Radiation Safety

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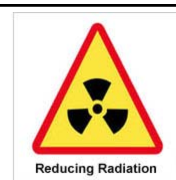
Disclosures

None

Objectives



- Review patient radiation exposure associated with diagnostic imaging & ways to reduce such exposure
- Outline risks of radiation exposure from diagnostic imaging
- Review patient radiation exposure from medical interventions & methods to reduce such exposure

Patient Safety Starts with me!

Patient Safety Starts with me!

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Stones on the Rise
Population at Risk

- Stone incidence increasing
- Recurrence rate high
- Diagnosis of asymptomatic stones increasing
  - Large screening studies – Prevalence 8-10%
- <u>More diagnostic testing & more intervention</u>

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Scope of Problem

- 1982-2006: per capita radiation exposure from <u>medical</u> sources in US increased nearly 600%
  - 0.54 → 3.0 mSv
  - CT = 49% of this exposure

<u>CT SCANS PERFORMED</u>

1980	1990	2000	2007
3 million	13 million	46 million	69 million

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Mettler et al. Health Phys 2008, 2007, Brenner et al. 2007, Berrington de Gonzalez et al. 2009

Defining Radiation Exposure

- Annual natural background exposure = 3.0 mSv
- KUB = 0.7 mSv
- KUB with tomograms 3.93 mSv
- IVP = 3.7 mSv
- Standard CT = 4.5–20.0 mSv
  - 13 fold variation depending on machine/equipment, settings/technique, & patient
  - Obesity triples radiation dose of stone protocol CT

Mancini & Ferrandino. Curr Opin Urol; 20 (2); 163-168, 2010.
Wang et al. J Urol; 189; 2142, 2013.

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International Commission on Radiologic Protection (ICRP)

- Occupational exposure recommendations: < 50mSv/year OR 100mSv/5 years
  - No recommended limit for patient medical exposure
  - Unnecessary exposure should be avoided
  - Necessary exposure should be justifiable & optimized

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Stone Population: How Much Radiation are They Getting?

- Evaluation & management for single stone event: 1.18-37.66 mSv for event

John et al. J Endourol 2008

- Radiation exposure associated with acute stone episode & 1 year follow-up at 2 academic centers
  - Median effective radiation dose → 29.7 mSv
  - 20% received > 50 mSv: average CT scans = 3.5

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Ferrandino et al. J Urol, 2009; 181; 668.

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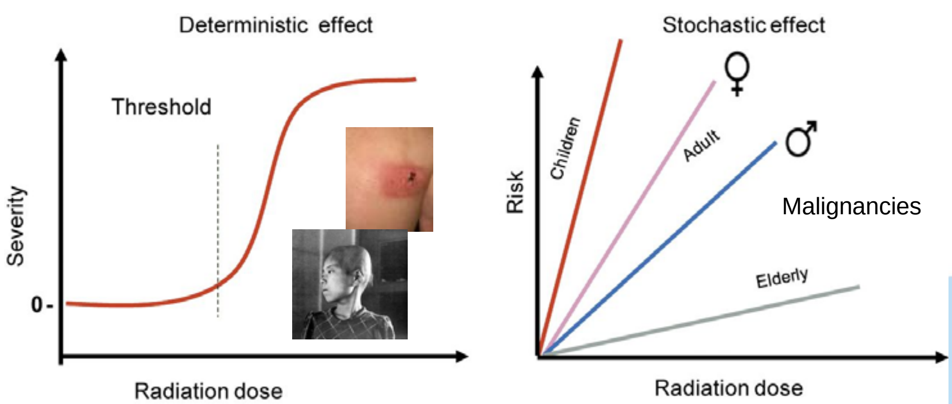
Actual Risk – What Does This Mean?



Threshold dose below which there is an absence of tissue reactions

No threshold but probability of an effect increases with increased doses

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http://d1vzuwdl7rxiz0.cloudfront.net/content/ehj/early/2014/01/06/eurheartj.eht394/F2.large.jpg

Actual Risk – What Does This Mean?

- Atomic bomb survivors in Japan
  - Extrapolated data, real risk unclear
  - Significantly increased cancer risk even at very low radiation exposures (<500 msv)

- Committee on the Biological Effects of Ionizing Radiation (BEIR) – 2006 Report
  - "Supports a *linear-no-threshold* risk model -- that the risk of cancer proceeds in a linear fashion at lower doses without a threshold & that the smallest dose has the potential to cause a small increase in risk to humans"

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Pierce & Preston. Radiat Res 2000
Preston et al. Radiation Research 2007.

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ARS Q1:

An example of stochastic effects of radiation is which of the following?

a) Temporary sterility
b) Cataracts
c) Alopecia
d) Malignancies

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Answer: D

D. Malignancies

Malignancies likely occur as a result of increased doses of radiation.

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Radiation Exposure Cancer Risk - Estimations

- *Past* - 1991-1996 CT radiation may have caused 0.4% of all cancers in US
- *Present* - 1.5-2% of cancers in US attributable to CT radiation exposure
- *Future* - Estimated 29,000 future cancers in US can be attributed to CT scan performed in 2007 (70 million scans)
  - CT with ED of 10 mSv - approximately 1/2000 increased risk of fatal cancer

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Sodickson et al. Radiology 2009,
Smith-Bindman et al. Arch Intern Med 2009, Brenner & Hall. NEJM 2007

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Lifetime Risk of Dying from Everyday Activities in US

Assault	214
Accident while riding in car	304
Accident as pedestrian	652
Choking	894
Accidental poisoning	1,030
Drowning	1,127
Exposure to fire or smoke	1,181
→ Cancer from ^{18}F-FDG PET scan (10-y-old)	1,515
Falling down stairs	2,024
→ Cancer from ^{99m}Tc-MDP bone scan (10-y-old)	2,560
→ Cancer from ^{18}F-FDG PET scan (40-y-old)	2,700
All forces of nature	3,190
Accident while riding bike	4,734
→ Cancer from ^{99m}Tc-MDP bone scan (40-y-old)	4,760
Accidental firearms discharge	6,333
Accident while riding in plane	7,058
Falling off ladder or scaffolding	10,606
Hit by lightning	84,388

Fahey FH, et al. JNMT 40; 13, 2012.

Radiation Reduction – ALARA Alternate Methods of Imaging

- **Low dose CT (LDCT)**
  - Meta-analysis 1995-2007 – sensitivity 96.6% & specificity 94.9%
  - Mean ED 1.40mSv males, 1.97mSv females
- **Ultra-Low dose CT**
  - ED <1 mSv ; < 2 view KUB
  - Reduces radiation doses by 23-90%
  - Accurate detection – 4mm threshold
  - Sensitivity and specificity 97% and 95%

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Pooler et al. J Urol 2014, McLauglin et al. Insights Imaging 2014 ,
Kluner et al. J Comput Assist Tomogr 2006, Niemann et al. AJR 2008

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Alternate Methods of Imaging

- **Limitations of LDCT**:
  - Sensitivity & specificity drops for stones <3mm
  - Less accurate for overweight, obese patients
  - Less able to diagnose non-urologic pathology

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Radiation Reduction – ALARA Alternate Imaging - Ultrasound

Advantages	Disadvantages
Noninvasive	Sensitivity 45%, Specificity 88%
No radiation, no contrast	Poor accuracy (65%)
Less expensive	Limited in obesity
Widely available	Operator dependent
Radiolucent stones visible	Not reproducible

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Pichler et al. BJUI; 109: 770, 2012
Ray et al. Urology; 76: 295, 2010

ARS Q2:

What is the strongest argument against low dose CT (LDCT) to work up suspected stone disease?

a) Stone size
b) Sensitivity for finding stone
c) Obese patients
d) Non urologic pathology

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Answer: C

C. Obese patients

LDCT has decreased sensitivity in obese patients so smaller stones may be missed.

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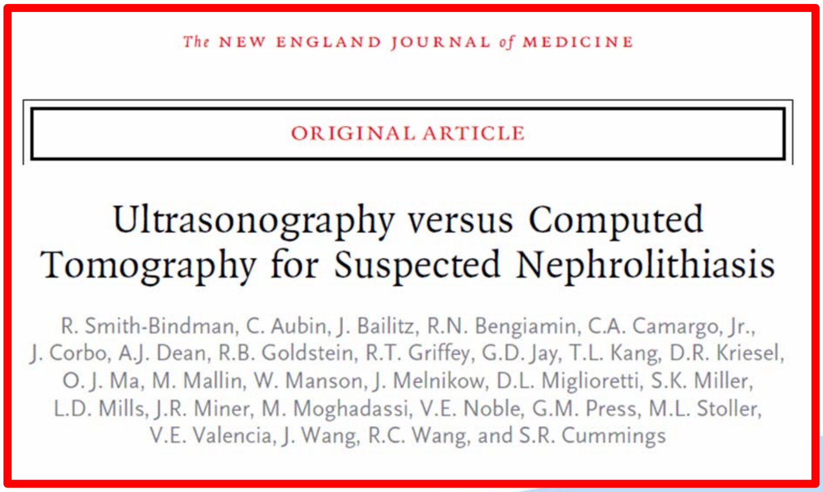

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Ultrasonography versus Computed Tomography for Suspected Nephrolithiasis

R. Smith-Bindman, C. Aubin, J. Bailitz, R.N. Bengiamin, C.A. Camargo, Jr., J. Corbo, A.J. Dean, R.B. Goldstein, R.T. Griffey, G.D. Jay, T.L. Kang, D.R. Kriesel, O. J. Ma, M. Mallin, W. Manson, J. Melnikow, D.L. Miglioretti, S.K. Miller, L.D. Mills, J.R. Miner, M. Moghadassi, V.E. Noble, G.M. Press, M.L. Stoller, V.E. Valencia, J. Wang, R.C. Wang, and S.R. Cummings

- Initial presentation of renal colic → Ultrasound
  - lower cumulative radiation exposure
  - no difference in complications (e.g. hospitalizations, return ER visits, serious adverse events)

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NEJM 371; 12; 2014

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Diagnostic Imaging Current AUA Guidelines

- BMI <30 LDCT
- BMI >30 Standard NCCT
- Stone tracked with KUB (if visible) & ultrasound
- Postop SWL or URS – ultrasound and/or KUB

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Radiation Exposure Interventions

- URS – 1.13 mSv
- SWL – 0.76 - 1.18 mSv
- PCNL - 8.66 mSv – more radiation exposure than CT
- Risks:
  - Obesity
  - Multiple tracts
  - Large stone burden, non-branched stones
  - Operator inexperience

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Morris et al. J Urol 2006, Mancini et al. J Urol 2010
Tepeler et al. J Endourol 2009, Torrecilia et al. Urology 2014

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Radiation Exposure Interventions - PCNL

- Obesity increases FT by 36% and ED by 177%

BMI	Effective dose (mSv)
<25	2.66
30-40	6.49 2 FOLD HIGHER
>40	9.1 3 FOLD HIGHER

Morris et al. J Urol 2006, Mancini et al. J Urol 2010
Tepeler et al. J Endourol 2009, Torrecilia et al. Urology 2014

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Radiation Reduction – Interventions Technique

- Pulsed fluoro - lowest possible frames per second
  (Standard – 30)
- 30 → 4 – reduces FT by 2.5-2.8 times

Frames per Second	Radiation Reduction
15	22%
10	38%
7.5	49%
3.75	87%

- Low dose

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Radiation Reduction – Interventions Technique

Machine Settings	Surgeon Involvement
Collimation	Visual, tactile cues
Last image hold	Dedicated technician
Save & swap	Foot pedal
Laser Guide	Marking areas of interest
Image intensifier location	Timing fluoro activation

Fluoro protocols/Preop checklist - 80% FT reduction

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Blair et al. J urol 2013

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ARS Q3:

Radiation exposure reduction techniques include all the following, except:

a) Collimation
b) Lower pulse rate
c) Low dose technique
d) Tech controlled activation

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Answer: D

D. Tech controlled activation

Surgeon controlled fluoroscopy reduces overall exposure time.

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RADIATION SAFETY AWARENESS

4 KEY FACTORS TO REDUCE RADIATION

QUICK OVERVIEW HOW YOU CAN REDUCE THE RADIATION DOSE FOR BOTH YOURSELF AND THE PATIENT

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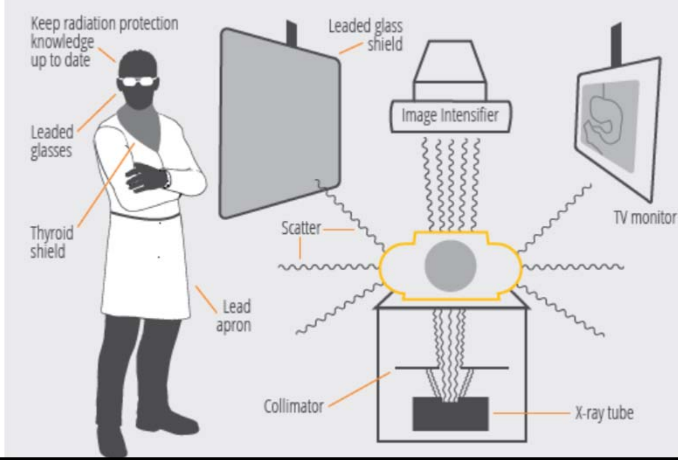
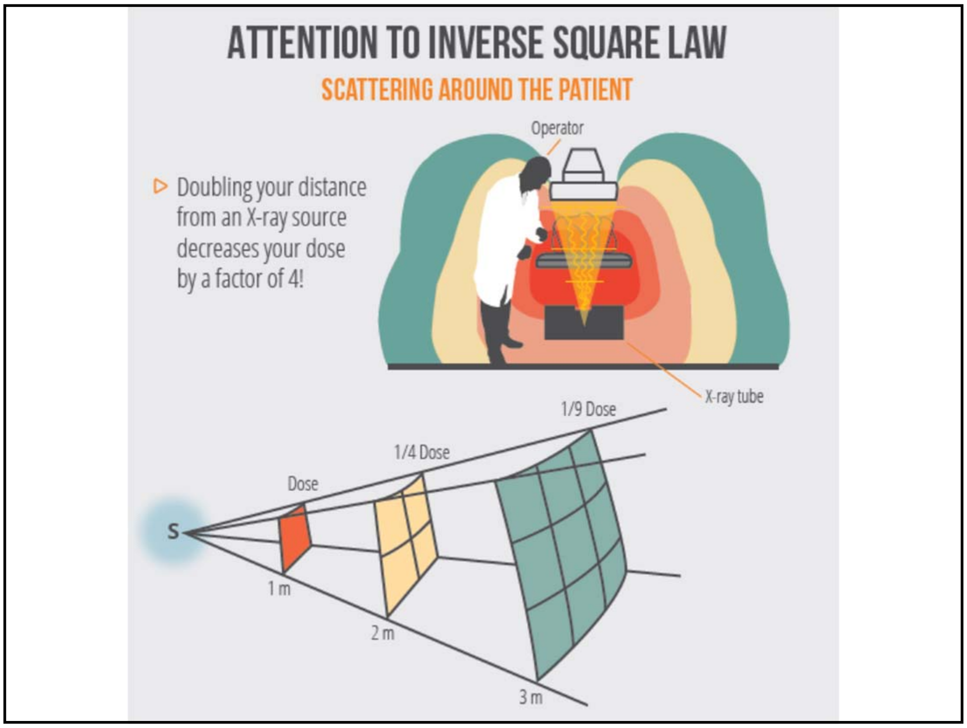
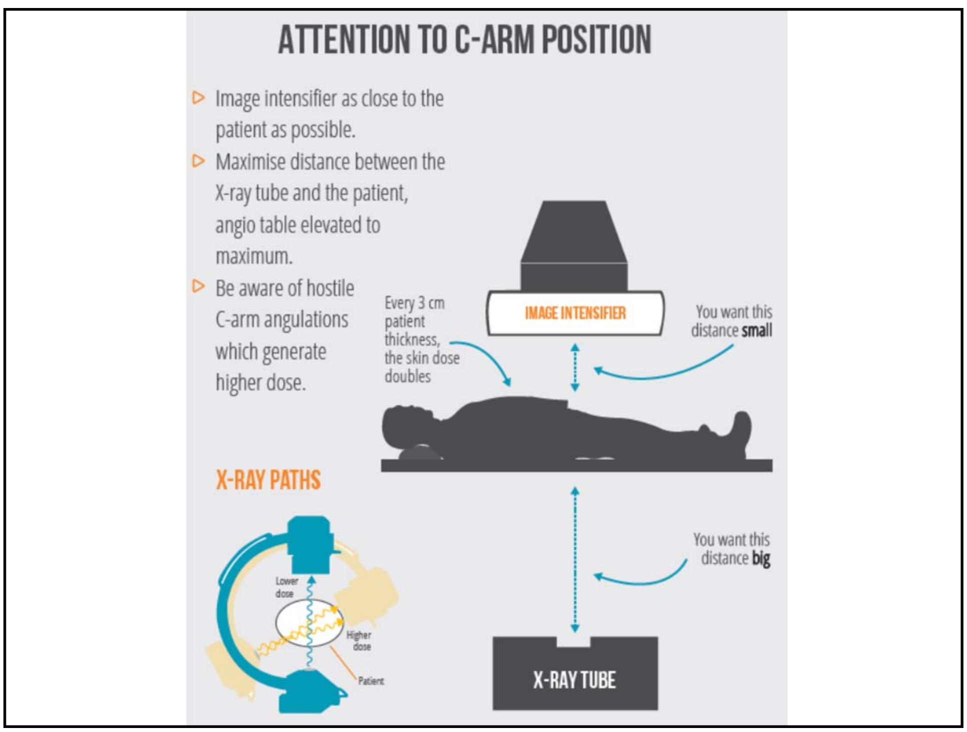
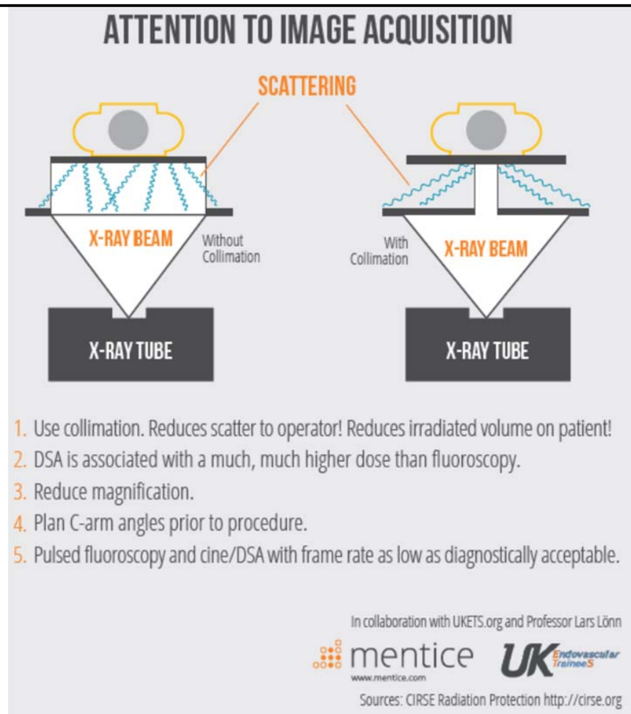
ATTENTION TO PROTECTION

- Use personal lead shields. Use protective gear.
- Use a dosimeter.
- Use table shields.
- Use leaded plastic barriers.
- Use leaded glass barriers and glass panels.




ATTENTION TO INVERSE SQUARE LAW
SCATTERING AROUND THE PATIENT
Doubling your distance from an X-ray source decreases your dose by a factor of 4!
Operator
X-ray tube
1/9 Dose
1/4 Dose
Dose
S
1 m
2 m
3 m


ATTENTION TO C-ARM POSITION
Image intensifier as close to the patient as possible.
Maximise distance between the X-ray tube and the patient, angio table elevated to maximum.
Be aware of hostile C-arm angulations which generate higher dose.
Every 3 cm patient thickness, the skin dose doubles
IMAGE INTENSIFIER
You want this distance small
X-RAY PATHS
Lower dose
Higher dose
Patient
You want this distance big
X-RAY TUBE



ARS Q4:

To minimize radiation scatter, the urologist should:

a) Keep the image intensifier as close to the patient as possible
b) Use the image intensifier above the patient
c) Use leaded protection on eyes, thyroid and body
d) Use collimation

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Answer: A

A. Keep the image intensifier as close to the patient as possible

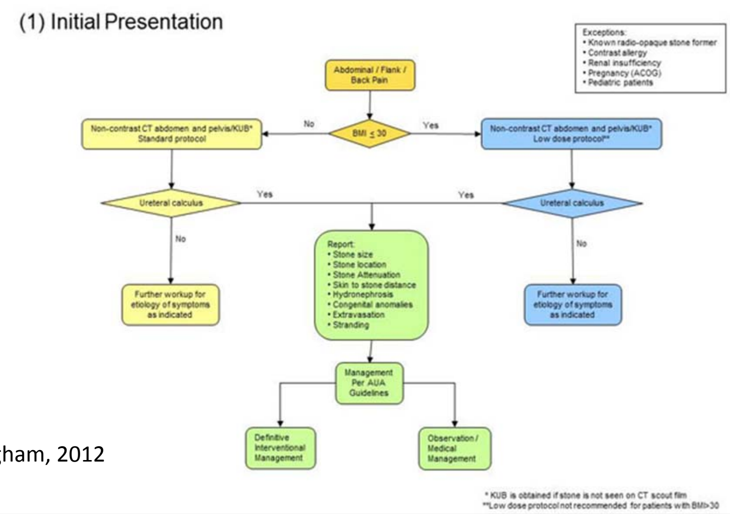
The image intensifier should be positioned as close to the patient as possible to reduce scatter.

Radiation Reduction – PCNL Image Guidance

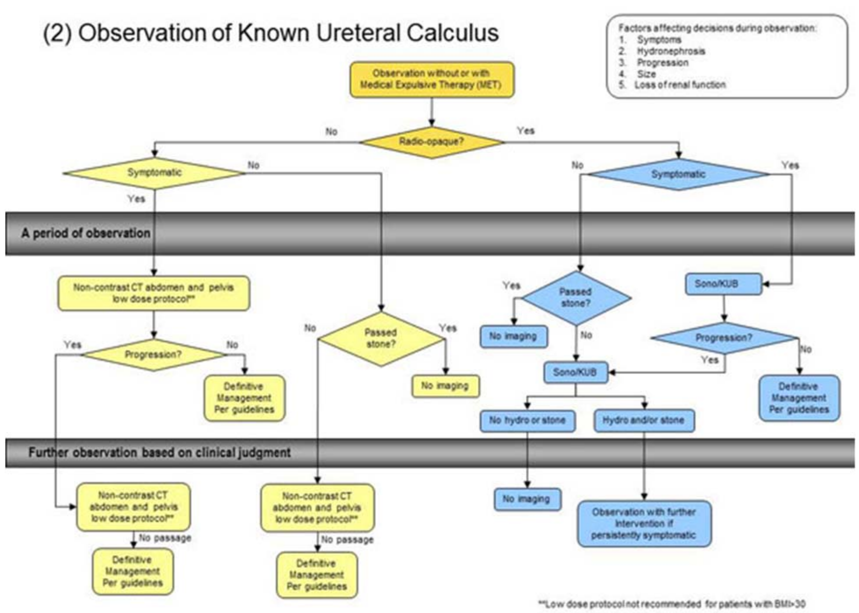
- Ultrasound access if BMI <30
  - Challenges – user dependent, significant training & experience, difficulty seeing stone/ureter
  - Series using only ultrasound with good outcome
  - 2 RCT - combined ultrasound/fluoro v fluoro alone
    - Less FT in ultrasound group
    - Similar outcomes

Hosseini et al. J Endo 2009, Gamal J Endo 2011, Basiri et al J Endo 2008, Agarwal et al. BJUI 2011

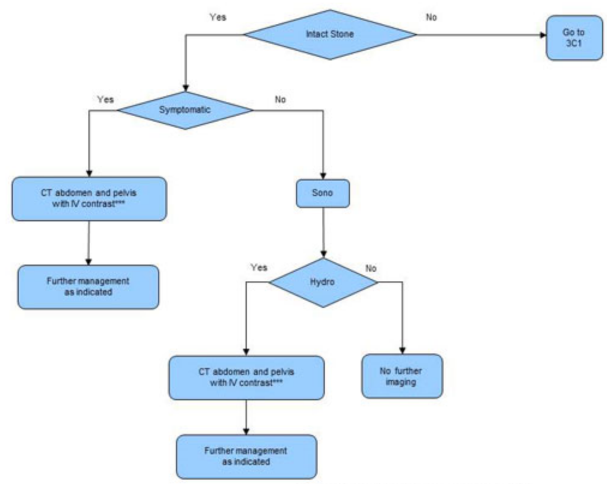
Clinical Effectiveness Protocols for Imaging in The Management of Ureteral Calculous Disease



Fulgham, 2012



(3C) Follow Up After Ureteroscopic Extraction, Intact Stone



*** Assuming normal renal function and no contrast allergy

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Summary

- Diagnostic imaging and interventions can result in significant radiation exposure
- Cancer risk increases with increased radiation doses in a linear fashion
- Alternative imaging should be selected when possible and unnecessary testing avoided
- Methods to reduce exposure during imaging and interventions should be actively utilized

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