Low-Dose Radiation in Early Detection: Weighing Risks and Benefits

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Dialogue for Action

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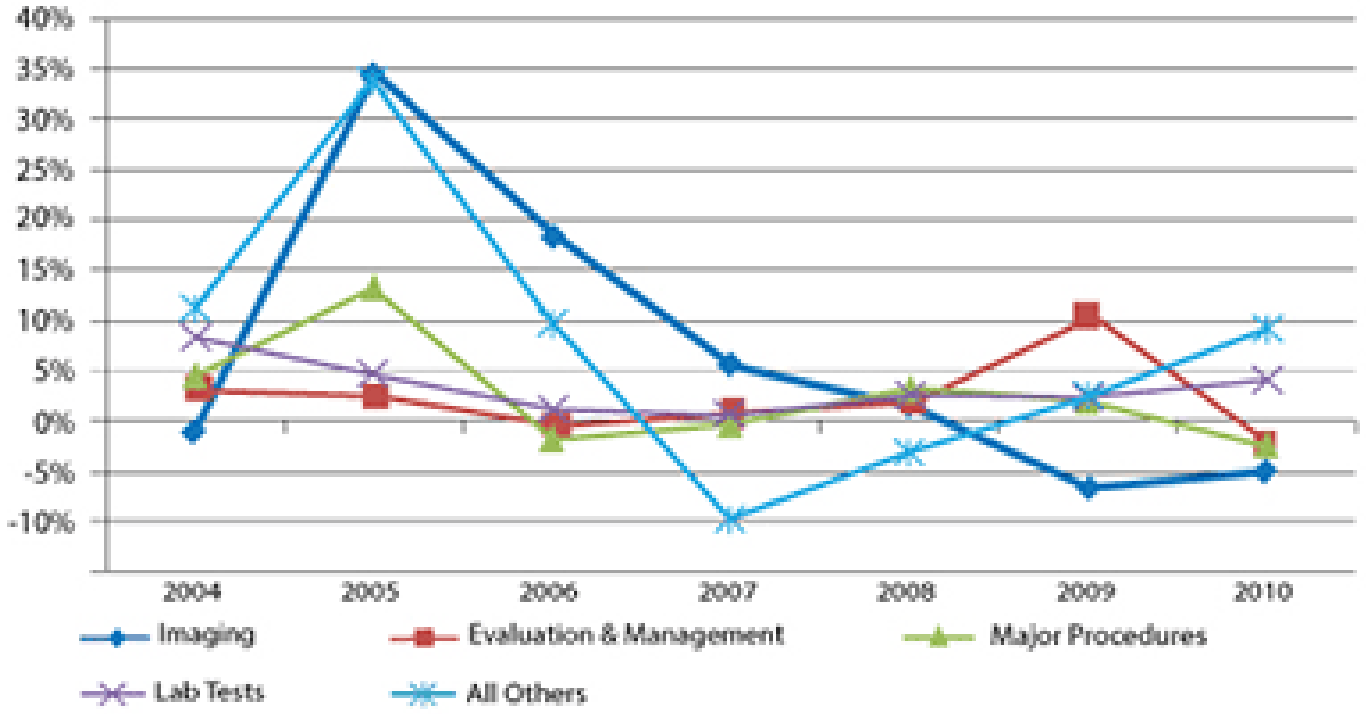
Disclosure

Consultant for Medial Cancer Screening, Ltd.

Overview

- Imaging volume in United States
- Recent cohort studies on CT risks in children
- Initiatives to improve use of imaging
- Benefit and radiation risk
  - Lung cancer screening
  - Virtual colonography
  - Breast imaging

Medicare Part B annual program dollars spent per enrolled beneficiary by procedure category.



http://www.acr.org/Research/Health-Policy-Institute/Neiman-Report-Index/Brief-01-Is-the-Medical-Imaging-Growth-Boom-Over

Standard Dose CTs associated with increased risk of cancer in children

- CT scans in childhood and risk of leukemia and brain tumors in UK study
  - Pearce MS, Salotti JA, Little MP et al. Lancet 2012;380:499-505.
  - Younger than 22; no prior cancer dx; first CT between 1985 – 2002 NHS central registry data from 1985 – 2008
  - 74 of 178,604 diagnosed with leukemia
  - 135 of 176,587 diagnosed with brain tumors
- Absolute risk small: one excess case of leukemia and one of brain tumor per 10,000 CT scans in those under 10
- Similar study in Australia in 10.9 million children of whom 680,000 had CT scans
  - Mathews JD, Forsythe AV Brady Z et al BMJ 2013;346:f2360.

The Alliance for Radiation Safety in Pediatric Imaging

Image Gently® and CT Scans

http://www.pedrad.org/associations/5364/ig/Procedures/ComputedTomography.aspx

One size does not fit all...

There's no question: CT helps us save kids' lives.

But when we image, radiation matters!

- But when we image, radiation matters!
- Children are more sensitive to radiation.
- What we do now lasts their lifetimes.
- So when we image, let's image gently: More is often not better.
- When CT is the right thing to do:

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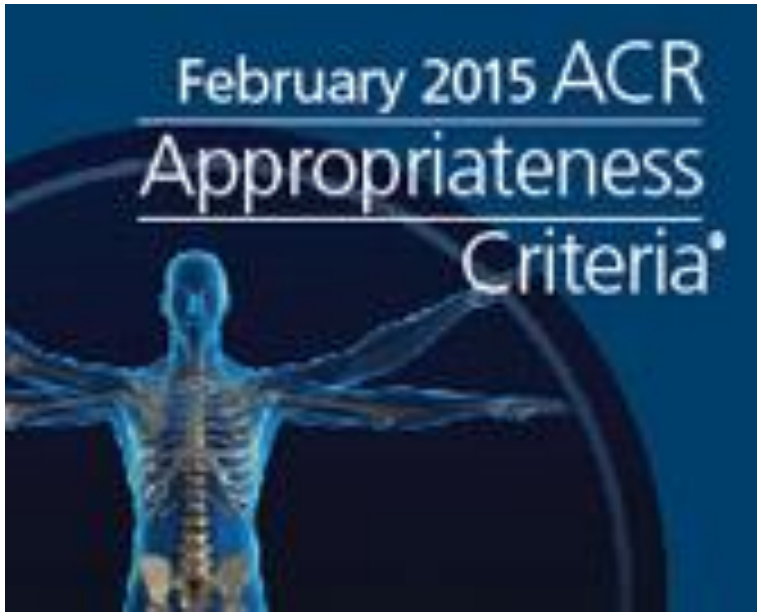
- Child size the kVp and mA.
- One scan (single phase) is often enough.
- Scan only the indicated area.

IMAGE WISELY®

Radiation Safety in Adult Medical Imaging

http://www.imagewisely.org/About-Us

- The American College of Radiology and the Radiological Society of North America formed the Joint Task Force on Adult Radiation Protection to address concerns about the surge of public exposure to ionizing radiation from medical imaging. The Joint Task Force collaborated with the American Association of Physicists in Medicine and the American Society of Radiologic Technologists to create the Image Wisely campaign with the objective of lowering the amount of radiation used in medically necessary imaging studies and eliminating unnecessary procedures.
- Image Wisely offers resources and information to radiologists, medical physicists, other imaging practitioners, and patients.

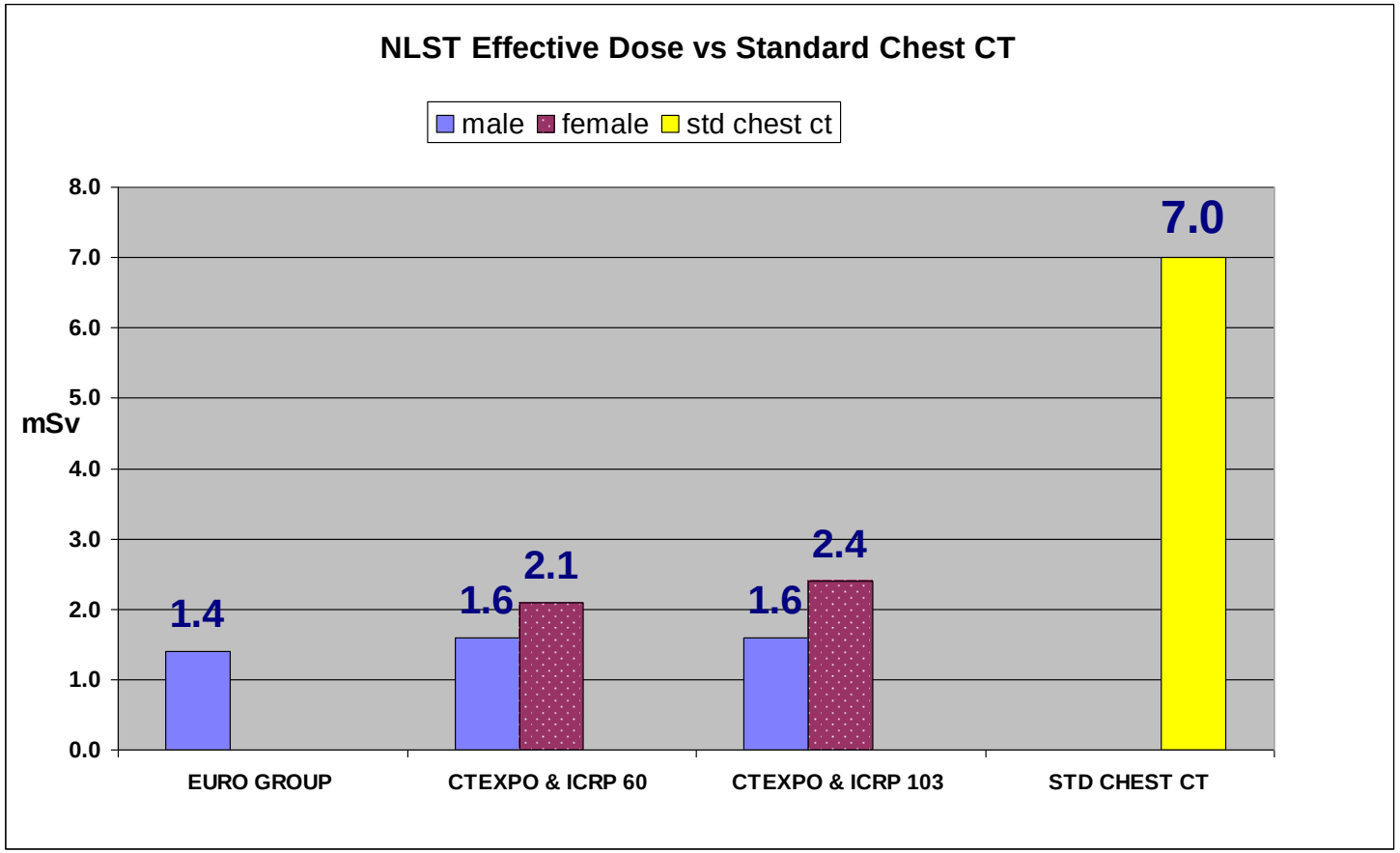


http://www.acr.org/Quality-Safety/Appropriateness-Criteria

- The ACR Appropriateness Criteria® (AC) are evidence-based guidelines to assist referring physicians and other providers in making the most appropriate imaging or treatment decision for a specific clinical condition. Employing these guidelines helps providers enhance quality of care and contribute to the most efficacious use of radiology. Learn More
- **February 2015 Update** — The latest release of the ACR Appropriateness Criteria includes **eight new and 19 revised topics** covering a total of 208 clinical conditions.
- **Methodology Documents**

Lung Cancer Screening and Radiation Risk

Comparison to Standard Chest CT



Acceptable chest CT screening can be accomplished at a small fraction of the dose of a standard chest CT

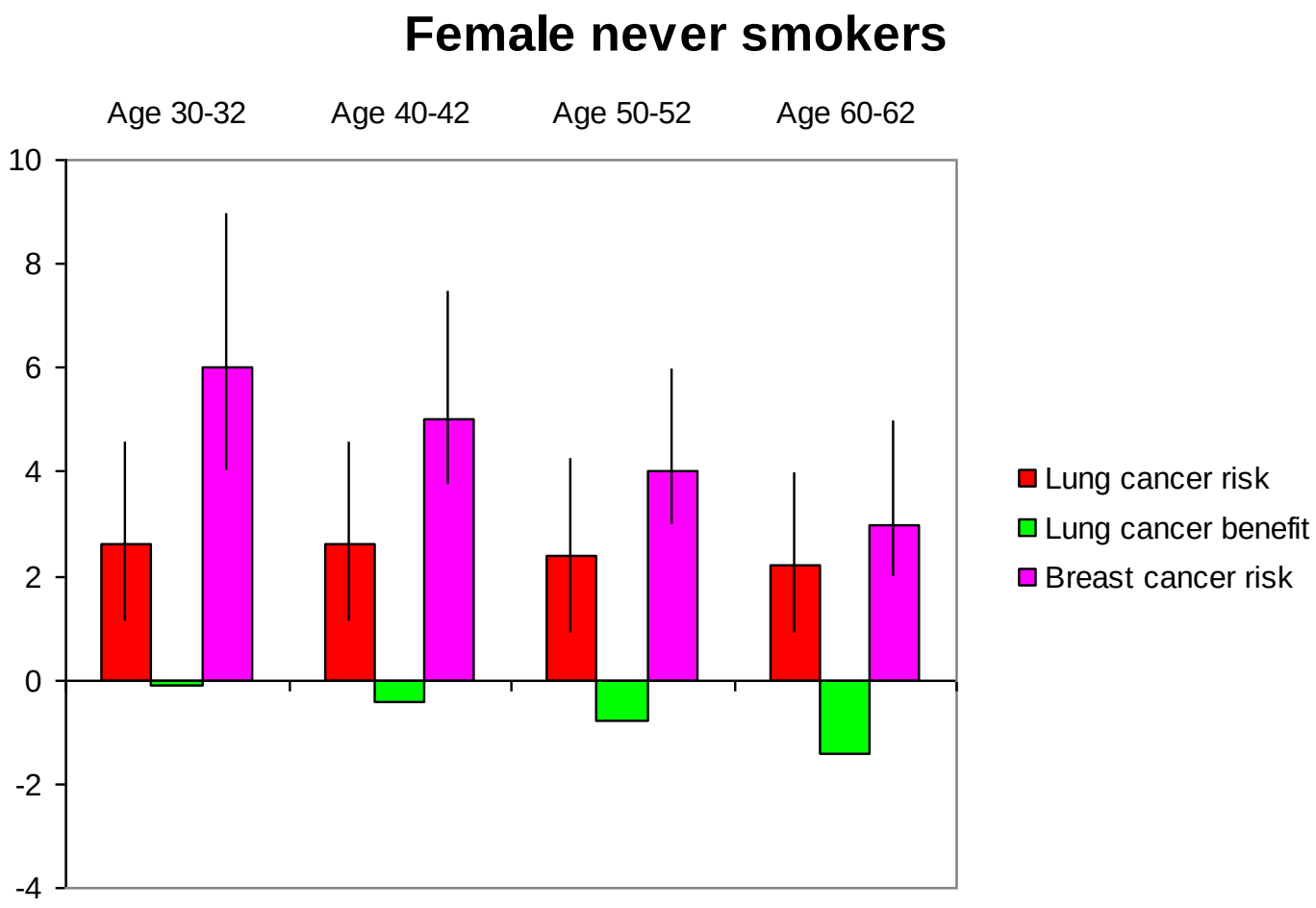
Larke FJ et al. AJR Am J Roentgenol 2011 Nov 197(5):1165-1169.

Radiation Risks vs Benefits

- 3 screens Smokers Age 55 – 57
- Whole body effective dose (weighted average dose to each organ)
  - Low dose helical CT: 1.5mSv
- Radiation risk from screens
  - 1-3 lung cancer deaths per 10,000 screened
  - 0.3 breast cancers per 10,000 females screened
- Radiation risk from follow-up CT scans
  - Low-dose or thin-section chest CT + 25%
  - Diagnostic chest CT + 100%
- Cumulative mortality reduction NLST
  - 30 lung cancer deaths per 10,000 screened

Amy Berrington de Gonzalez (personal communication)

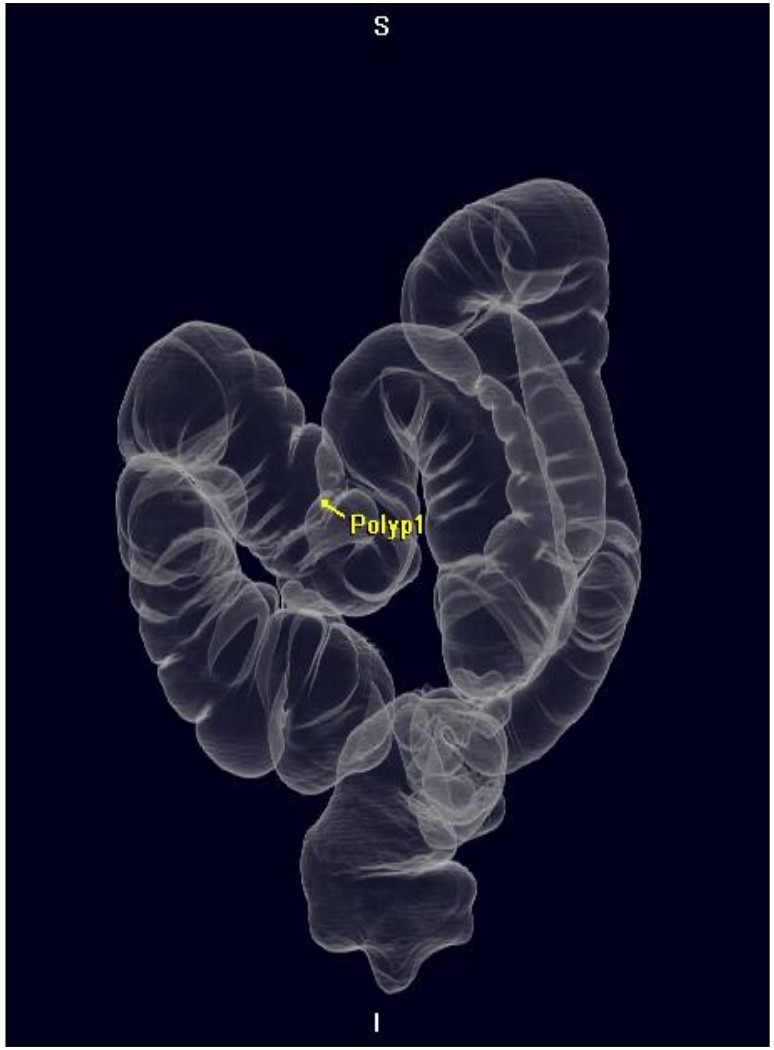
Change in cancer risk per 10,000 screened (assuming 20% mortality reduction)

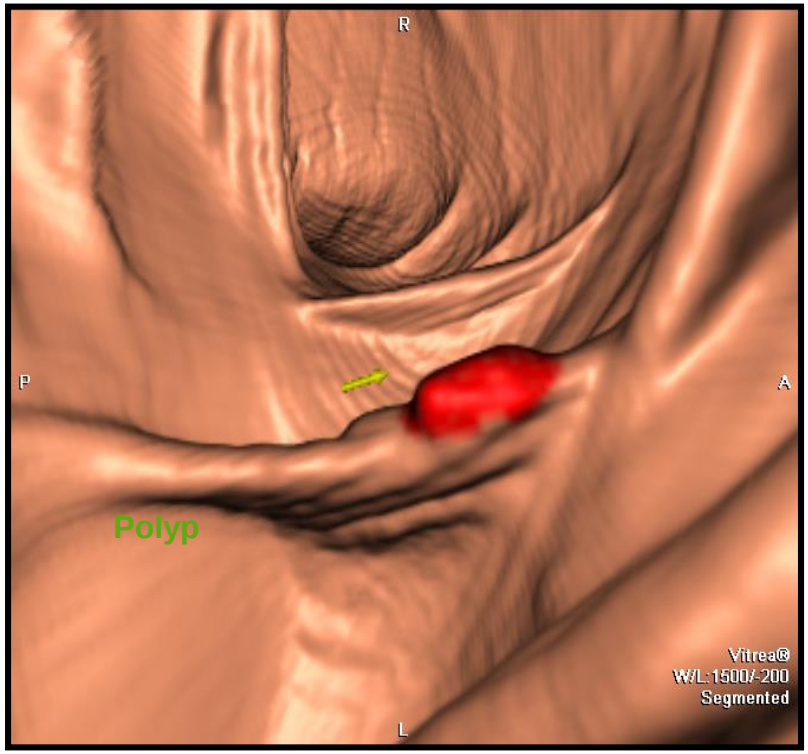


Berrington de Gonzalez A, Kim KP, Berg CD. J Med Screen 2008;15:153-158.

CT Colonography and radiation risks

2-D view and 3-D view





Courtesy of Beth McFarland, MD

CTC to Screen for Colorectal Neoplasia in Asymptomatic Adults:

Pickhardt PJ, Choi JR, Hwang I, et al. N Engl J Med 2003;349:2191-2200

Prospective multi-center DoD trial
of 1,233 asymptomatic adults

Size Threshold:	≥ 6 mm	≥ 8 mm	≥ 10 mm
By-Patient			
CTC Sensitivity	**88.7%**	**93.9%**	**93.8%**
OC Sensitivity	**92.3%**	**91.5%**	**87.5%**
CTC Specificity	**79.6%**	**92.2%**	**96.0%**

Conclusion: CTC comparable to OC for detection of clinically relevant polyps

Comparison of the estimated number of radiation-related cancers with the number of colorectal cancers prevented by CT colonography screening every five years (per 100,000): according to microsimulation model and age at screening

Berrington de Gonzalez A, Kim KP, Knudsen AB et al. AJR Am J Roentgenol 2011; 196:816-823.

Microsimulation model	Age at screening (yrs)	Average number of screens (per person)	Colorectal cancers prevented (per 100,000)	Radiation-induced cancer incidence (per 100,000 {95% UL})	Benefit-risk ratio (prevented:induced) {95%UL}
MISCAN	50-80	3.5	3580	150 {80-280}	24:1 {13:1-45:1}
	40-80	4.5	3740	230 {110-410}	16:1 {27.1-90:1}
	65-80	2.0	2700	60 {30-100}	45:1 {27:1-90:1}
	50-64	2.3	880	120 {70-220}	7:1 {4.1-13.1}
	40-49	1.8	160	110 {50-210}	1.5:1 {0.8:1-3:1}

Dose Reduction Approaches

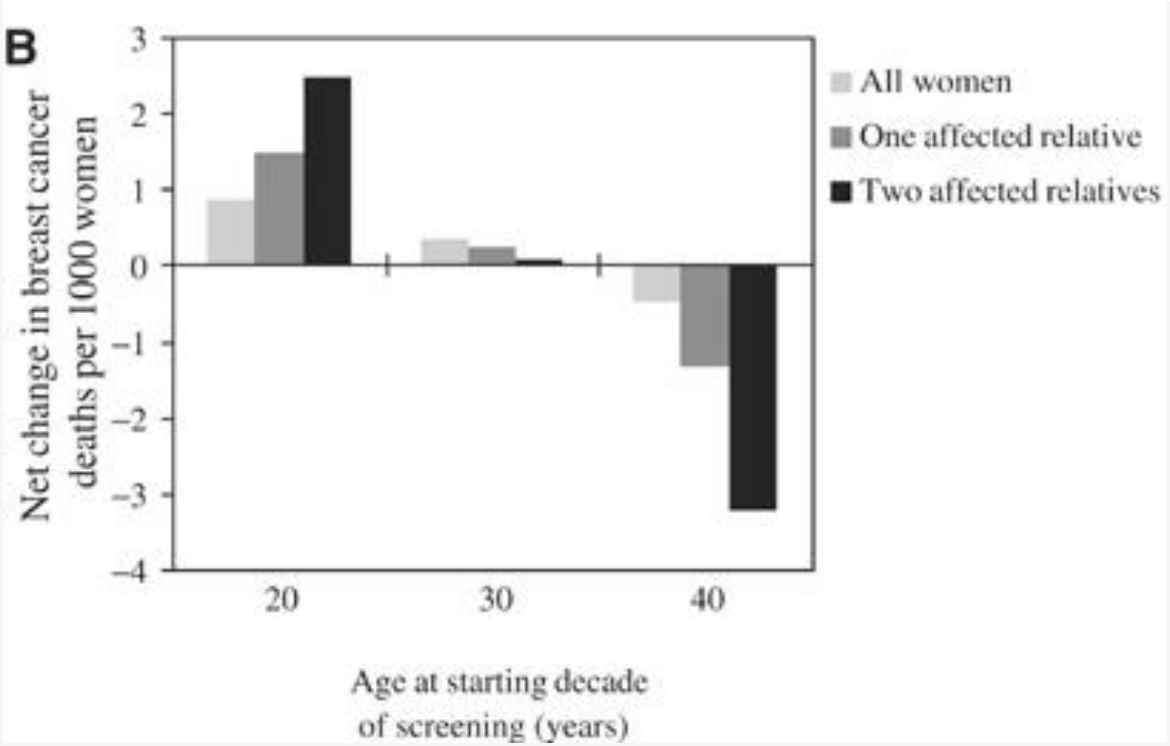
Chang KJ, Yee J Abdom Imaging 2013; 38;224-232

- Goal to keep dose at or below 5 mSv
- Must adjust for patient size
- Colonic air-mucosal interface does not require a significant amount of radiation
- Lower tube current (mAs) and/or tube voltage (kVp); need to adjust for contrast to noise ratio
- Automatic dose modulation: can be done in 3D
- Iterative reconstruction based upon mathematical models becoming more robust and time efficient
- Other: only perform indicated exams, patient positioning, optimize colonic distention, minimizing scan phases, scan volume, reading strategies,

Breast Imaging and Radiation Risks

Mammographic screening before age 50 years in the UK: comparison of the radiation risks with the mortality benefits

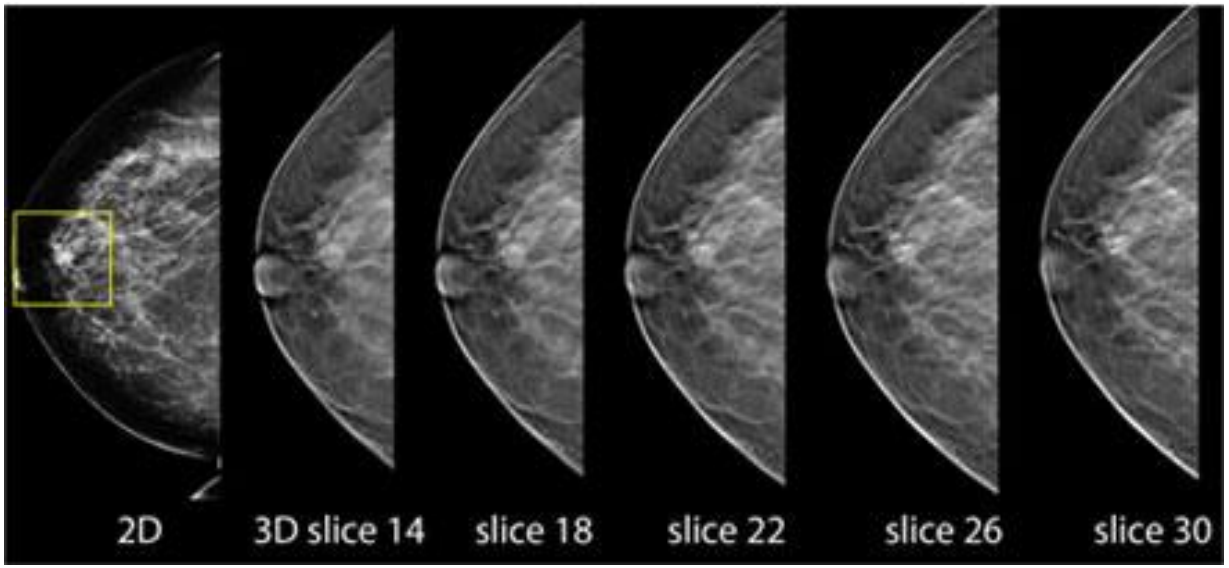
A Berrington de González and G Reeves

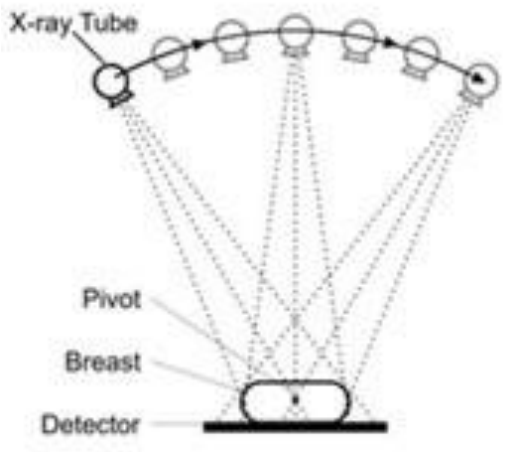


Estimated net change in breast cancer deaths per 1000 women screened in the UK according to age at starting decade of annual screening: all women and women with affected first degree-relatives. (**A**) Assuming a 10% mortality reduction, and (**B**) assuming a 20% mortality reduction.

Breast tomosynthesis

Svahn TM, Houssami N, Mattson S et al. Breast 2015; 24:93-99.





- Tomosynthesis alone is associated with similar radiation dose to full-field digital mammography but if both are used the dose is doubled. There is now the ability to do 2-D reconstruction from the tomosynthesis images eliminating the need for a combined exam.

Other breast imaging techniques

- Nuclear medicine studies such as breast-specific gamma imaging, positron emission tomography and molecular breast imaging have higher radiation doses with exposure to other organs and are currently in research environments
  - Hendrick RE Radiology 2010;257:246-253.
  - Rhodes DJ, Hruska CB, Conners AL et al AJR Am J Roentgenol 2015; 204:241-251.
- MRI and ultrasound do not use ionizing radiation; both have high false-positive rates but are useful in high-risk women particularly those with dense breasts
  - American College of Radiology Imaging Network Trial 6666, MRI and ultrasound had benefit in high-risk women
    - Berg WA, Zhang Z, Lehrer D et al JAMA. 2012;307(13):1394-1404.

ACR Initiatives on Quality-Safety

- http://www.acr.org/Quality-Safety/National-Radiology-Data-Registry/Dose-Index-Registry

- http://www.acr.org/Quality-Safety/National-Radiology-Data-Registry/National-Mammography-DB
- http://www.acr.org/Quality-Safety/National-Radiology-Data-Registry/CT-Colonography-Registry
- http://www.acr.org/Quality-Safety/Lung-Cancer-Screening-Center

Conclusion:
Next-Gen Imaging for Screening is Here

- Radiation doses in the range of standard CT scans have been correlated with increased risk of cancer
- The American College of Radiology and other medical organizations have developed approaches to appropriate use of imaging modalities
- Imaging technology with attention to dose-minimization is advancing
- Appropriate screening for lung, colorectal and breast cancer is associated with a favorable benefit:risk ratio

Acknowledgements

Amy Berrington de González and colleagues in the Radiation Epidemiology Branch, DCEG, NCI