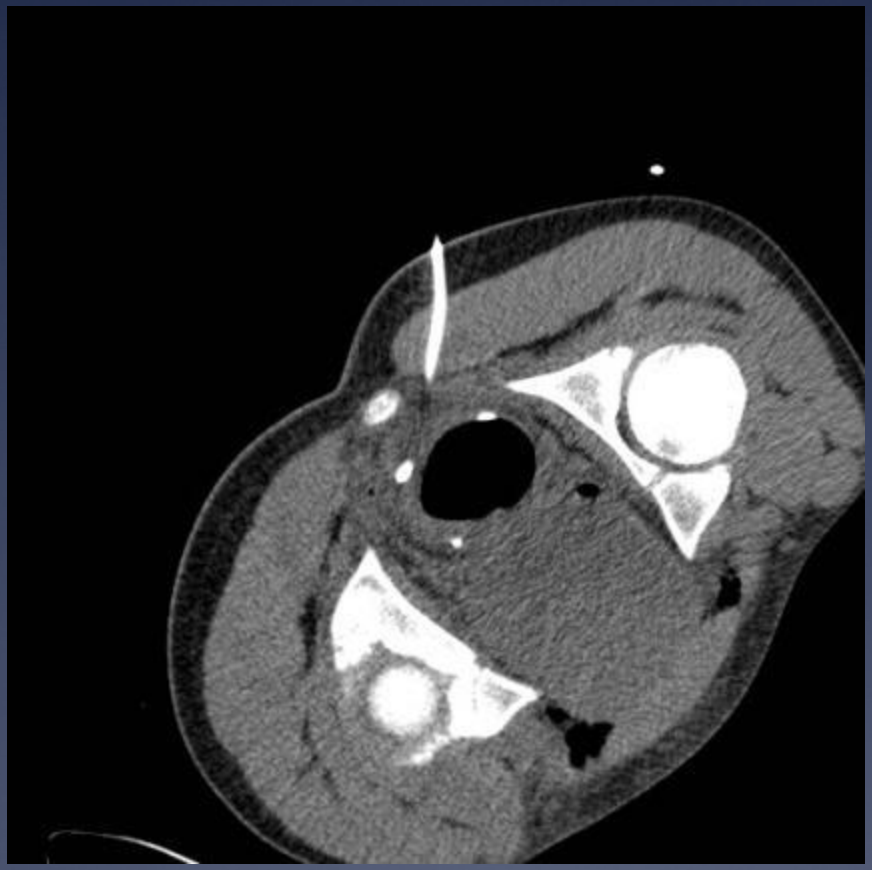
Ward: 7CH&7 Children'sHospital
Physician:
Operator:

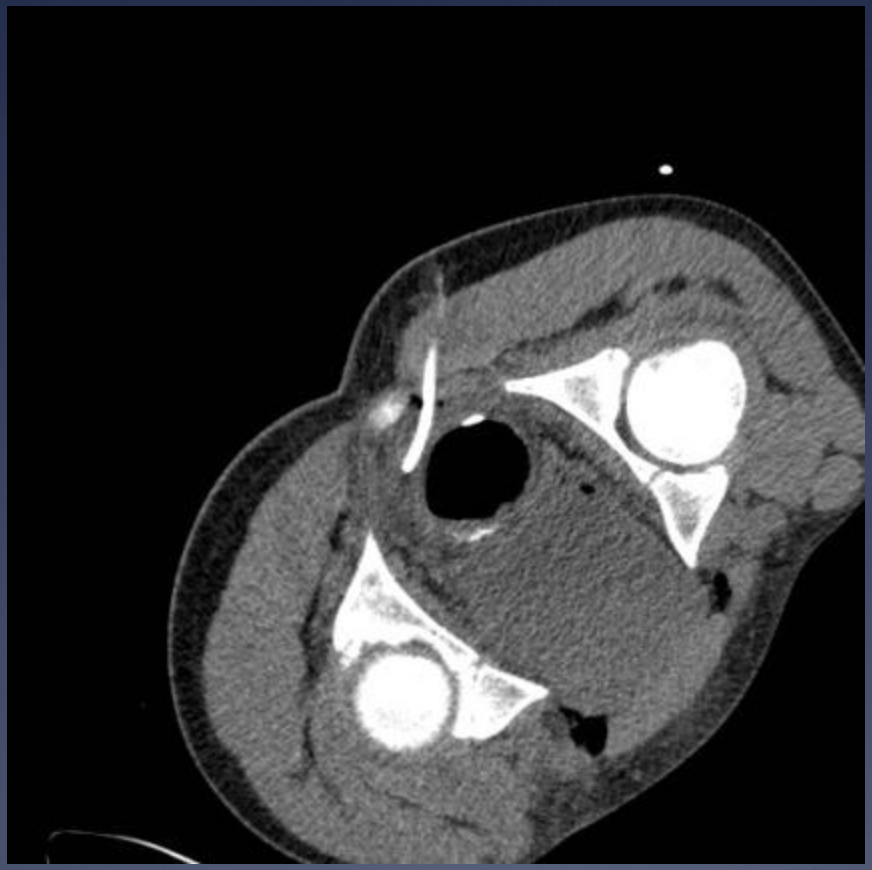
Total mAs 1173 Total DLP 198

	Scan	kV	mAs / ref.	CTDIvol	DLP	TI	cSL
Patient Position H-SP							
Topogram	1	120				5.3	0.6
Abd/Pelvis	2	120	65 / 30	4.42	198	0.5	1.2

CT Suite







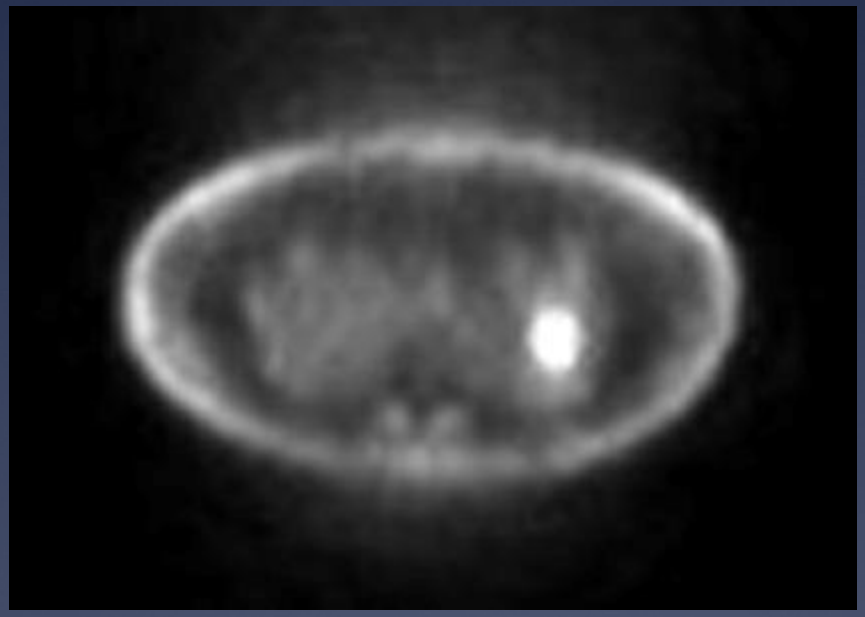
15-Dec-2011 10:39

Ward: 7CH&7 Children'sHospital
Physician:
Operator: eg

Total mAs 360 Total DLP 34

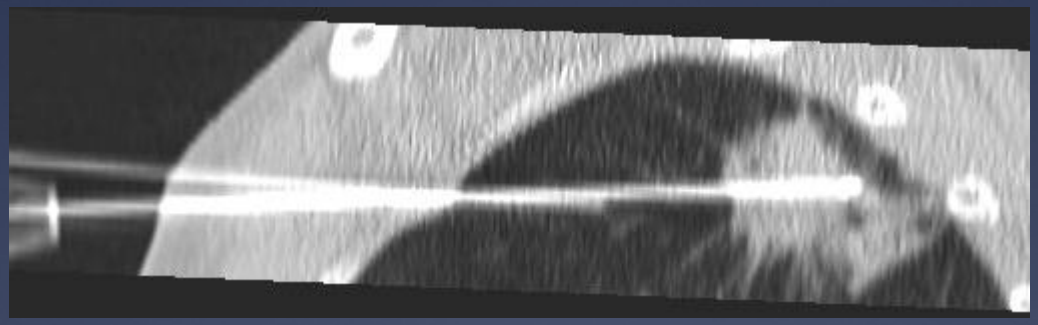
	Scan	kV	mAs / ref.	CTDIvol	DLP	TI	cSL
Patient Position H-LL							
Topogram	1	80				5.3	1.0
Pre Scan	2	120	17 / 21	1.23	25	0.75	1.5
Bx. Mode	3	120	17	4.90	9	0.5	1.5

Lung Cancer

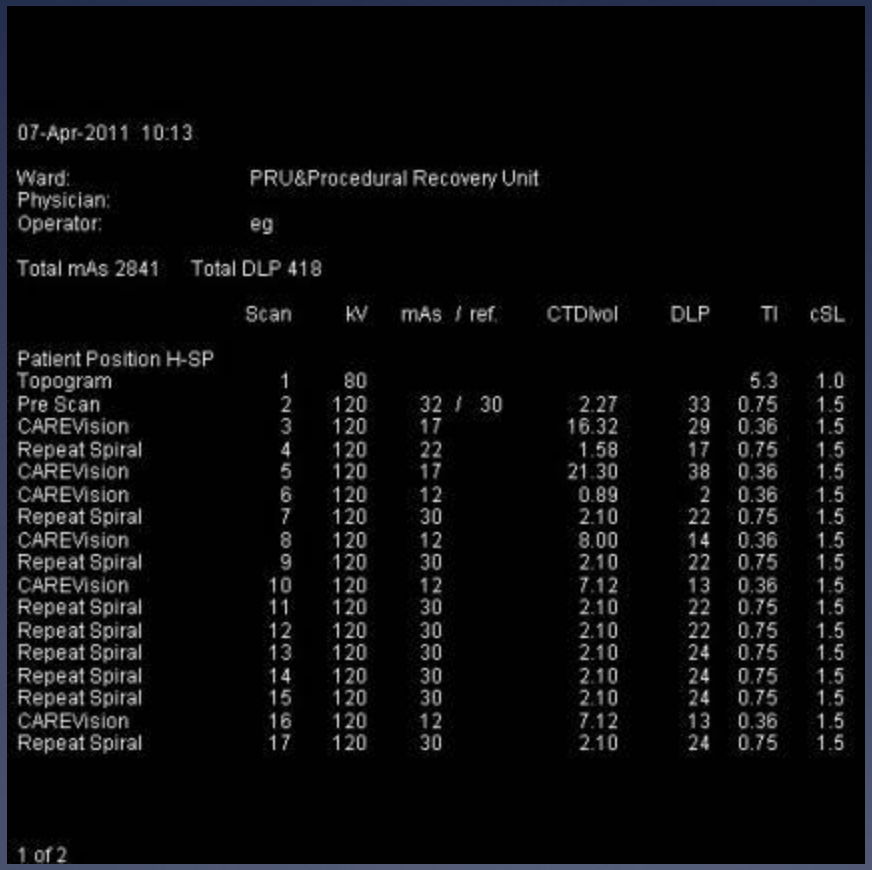


Lung Cancer

Lung Cancer



Lung Cancer



07-Apr-2011 10:13

Ward: PRU&Procedural Recovery Unit
Physician:
Operator: eg

Total mAs 2841 Total DLP 418

	Scan	kV	mAs / ref.	CTDIvol	DLP	TI	cSL
Patient Position H-SP							
Topogram	1	80				5.3	1.0
Pre Scan	2	120	32 / 30	2.27	33	0.75	1.5
CAREVision	3	120	17	16.32	29	0.36	1.5
Repeat Spiral	4	120	22	1.58	17	0.75	1.5
CAREVision	5	120	17	21.30	38	0.36	1.5
CAREVision	6	120	12	0.89	2	0.36	1.5
Repeat Spiral	7	120	30	2.10	22	0.75	1.5
CAREVision	8	120	12	8.00	14	0.36	1.5
Repeat Spiral	9	120	30	2.10	22	0.75	1.5
CAREVision	10	120	12	7.12	13	0.36	1.5
Repeat Spiral	11	120	30	2.10	22	0.75	1.5
Repeat Spiral	12	120	30	2.10	22	0.75	1.5
Repeat Spiral	13	120	30	2.10	24	0.75	1.5
Repeat Spiral	14	120	30	2.10	24	0.75	1.5
Repeat Spiral	15	120	30	2.10	24	0.75	1.5
CAREVision	16	120	12	7.12	13	0.36	1.5
Repeat Spiral	17	120	30	2.10	24	0.75	1.5

1 of 2

Summary

- Appreciation of the clinical perspective
  - Need for operator education
  - Target the young physicians
- Simple techniques to optimize dose
- Discuss the question: “Do I really need all that image quality?”