Computed Tomography-guided Interventional Procedures

AAPM 2019

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Disclosures

I ❤ AAPM – thank you for your commitment to Lung Cancer Screening !

Unrelated

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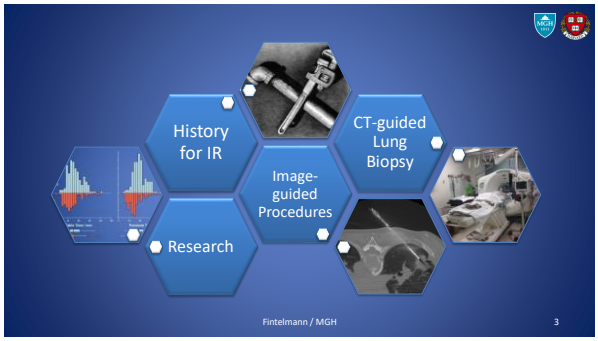
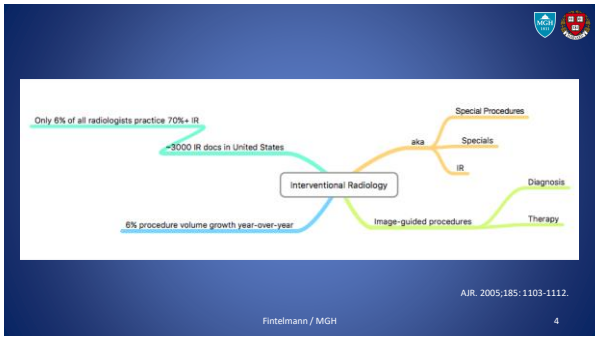
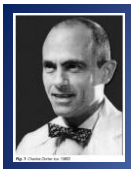
- American Roentgen Ray Society *[research grant]*
- William M. Wood Foundation *[research grant]*
- Jounce Therapeutics *[consulting]*
- Elsevier *[royalties]*

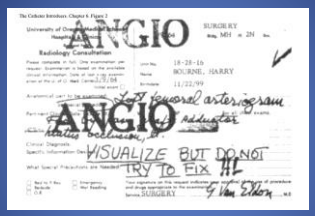




AJR. 2005;185:1103-1112.



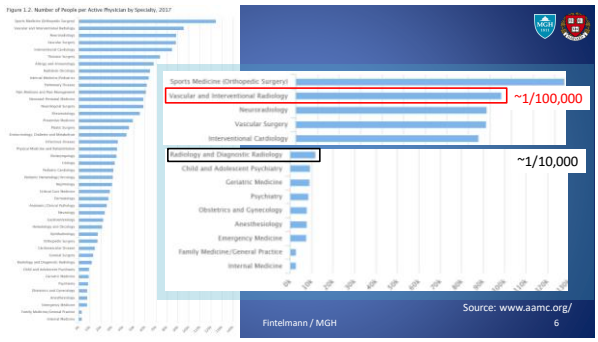
Charles T. Dotter (1920-1985)



1973: Society of Angiography & Cardiovascular Radiology

Society of Interventional Radiology — The vision to heal

Tex Heart Inst J 2001;28:28-38



Source: www.aamc.org/

Interventional Radiology - Scope of Practice

- Abdominal aortic aneurysms
- Abscess and other fluid drainages
- Angiography
- Angioplasty and stent placement
- Biliary obstruction
- Deep vein thrombosis
- Gastrostomy & other feeding tubes
- Gastrointestinal hemorrhage
- Hereditary hemorrhagic telangiectasia
- Hypertension and end-stage renal disease
- Infertility
- Liver disease/portal hypertension
- Lymphatic and venous disorders
- Mesenteric ischemia
- Needle biopsy
- Pediatrics
- Pelvic pain (chronic)
- Peripheral arterial disease
- Pulmonary embolism
- Stroke and carotid artery disease
- Trauma
- Tumor treatment
- Tuberous sclerosis
- Urinary tract obstruction
- Uterine fibroids
- Varicose veins
- Vascular malformations
- Venous access
- Vertebroplasty

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Tools

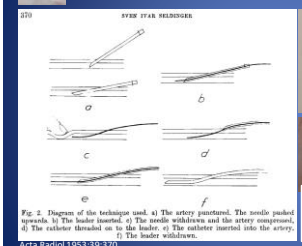
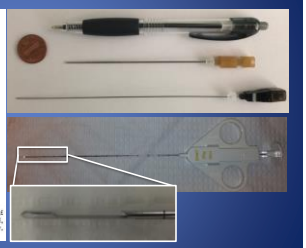


Fig. 2. Diagram of the technique used. a) The artery punctured. The needle pushed upwards. b) The leader inserted. c) The needle withdrawn and the artery compressed. d) The catheter threaded on to the leader. e) The catheter inserted into the artery. f) The leader withdrawn.

Acta Radiol 1953;39:370



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Our Job

1. Localize target
2. Guide needle/probe/catheter to target
3. Avoid critical structures
4. Intervention


CT


Fluoroscopy

Outcomes

- Technical success
- Patient safety
- Procedure time
- Radiation dose


Ultrasound


MRI

Mammography

PET-CT

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Ultrasound

1. Identify the target. Is the lesion visible on ultrasound?
2. Choose entry site
3. Real time trajectory to the lesion
   - Dependant on operator skill to line up lesion with needle trajectory on the same ultrasound plane
4. Adjust for patient breathing and organ motion

Curr Probl Diagn Radiol 2017. 46(3), 225–233

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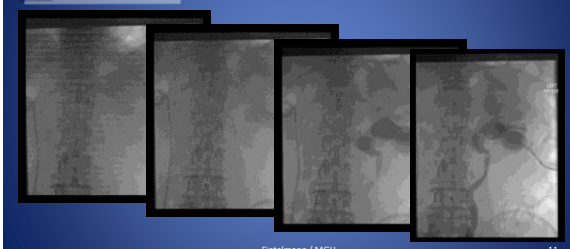
Fluoroscopy



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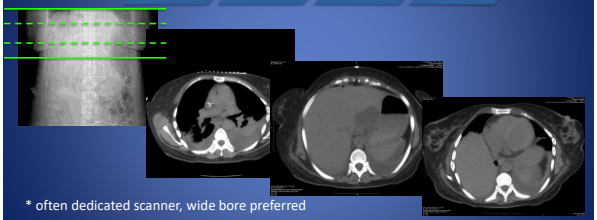
CT *

Scout → Planning → Intervention → Post intervention



* often dedicated scanner, wide bore preferred

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	CT	Fluoroscopy	Ultrasound	MRI
Cost	X X	X X	X X X	X
Visualize structures <1cm	X X	X	**X X X**	X X (X)
Visualize deep structures	X X X	X X	X	X X
Continuous image guidance	X	X X	X X X	X X X
3D image data	X X X	X	X X	X X X
Z axis coverage	X X	X X X	X	X X
Time resolution	X	X X X	X X X	X X

(X=least favorable)

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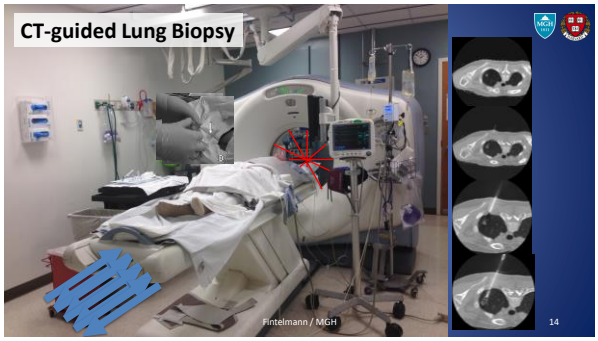

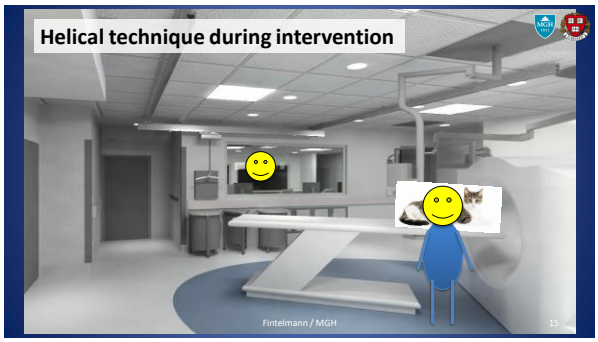

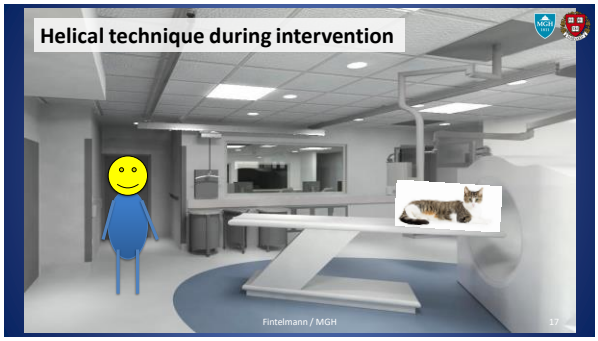

CT-guided Lung Biopsy

Scout | Planning | Intervention | Post intervention

"CT fluoroscopy" (≠ cone beam CT)

Intermittent fluoro

- Compared to helical, 50% less complications during lung biopsy. However,
  - ~200% + operator dose,
  - ~300% + patient dose

Single-slice ("real-time CT", biopsy mode, quick-check)

Cave: Ambiguous terminology for radiologists and technologists

Eur. Radiol. 21, 232–239 (2011)
Eur. J. Radiol. 81, 1029–1033 (2012)
Eur J Radiol. 82(12), 2253–2257 (2013)
Radiology 2019; 291:241–249

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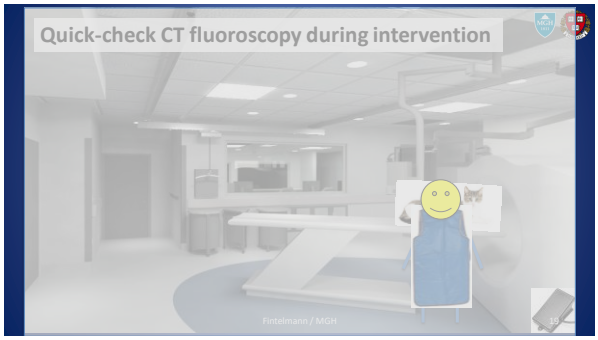
Quick-check CT fluoroscopy during intervention
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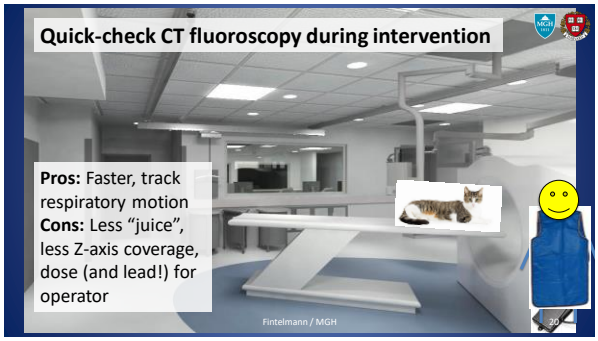
Quick-check CT fluoroscopy during intervention
Pros: Faster, track respiratory motion
Cons: Less "juice", less Z-axis coverage, dose (and lead!) for operator
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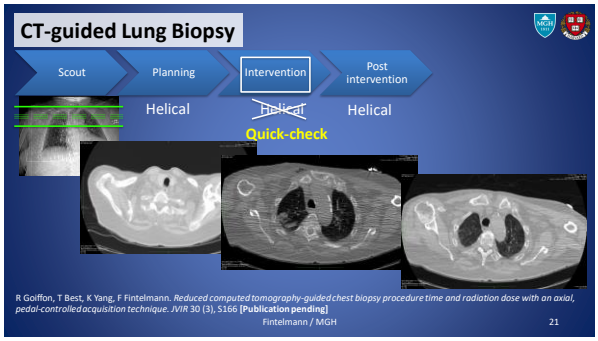
CT-guided Lung Biopsy
Scout
Planning
Intervention
Post intervention
Helical
Helical
Helical
Quick-check
R Golffon, T Best, K Yang, F Fintelmann. Reduced computed tomography-guided chest biopsy procedure time and radiation dose with an axial, pedal-controlled acquisition technique. JVIR 30 (3), S166 [Publication pending]
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Helical vs. quick-check: Time

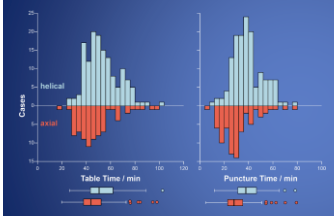
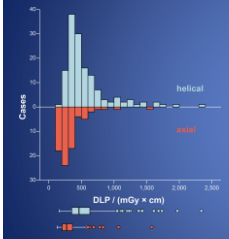


Table time
5.2 (1.5–9.0) min shorter
11% (5-17%) improvement
$p = 0.007$

Puncture time
8.1 (4.8-11) min shorter
23% (16-30%) improvement
$p < 0.001$

R Golfon, T Best, K Yang, F Fintelmann. *Reduced computed tomography-guided chest biopsy procedure time and radiation dose with an axial, pedal-controlled acquisition technique. JVIR* 30 (3), S166 **[Publication pending]**

Helical vs. quick-check: Radiation



Lower patient radiation
240 (140–330) mGy × cm lower
42% (33–49%) dose reduction

Same number of acquisitions
$p = 0.35$

No detectable dose to operator
Body and lens dosimeters, monthly reads

R Golfon, T Best, K Yang, F Fintelmann. *Reduced computed tomography-guided chest biopsy procedure time and radiation dose with an axial, pedal-controlled acquisition technique. JVIR* 30 (3), S166 **[Publication pending]**

The Future

- Navigational guidance
  - Image fusion (MRI, PET, US, CT)
  - Electronic needle visualization
  - Body global positioning system
- Ultra–low-dose CT fluoroscopy cf. Radiology 2019; 291:241–249
- Ablation volume planning
- Robotic-guidance
- Artificial Intelligence for procedure planning


Thank you!
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