CT: A Screening Modality for Lung Cancer, Colorectal Cancer, and Heart Disease

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Leading Causes of Death
Due to Disease in U.S.

#1—Cardiovascular disease: 710,760*

#2—Lung Cancer: 154,900**

#3—Colon CA: 56,300**

*http://www.cdc.gov/nchs/fastats/lcod.htm

**Cancer Facts and Figures 2000, American Cancer Society
All Are Space Occupying Lesions

• All three diseases are characterized by growing masses—plaques and tumors

• These masses are readily detected when contrasted with their environment on appropriate x-ray examination.
  
  CAD—Calcium with blood/ soft tissue
  Lung CA--Tumor with air filled alveoli
  Colon CA--Tumor with gas insufflated colon
With Early Dx, All Three Can Be Positively Impacted

**CAD:** No Smoking, Diet, Exercise, Statins, B-blockers, Surgical Intervention

**Lung CA:** No Smoking, Surgical Resection

**Colon CA:** Diet—High fiber, Polyp Removal, Surgical Resection
Benefits of Early Detection

- Early detection of mass with subsequent intervention significantly reduces mortality and morbidity in CVD and Colon CA
- Early detection and intervention with Lung CA...Reduction in mortality and morbidity is probable but uncertain
Clinical Relevance

• Nearly 1 million people die per year from CAD, Lung CA, and Colon CA

• These diseases can be readily identified by CT in early stages

• Once identified, these diseases can be minimized

• Early detection and prevention decreases mortality
CT Screening for Lung Cancer
Relevant Lung CA Facts

• Lung Cancer manifests primarily when symptomatic or incidentally on CXR.

• Majority of patients are found with Stage II or greater Lung CA.

• Stage II is characterized by a mass either < or > than 3 cm and lymph node metastasis.

• Stage II prognosis is grim—5 year survival ~30%.
Early Detection Using CT Finds Smaller Masses

- Screening with Single Slice Helical CT can identify lesions on the order of several millimeters.
- A majority of these tumors are categorized as Stage I. (ELCAP Trial)
- Stage I is characterized by mass of <3cm and no nodal metastasis.
- Stage I tumors have a markedly better 5 year survival at ~80%.
Does Early Detection = Reduced Mortality?

- Intuitive to believe that the overall mortality will be reduced
- However, there is no clinically proven reduction in mortality with CT screening
- This remains a topic of much debate and is the basis for the National Lung Screening Trial (NLST)
- Randomized control trial, 50,000 subjects, positive smoking history, 54-75 yrs old, comparing CXR with chest CT in reducing mortality
Basic Concepts of CT—Intersecting Lines of Attenuation
What Is A Helical CT Scan?

• Differs from conventional CT in that a helical CT can continuously image the body

• This increases speed of data acquisition and spatial resolution

• Maintains relatively low radiation dose (wide collimation—10mm)

• Other relevant benefits include: improved 3D and volumetric analysis
How is Lung CA screening procedure performed?

- No preparation necessary
- Total scanning time: 15 – 20 seconds
- High risk patients—positive smoking history and age 55 to 74 years old
- Low radiation dose (10 mm collimation)
SSCT of Pt. H.M.—Stage I Lung CA

http://bidmcpacs.caregroup.org
Scout Film of Pt. H.M.

http://bidmc.pacs.caregroup.org
Classic Locations of Lung Cancer

- Non-Small Cell (80%)
  - Squamous Cell (25-40%)
  - Adenocarcinoma (30-40%)
  - Large Cell (10%)
- Small Cell (20%)
  - Oat Cell
  - Intermediate

www.vh.org
SSCT of Pt. H.M. Shows Peripheral Spiculated Nodule

Biopsy Revealed… Adenocarcinoma

http://bidmcpacs.caregroup.org
Measuring Growth of Nodules to Monitor for Malignancy

Source: Henschke, C et al. CT Screening for Lung Cancer. Rad Clin of N Amer May 2000
Summary of CT Screening for Lung Cancer

- Spiral CT allows for fast scans with relatively high resolution and low radiation dose. Multislice CT scans can further increase speed and resolution.
- Malignant lung nodules can be detected in early curable stages.
- NLST will determine if early detection can reduce mortality.
CT Screening for Colorectal Cancer
Colorectal Cancer Facts

• Colorectal Cancer (CRC) is the second leading cause of cancer mortality in the U.S.

• Principle behind screening is to intervene on the natural history of the adenoma to invasive carcinoma development.

• Countless large clinical trials have shown a 30-50% mortality reduction with screening.
Screening Modalities

- FOBT
- Double Contrast Barium Enema
- Flexible Sigmoidoscopy
- Conventional Colonoscopy
- CT-Colonoscopy (Virtual Colonoscopy)
Poor Resolution with SSCT v. MSCT

- CT colonoscopy requires large exam area (40cm) and breath hold
- Single-Slice Helical CT is poor modality for detecting polyps < 10mm due to both insufficient spatial and temporal resolution
- Multislice CT—2x to 32x increase in acquisition speed with greater resolution of space and time
Multislice Helical CT Scanner

- Recent technological advancements have allowed for the addition of multiple detectors.
- This allows for quicker scans (10-20 seconds for entire torso) and with finer slices (collimation as low as 1 mm)
- High sensitivity detecting polypiod lesions < 5mm
Multislice CT Scanner (16 Detectors)

Advantages over Single Slice Helical CT (SSCT):
- Speed: 500ms/rotation
- Area covered: 4x, 8x, 16x
- Resolution: 1 mm collimation

Disadvantage:
- Radiation Dose: Greater than SSCT

www.medical.philips.com
Procedure

- Bowel cleansing 1 day prior
- Pt has CO2 or room air insufflated into rectum thru enema tip.
- Supine imaging is performed with single breath hold.
- Prone if image regions of interest not available
- Total procedure time: 10 minutes
- Interpretation time: 15-30 minutes
- Total office time: 1 hr

Courtesy of Dr. Martina Morrin, Virtual Colonoscopy Director, BIDMC Radiology
2D Axial and 3D Imaging of Ascending Colon

Courtesy of Dr. Martina Morrin, Virtual Colonoscopy Director, BIDMC Radiology
2D Axial CT Image of Annular Carcinoma in Transverse Colon

Courtesy of Dr. Martina Morrin, Virtual Colonoscopy Director, BIDMC Radiology
3D Reconstruction of CT Image of Annular Carcinoma in Transverse Colon

Courtesy of Dr. Martina Morrin, Virtual Colonoscopy Director, BIDMC Radiology
Common Anatomic Sites of Colorectal Neoplasia

- Transverse colon—15%
- Cecum and Ascending colon—25-35%
- Descending Colon—5-8%
- Sigmoid—35%
- Rectum—20-30%
Summary of CT Screening for CRC—A New Standard on the Horizon

• CRC can be detected early, prevented from progressing, and it’s mortality can be reduced

• CRC has traditionally been detected by endoscopic colonoscopy

• Development of MDCT scanners is helping to establish virtual colonoscopy as a clinically relevant screening tool. RCTs needed to verify
CT Screening for CAD
How do you detect CAD with CT?

- CT imaging of coronary artery calcium
- A CT scan of the heart using **EBCT or MDCT** along with ECG gating in order to visualize and quantitate the amount of calcium deposition in the coronary arteries
- The fast speed with which images are acquired (on the order of 10s of milliseconds) and ECG gating allows for minimal blurring due to heart motion
Hounsfield Units (HU)

- A unit of measurement used to measure ability of tissue to absorb an x-ray beam.
- Different tissue have different HU values. e.g. muscle/soft tissue—40 HU
- Used to provide quantitative value to degree of coronary calcification
- Serve as a prognostic tool in determining likelihood of future coronary event.

Hounsfield, GN, Nobel Prize in Physiology or Medicine Lecture—Computed Medical Imaging, December 8, 1979
Coronary Calcium Score

- Represents the quantity of Ca in the coronary arteries
- Indirect measure of stenosis
- An aggregate of CT slices are integrated into one and areas of calcification and density are automatically measured
- These 2 variables are calculated to yield a Coronary Calcium Score
- Scores range from 0 to ~2000. Zero representing no detectable coronary calcium
**e.g. Distribution of Coronary Calcium Scores**

### TABLE 1. Calcium Score Nomogram for 9728 Consecutive Subjects

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<th>Age, y</th>
<th>35–39</th>
<th>40–44</th>
<th>45–49</th>
<th>50–54</th>
<th>55–59</th>
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<td>0</td>
<td>3</td>
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<td>28</td>
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<tr>
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<td>0</td>
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<td>16</td>
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<td>362</td>
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</table>

The number of patients in each group is in parentheses.

Relationship of Coronary Calcium and CAD

EBCT
(Electron Beam Computed Tomography)

http://www.bidmc.harvard.edu/radiology
EBCT Image of Coronary Calcium

http://www.bidmc.harvard.edu/radiology
Multislice (16 Detector) CT Scan of Right Main, Left Main, LAD

Courtesy of Dr. Melvin Clouse, Chief, BIDMC Radiology
Anatomy of Coronary Arteries

- Aorta
- Left Main
- Right Main
- LAD
- LCX

Courtesy of Dr. Melvin Clouse, Chief, BIDMC Radiology
Multislice (16 Detector) CT Image of Left Main and Left Circumflex

Courtesy of Dr. Melvin Clouse, Chief, BIDMC Radiology
Aortic Root with **Right** and **Left** Main Arteries

Courtesy of Dr. Melvin Clouse, Chief, BIDMC Radiology
Summary of CT Screening of Coronary Calcium

- EBCT has been shown to detect early CAD
- Coronary Calcium Score can serve as a reliable prognostic factor for CAD and subsequent coronary events
- In future, may become a major prognostic tool
- MDCT (16) as newest modality in screening is promising
SUMMARY

By combining basic radiological principles of tissue contrast with the advances in CT imaging that have occurred over the past decade, which include the development of the Helical CT, MDCT, and EBCT, radiology is poised to become a major means of early detection and prevention of Cardiovascular Disease, Lung Cancer, and Colon Cancer.
References


Cancer Facts and Figures 2000, American Cancer Society 2002
Henschke, C et al  CT Screening for Lung Cancer. Rad Clin of N Amer, May 2000
Hounsfield, GN  Nobel Prize in Physiology or Medicine Lecture—Computed Medical Imaging. December 1979
http://www.cdc.gov/nchs/fastats/lcod.htm
http://www.bidmc.harvard.edu/radiology
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