CREATING A RADIATION DOSE MANAGEMENT STRATEGY

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OBJECTIVES

- We're going to (attempt to) answer these questions…

  - Why is radiation dose management important?
  - What is the true impact of dose on patients?
    - How does radiation produce biological damage?
    - What are the risks?
  - What is radiation dose optimization?
  - What is MultiCare's radiation dose optimization strategy?

A CHANGING LANDSCAPE

- The Joint Commission
  - Radiation Overdose as a Reviewable Sentinel Event
  - SEA 47
  - New requirements proposed
- California Senate Bill 1237
- Radiation Dose Benchmarking
  - ACR Dose Index Registry
  - Dose Tracking Software
- A new and increased awareness that image quality should be balanced with radiation dose

WHY SO MUCH ATTENTION?

- Medical radiation dose is newsworthy!
  - Cedars-Sinai – 206 patients overexposed
  - Mad River – 151 scans in 68 minutes

Many people unaware of radiation risk from CT scans

Published January 04, 2013 | Reuters

One-third of people getting a CT scan didn't know the test exposed their body to radiation, in a new study from a single U.S. medical center.

Researc

October 16, 2009

Radiation Overdoses Point Up Dangers of CT Scans

By WALT BOGDANICH

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Radiation overdoses from CT scans lead to maladies in patients

By **The New York Times**

on August 01, 2010 at 4:00 AM

By Walt Bogdanich

When Alain Reyes' hair suddenly fell out in a freakish band circling his head, he was not the only one worried about his health. His co-workers at a shipping company avoided him, and his boss sent him home, fearing he had a contagious disease.

Only later would Reyes learn what had caused him so much physical and emotional grief: he had received a radiation overdose during a test for a stroke at a hospital in Glendale, Calif.

Other patients getting the procedure, called a CT brain perfusion scan, were being overdosed, too -- 37 of them just up the freeway at Providence St. Joseph Medical Center in Burbank, 269 more at the renowned Cedars-Sinai Medical Center in Los Angeles and dozens more at a hospital in Huntsville, Ala.

HIGH RISK AREAS

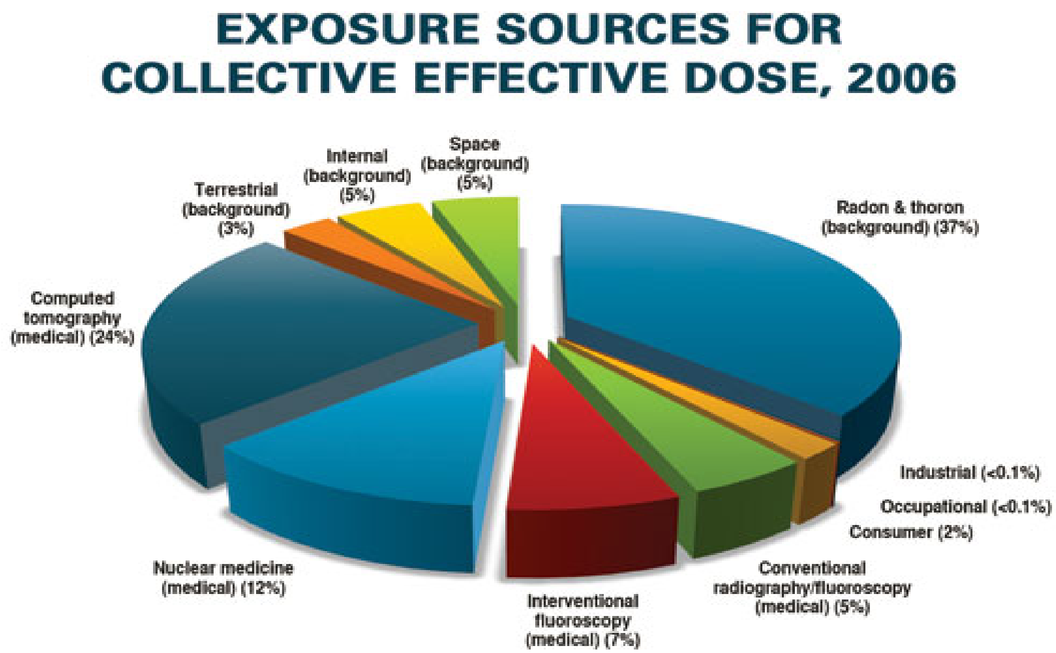
Fluoroscopy

Radiation Therapy

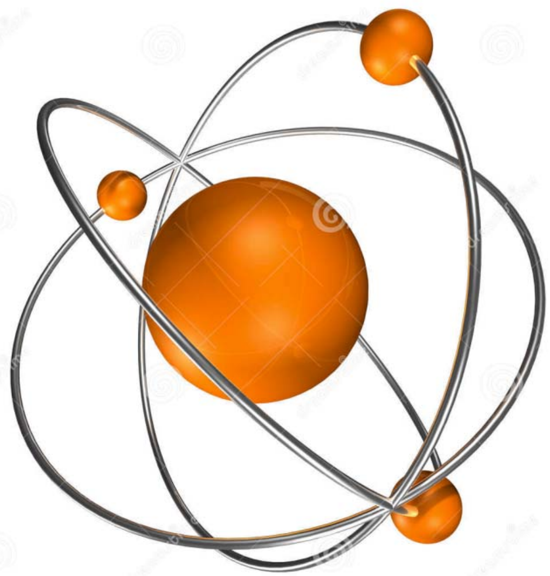
Computed Tomography

MEDICAL RADIATION DOSE

- Medical radiation dose accounts for nearly 50% of the US populations average effective dose
  - All sources – 620 mrem
  - Medical – 310 mrem
- Has dramatically increased over the years
  - 1980 – 5 million CT scans
  - 2012 – 70 million CT scans



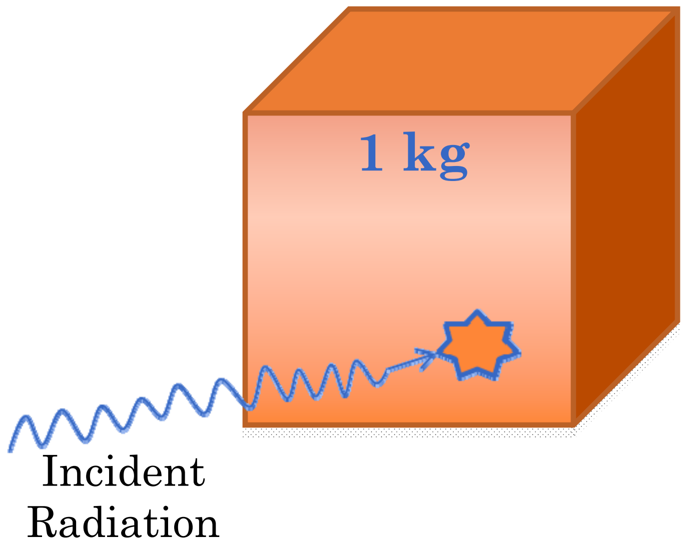
TO CREATE A RADIATION DOSE MANAGEMENT STRATEGY….



- It's helpful to be aware of
  - Radiation Dose
  - Radiation Biophysics
  - Risk Estimates and Their Limitations

WHAT IS DOSE?

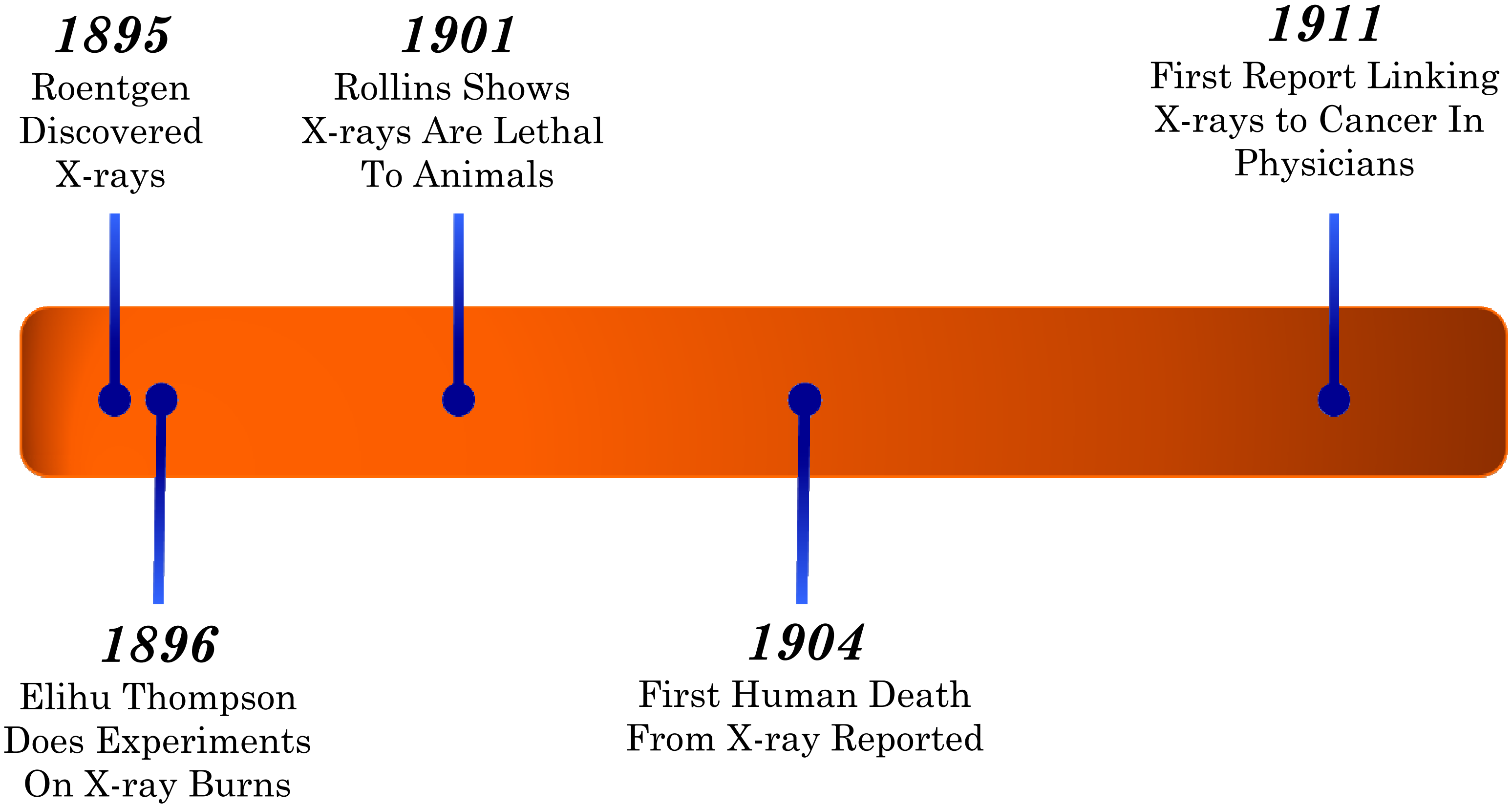
- Dose is defined as the energy deposited per unit mass
  - 1 J/kg = 1 Gray
- Measured in units of
  - Gy → absorbed dose
  - Sv → dose equivalent
  - 100 rem = 1 Gy
  - 100 rad = 1 Sv



1.6×10^{-19} Joules = 1 eV

RADIATION BIOLOGY TIMELINE

- Radiation has been proven to produce harmful biological effects



NON-STOCHASTIC VS. STOCHASTIC

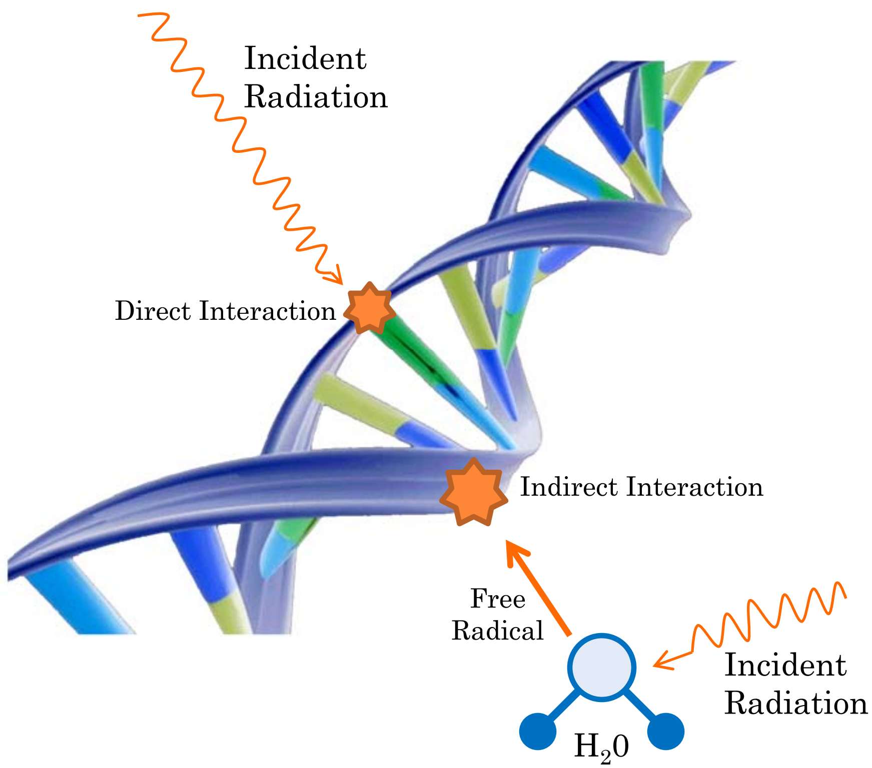
- Non-stochastic effects (non-probabilistic)
  - A threshold dose exists!
  - Erythema
  - Epilation
  - Dermal Necrosis
- Stochastic effects (probabilistic)
  - A threshold dose not exist - LNT
  - Most common stochastic effect - cancer

NON-STOCHASTIC EFFECTS

Radiation Effect	Threshold to Produce (Gy)	Amount of Fluoroscopy to produce at 5 R/min	Amount of Cine to produce at 30 R/min	Time to Effect
Transient Erythema	2	0.7 hours	0.1 hours	24 hours
Epilation	3	1 hour	0.2 hours	3 weeks
Main Erythema	6	2 hours	0.3 hours	10 days
Pericarditis	8	2.7 hours	0.4 hours	> 10 weeks
Dermal Necrosis	18	6 hours	1 hour	> 10 weeks

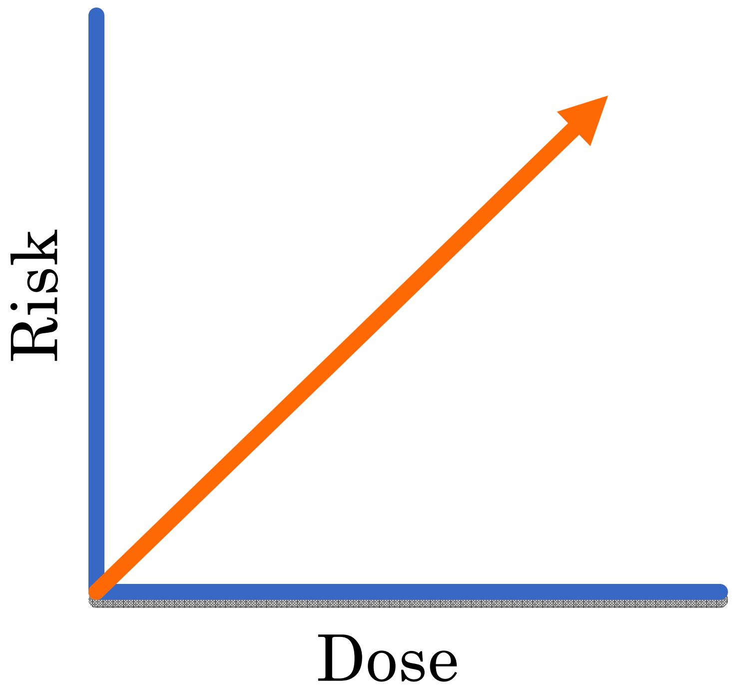
HOW DOES RADIATION CAUSE DAMAGE?

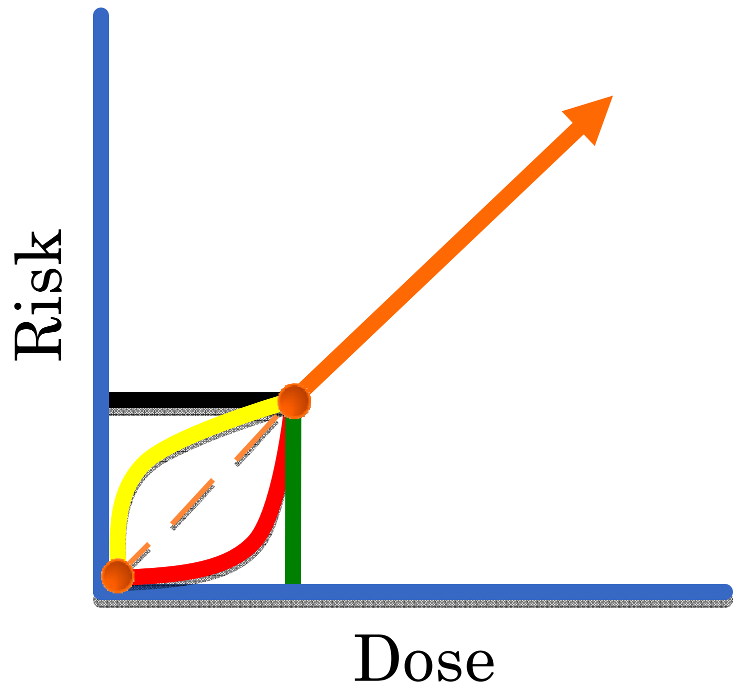
- Indirect Damage vs. Direct Damage
  - SSB vs. DSB
- 3 stages to forming cancer
  - Initiator – mutational event
  - Promoter – functional change
  - Progression – tumor invasion
- Radiation is a weak carcinogen because it acts only as an initiator.



LINEAR NON-THRESHOLD

- Most conservative dose-response model
- Every exposure carries some risk for tumor development





RISK ESTIMATES

- Cancer mortality in US
  - ~20%
  - For every 10 mSv increase in dose, there is a 0.05% cancer mortality risk increase
- Risk of cancer from a 10 mSv CT scan 1/2000 ~0.05%
  - Total risk of 20.05%
- Previous risk does not affect future risk
  - Risk of 1st scan = 10th scan = nth scan

RISK GETS COMPLICATED

- What are we measuring?
  - CT – $CTDI_{vol}$, $CTDI_{100}$, $CTDI_w$, (mGy)
  - XR – DAP (mGy-cm^2)
  - Fluoro – Air Kerma (mGy)
  - NM – mCi, μCi

- Converting to effective dose and assessing risk is difficult
  - Based on estimates, assumptions, and models
  - High degree of variance
    - Organ properties, organ geometry, statistical models, uncertainty of data from cancer studies (LSS), LNT extrapolation, patient age, gender, body mass, genetic factors

AAPM POSITION STATEMENT ON RADIATION RISK FROM MEDICAL IMAGING PROCEDURES

- Procedures should be appropriate and conducted at the lowest radiation dose to obtain the desired information
- Discussion of risks vs. benefits with patient
- Risks below 50 mSv may be non-existent
- Predictions of hypothetical cancer incidence is highly speculative and discouraged

REDUCING RADIATION DOSE

- Two ways to reduce radiation dose
  - Fewer exams performed – The lowest dose procedure is the one that is not performed
    - Reduce repeat rates
    - Consult with radiologist regarding questionable exams
  - Reduce the amount of radiation per exam
    - Must be balanced with maintenance of diagnostic image quality ➔ *Dose Optimization*

DOSE OPTIMIZATION DEFINED

- The lowest radiation dose possible while maintaining diagnostic image quality
  - Must have photons to create an image
- Lower Dose ≠ Better Exam
  - Best exam is the one that is diagnostic
- Close work between radiologist, technologist, and physicist

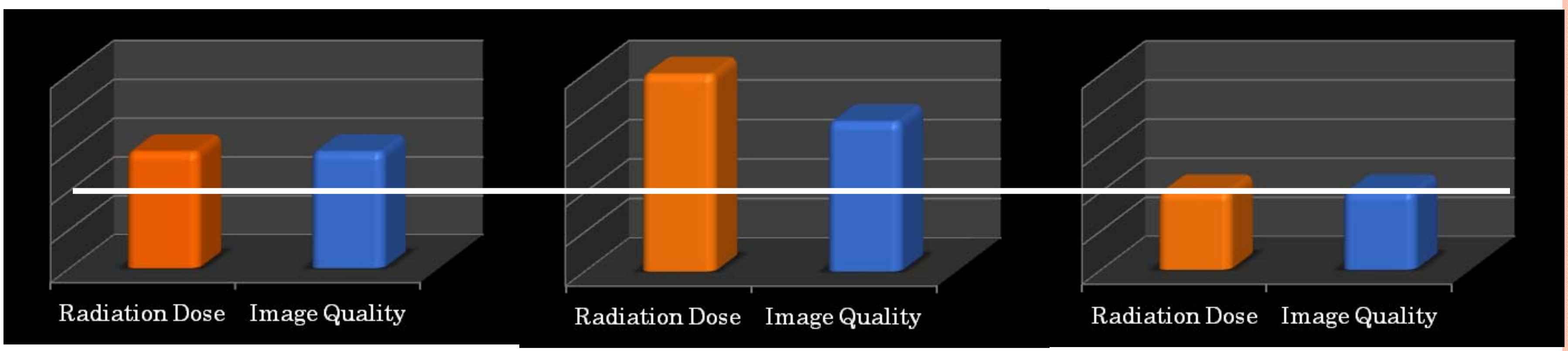


Fig. 1 Fig. 2 Fig. 3

MULTICARE'S RADIATION DOSE MANAGEMENT STRATEGY

IN THE BEGINNING…

- Strong emphasis on dose reduction for CT at Tacoma General
  - Investment in dose reduction technology
  - Partnership with Siemens
- Springboard for future dose optimization work
- Obstacles
  - Only one modality
  - Only one location

A SYSTEM APPROACH

- Dose optimization efforts should be focused on all modalities at a system level
  - CT, Nuclear Medicine, & Fluoroscopy
- Patients should be imaged the same way across MHS
- Increased radiologist and physicist involvement
- Provide radiation dose education to physicians, technologists and patients
- Provide for a way of tracking radiation dose

MULTICARE'S RADIATION DOSE MANAGEMENT STRATEGY – 4 AIMS

Establish Collaboration

Standardize & Optimize Protocols

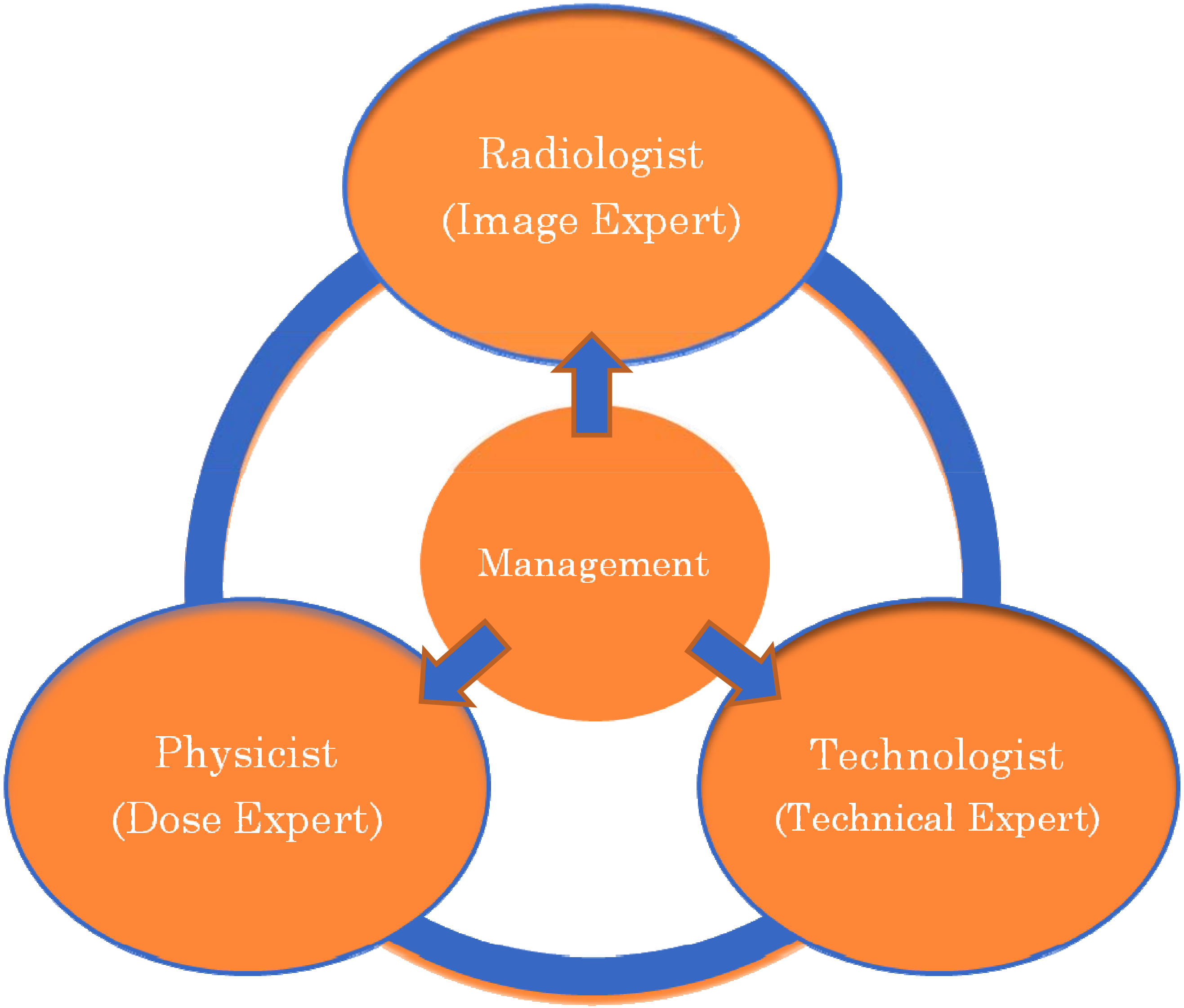
Education

Assess The Doses We Use

COLLABORATION

- Outline of how we work together
- Establish modality workgroups to work on radiation dose optimization
  - Consists of Radiologists, Technologists, Physicist, and Management
  - Representatives across MHS
  - Managing multiple radiologist groups
  - CT workgroup, NM workgroup, etc
- Process & Roles
  - Radiologist, Physicist, Management, Technologist

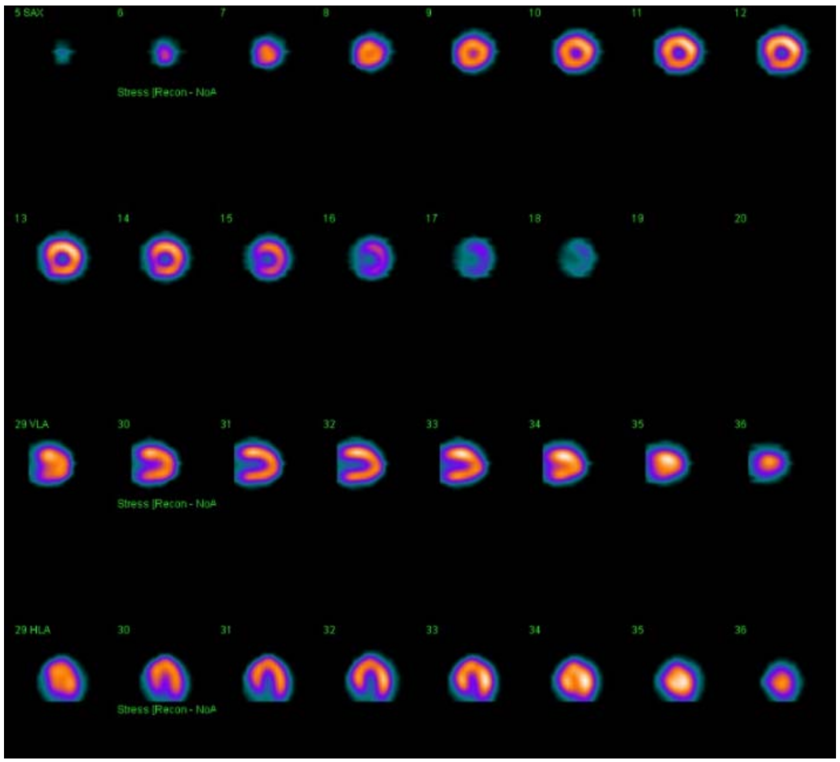
PROCESS & ROLES



STANDARDIZATION AND OPTIMIZATION OF IMAGING PROTOCOLS

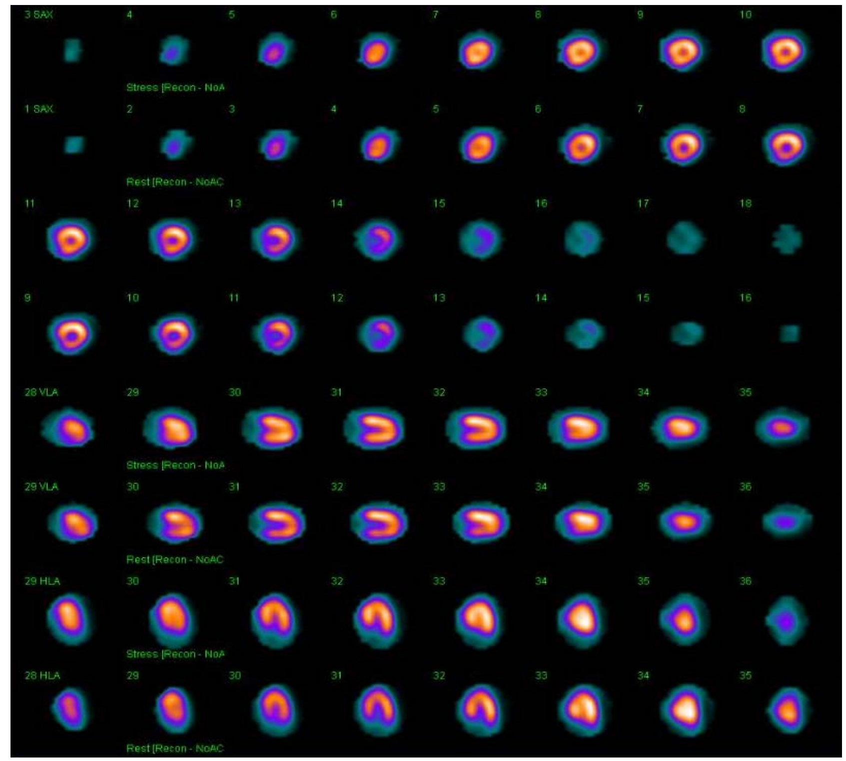
- Create Standard Protocols
  - Applied system-wide
  - Reduction in unnecessary variation
- Optimization
  - Protocols reviewed annually
  - Commitment to annual physics testing (ACR)
  - Fluoroscopy review of practices

DOSE OPTIMIZATION REALIZED – CASE STUDY 1



4 mCi 99mTc Sestamibi

Effective Dose – 1.17 mSv



40 mCi 99mTc Sestamibi

Effective Dose – 11.7 mSv

DOSE OPTIMIZATION REALIZED – CASE STUDY 2

- Siemens Definition Flash
  - CARE-kV, CareDose 4D, X-CARE, SAFIRE

	Pre-SAFIRE	Post-SAFIRE	% reduction	ACR Reference Dose
CT Head 16 cm Phantom	48.3 mGy	33.6 mGy	30.4%	75 mGy
CT Abdomen 32 cm Phantom	14.5 mGy	10.5 mGy	27.6%	25 mGy

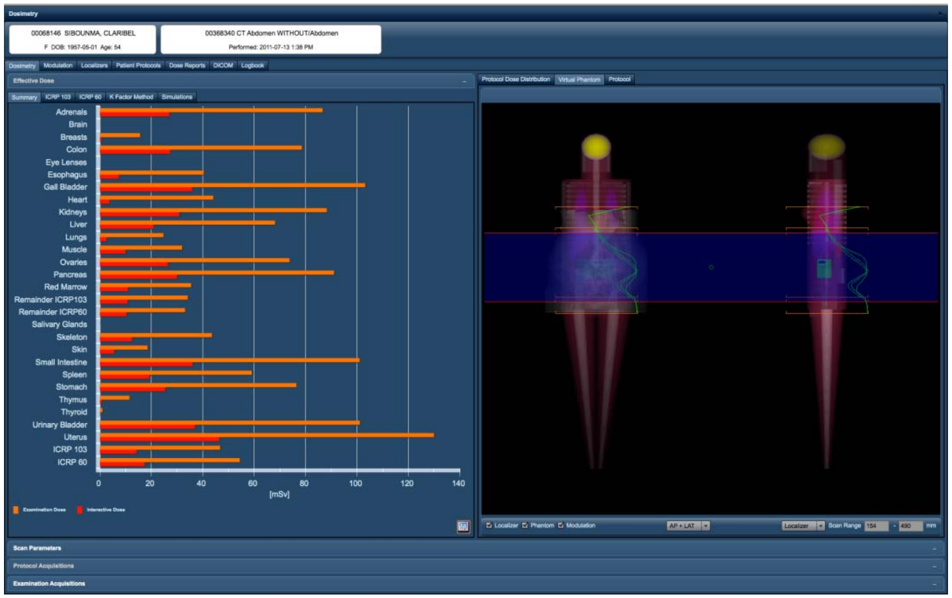
	Pre-SAFIRE (N=50)	Post-SAF IRE (N=50)	% reduction
CT Head	43.5 mGy	32.1 mGy	26.2%

EDUCATION

- Provide education to physicians, technologists, and patients
  - Radiation dose information for patients
    - Website
    - Brochures
    - Qualitative Risk Estimates
  - Technologists
    - Annual competencies
    - Advanced modality certifications
  - Physicians
    - Knowledge of current doses used
    - Fluoroscopy Training

ASSESSING OUR DOSES

- eXposure - Radimetrics
  - Coming soon!
  - Ability to assess our doses
  - Make inter-comparisons
  - Recognize outliers
  - Dose Modeling
  - Protocol Management



OBSTACLES

- Equipment
  - We've got volume AND variety
- Large number of sites
- Radiology groups
- Time requirements

ADVANTAGES

- MHS Safety Culture
- Organizational Support
- Devoted Resources
- Technology
  - CT
  - NM
- Our staff

KEY LEARNINGS

- Rapidly changing landscape
- Increased public awareness
  - Dramatic increase in the number of diagnostic radiological exams performed
- Radiation can produce harmful biological effects
  - Careful assessment of how risk is communicated
- Most importantly, we can be better stewards of diagnostic radiation!
  - Seek to optimize radiation dose
  - Implementation of dose optimization strategies
  - MultiCare's approach is one of many

QUESTIONS

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