CT Protocol Optimization: People and Tools

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Introduction

- CT Protocol Optimization should be viewed broadly
  - More than a process
  - More than episodic
  - Involves all aspects of CT imaging
- Dose is not the only consideration
  - Not even be the main consideration
- People are central to the process
  - Patients
  - Staff
  - Radiologists

Why Worry About Optimization?

- Dose is not the reason!
  - "Risks of medical imaging at effective doses below 50 mSv for single procedures or 100 mSv for multiple procedures over short time periods are too low to be detectable and may be nonexistent." (American Association of Physicists in Medicine)
  - Most CT scans are about 15-20 mSv
  - We don't want to be careless, but don't go nuts
- Image quality is of primary importance
  - If not adequate, then the dose is wasted
  - Risk of missing lesion is much greater than radiation risk
- Optimized protocols can save money
  - Patient throughput
  - Resource utilization

Joint Commission Compliance

- The hospital verifies and documents that technologists who perform diagnostic computed tomography (CT) examinations participate in ongoing education that includes annual training on the following:
  - Radiation dose optimization techniques and tools for pediatric and adult patients addressed in the Image Gently® and Image Wisely® campaigns
  - Safe procedures for operation of the types of CT equipment they will use
- Radiation dose optimization = protocol optimization

Joint Commission Compliance

- The hospital establishes or adopts diagnostic computed tomography (CT) imaging protocols based on current standards of practice, which address key criteria including clinical indication, contrast administration, age (to indicate whether the patient is pediatric or an adult), patient size and body habitus, and the expected radiation dose index range.

Joint Commission Compliance

- Diagnostic computed tomography (CT) imaging protocols are reviewed and kept current with input from an interpreting radiologist, medical physicist, and lead imaging technologist to make certain that they adhere to current standards of practice and account for changes in CT imaging equipment. These reviews are conducted at time frames identified by the hospital.

Joint Commission Compliance

- The hospital uses statistical tools and techniques to analyze and display data.
- The hospital analyzes and compares internal data over time to identify levels of performance, patterns, trends, and variations.
- The hospital compares data with external sources, when available.
- The hospital reviews and analyzes incidents where the radiation dose index (computed tomography dose index [CTDIvol], dose length product [DLP], or size-specific dose estimate [SSDE]) from diagnostic CT examinations exceeded expected dose index ranges identified in imaging protocols. These incidents are then compared to external benchmarks.

Optimization is Good Patient Care

- The American College of Radiology Diagnostic Imaging Center of Excellence
- Image quality
- Contrast utilization
- Patient flow
- Image access
- Radiation dose

ACR Diagnostic Imaging Center of Excellence

- Next level of accreditation
- Comprehensive assessment of the entire medical imaging enterprise including structure and outcomes
- Requires participation in
  - ACR accreditation programs for all modalities offered
  - GRID (General Radiology Information Database)
  - Dose Index Registry
- Site survey by ACR

ACR Diagnostic Imaging Center of Excellence

- Areas of assessment include
  - Governance
  - Personnel
  - Facility organization and management
  - Physical environment
  - Equipment including viewing conditions and IT infrastructure
  - Radiation and general safety
  - Quality management and outcomes measurement system
  - Policies and procedures
  - Patient rights
  - Medical records
  - Infection control
  - Communication
  - Utilization review
  - Outcomes

ACR Diagnostic Imaging Center of Excellence

- Personnel involved
  - Radiology medical director
  - Medical physicist
  - Lead technologist
  - Chief administrator
  - Head of quality assurance
- Preparation
  - Ensure that all policies are in place
  - Ensure that procedures match policies
  - Focus is on quality of patient care

ACR Diagnostic Imaging Center of Excellence

- Standards
  - The facility must have policies and procedures in place to address all areas of safety for patients and personnel including limiting unnecessary exposure to radiation and insuring safety of the MRI environment.
    - All diagnostic imaging patients must be screened regarding previous or recent exams.
    - Standardized protocols must be in place for all exams. The medical physicist should participate in the development of the protocols in consultation with the radiologist.
    - The facilities must have protocols in place to optimize dose. Dose optimization entails controlling the amount of radiation received by the patient while ensuring the diagnostic integrity of the exam.
    - There must be adequate shielding for patients, personnel and facilities
  - The entity has a quality management system that is a framework for continuous quality improvement.
    - The QM system ensures corrective and preventive actions are implemented, measured, monitored and documented
    - The QM system has a methodology for how quality and performance are measured, monitored, analyzed and improved

ACR Diagnostic Imaging Center of Excellence

- Standards
  - The entity clearly outlines its methodology, practices and policies for addressing how quality management is conducted
    - The entity maintains a Quality Manual that should include:
      - Statement of Quality Policy
      - Measurable Quality Objectives
      - Goal Measurement/Prioritization of activities
  - As part of the Quality Management System, the entity should evaluate all services and processes.
    - Evaluation should include monitoring through internal audits or reviews at scheduled intervals
    - The entity conducts performance improvement projects annually in proportion to scope/complexity of operations/services
    - Projects are documented and include rationale for selection and progress achieved
    - Technologists must participate in performance improvement projects relevant to their roles

ACR Diagnostic Imaging Center of Excellence

- Standards
  - The entity participates in Image Gently, Step Lightly and Image Wisely as appropriate to modalities available (CT, fluoroscopy and interventional procedures)
  - The entity must define the frequency and detail of measurement but at minimum the following functions should be measured
    - Threats to patient safety
    - Medication use
    - Procedures- wrong site, wrong patient, wrong procedure
    - Sedation
    - Effectiveness of pain management system for interventional procedures including all biopsies
    - Infection control system
    - Patient flow issues, excess wait time
    - Customer satisfaction (clinical and administrative areas, both for patients and referring providers
    - Discrepant radiology reports
    - Deaths, non-sentinel event, sentinel event, near-miss
    - Other adverse events
    - Medical record delinquency

ACR Diagnostic Imaging Center of Excellence

- Standards
  - The entity should have in place a system to ensure appropriate utilization of services offered
    - The entity provides patient education materials related to imaging appropriateness, such as Image Gently materials
    - The entity will verify whether the patient had prior imaging studies of the same anatomic area and consult with the referring provider regarding the most appropriate course of action
    - The entity should provide consultative services to ordering/referring providers to assist in determination of the most appropriate exam(s) as necessary or appropriate
    - There should be a process to ensure exam indications, advantages-benefits and limitation-risks are readily available to the referring provider
    - The entity should have a written policy and procedure for verifying that orders contain enough standardized information
    - The entity has policies for use of specific protocols aimed at reducing unwarranted, inappropriate procedures

ACR Diagnostic Imaging Center of Excellence

- Site survey
  - Personnel
    - ACR staff/Radiologic Technologist
    - Radiologist
    - Medical Physicist
  - Optional presentation by facility
  - Site tour
  - Review of documentation
  - Final report out
- Bragging rights

Features of Protocol Optimization

- **Standardized** protocols must be in place for all exams.
- The **medical physicist** should participate in the development of the protocols in consultation with the **radiologist**
- The facilities must have protocols in place to **optimize dose**
- Dose optimization entails controlling the **amount** of radiation received by the patient while ensuring the diagnostic **integrity** of the exam
- The entity has policies for use of specific protocols aimed at reducing **unwarranted, inappropriate procedures**

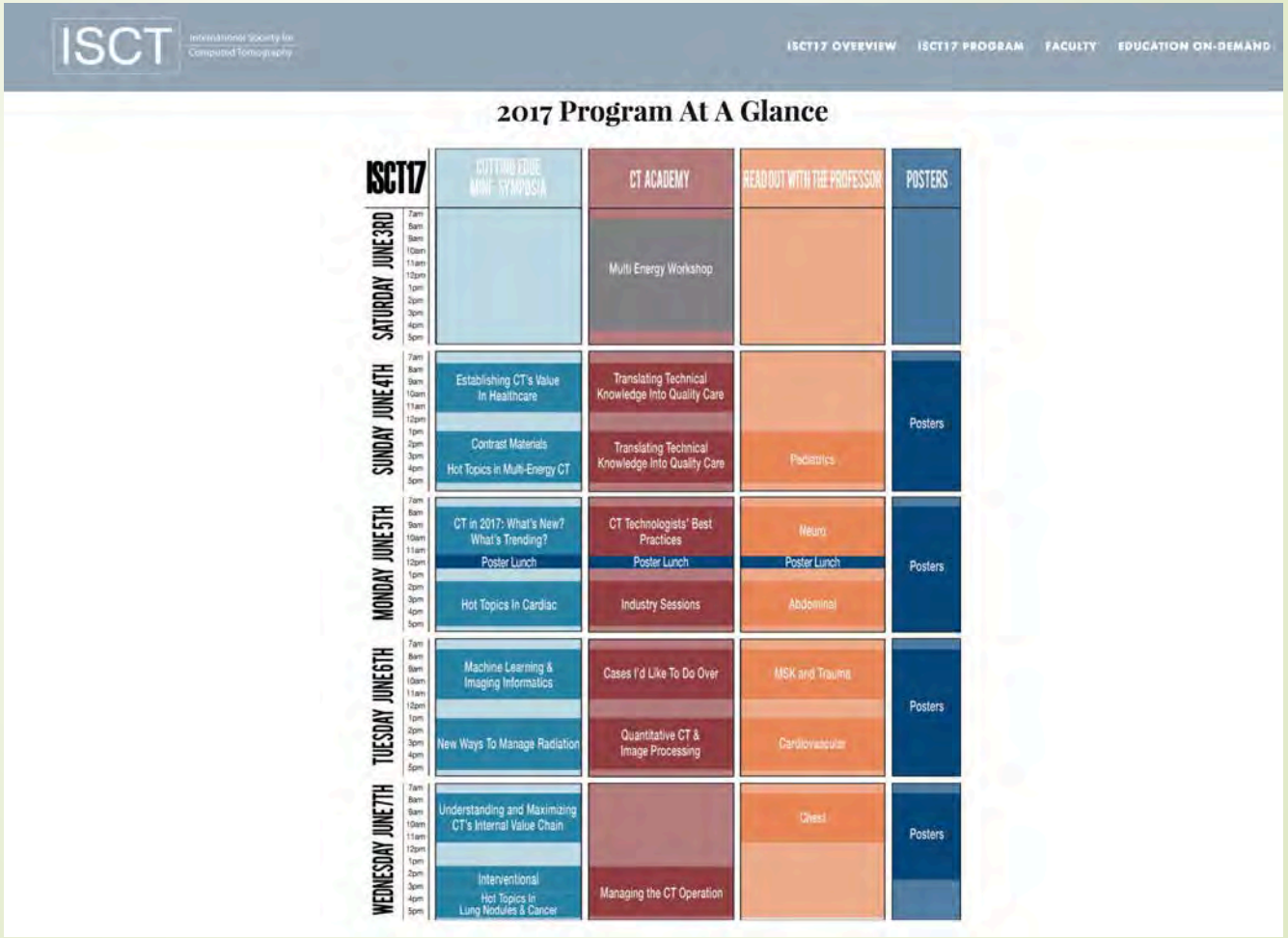
Personnel Involved

- Radiologist
  - Understands image quality needs
  - Knows current recommendations
- Supervising technologist
  - Understands clinical situation
  - Knows patient flow issues
- Line technologist
  - Understands scanner function
- Medical Physicist
  - Should know technical aspects of scanners
  - Understands impact of changes on dose and image quality

Tools

- Peers
  - University of Wisconsin, CTisUs
  - International Symposium on Multidetector Row CT
  - Conferences
  - Journal articles
- Experience
- Dose Monitoring Software
  - I will be using Radimetrics for examples, as that is the software with which I have experience. No recommendation or endorsement is implied or stated.

International Symposium on Multidetector Row CT

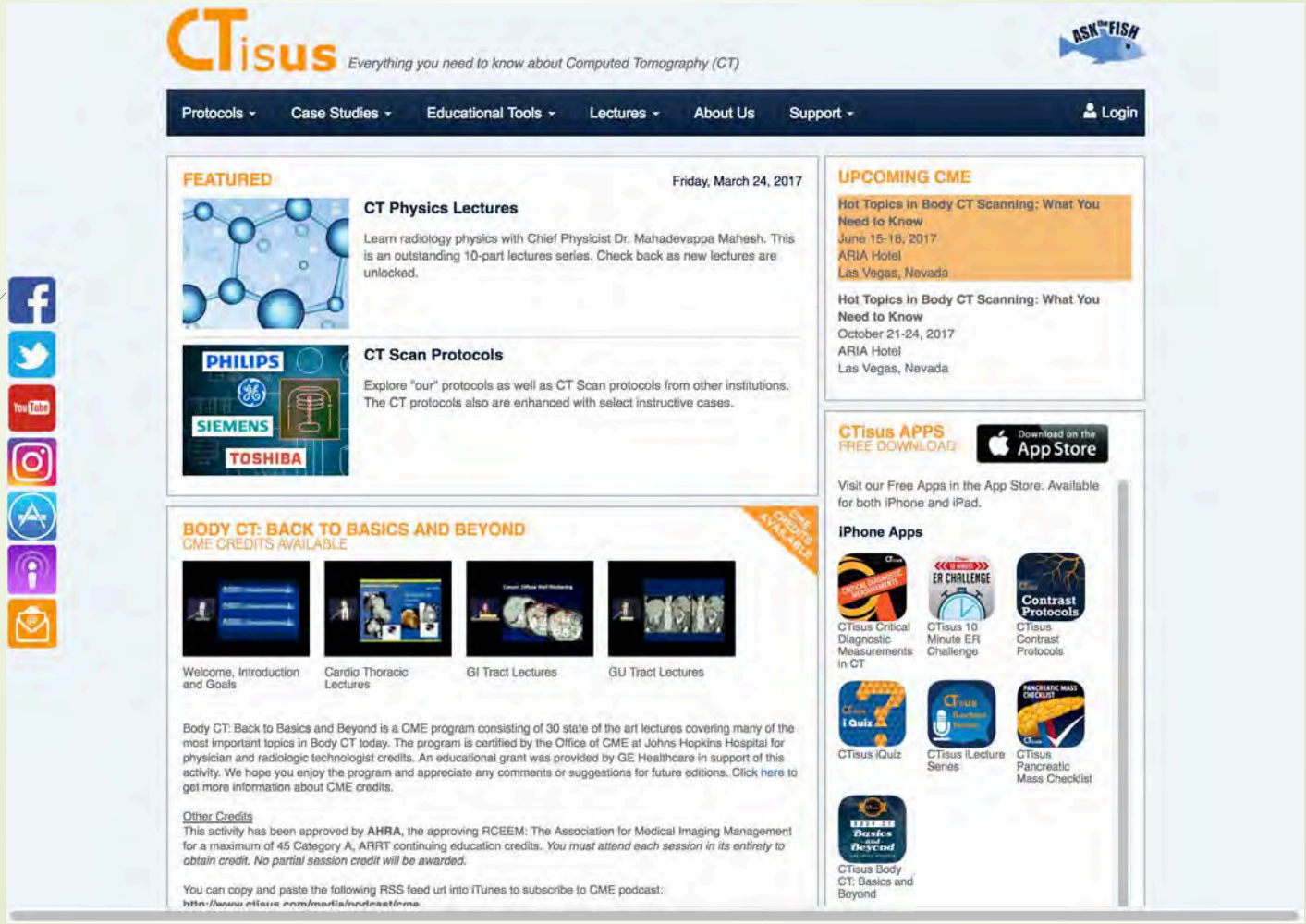


http://www.isct.org/trifecta-symposium#trifecta-symposium-on-ct

University of Wisconsin

https://www.radiology.wisc.edu/protocols/CT/resources.php

CTisUS

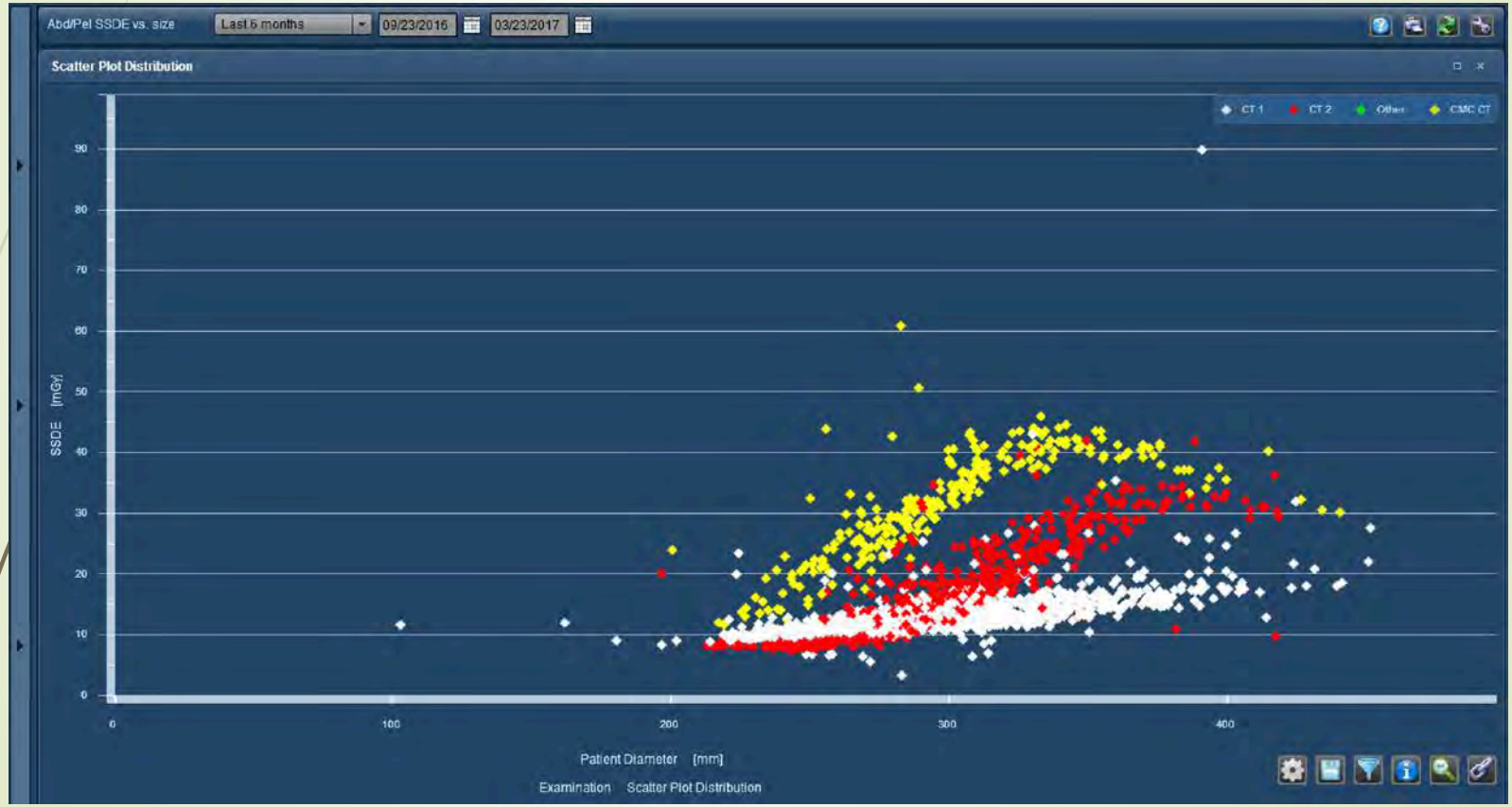


http://www.ctisus.com

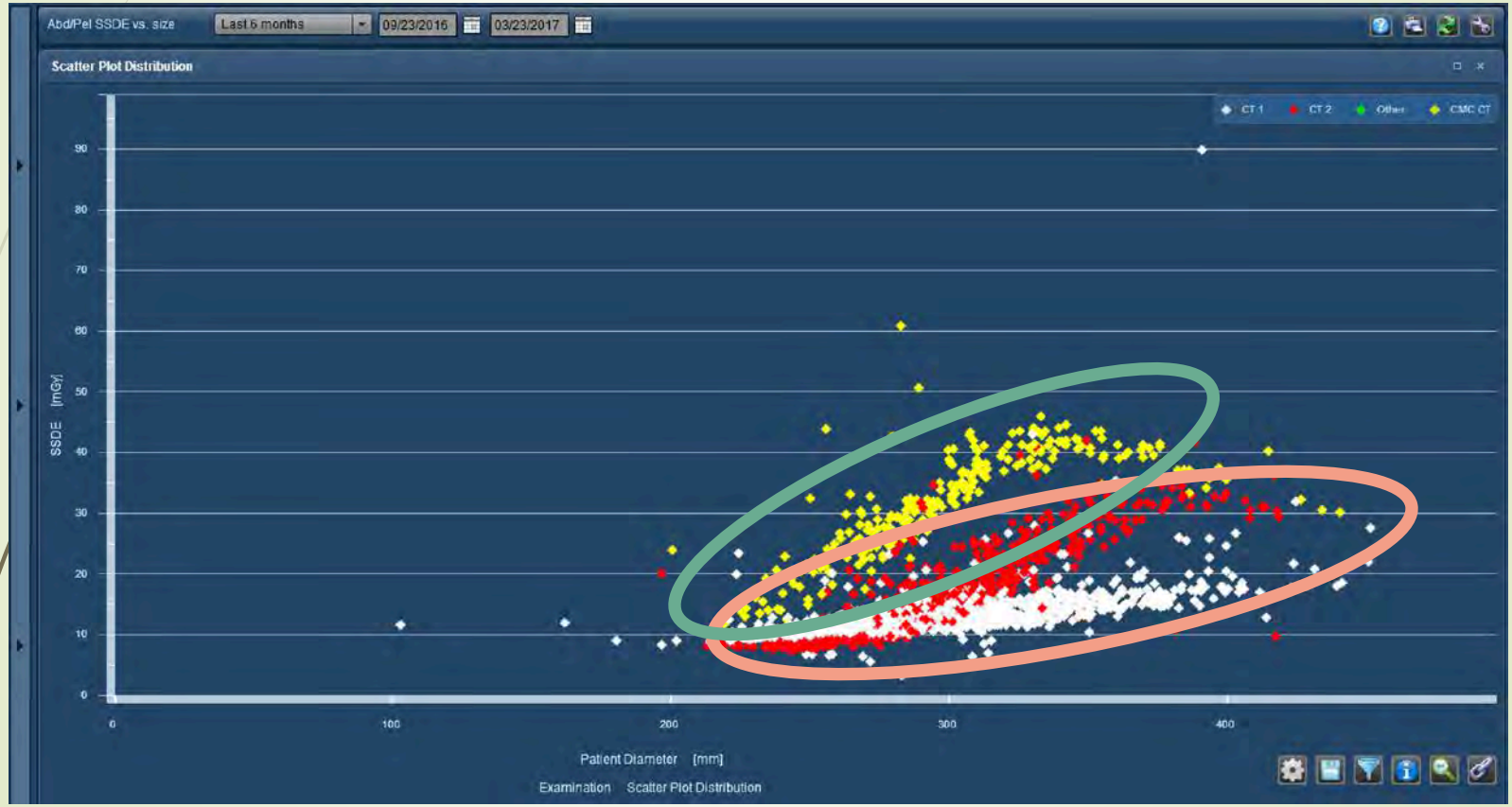
Protocol Standardization

- Technical aspects
  - All scanners should provide similar image quality
  - Not all scanners have same capabilities
  - Different manufacturers have different approaches
  - Must modify protocols as needed to yield standardized image quality
    - Specific parameters will likely be different
    - Dose will likely be different
- Pre- and post-scan
  - How much contrast and when?
  - How much water and when?
  - Patient transport
  - Access to stat images – PACS issues
    - Scan order and linking vs. delivery to radiologists
- Uniformity between facilities
  - Recently acquired?
  - Same approach and philosophy?

Protocol Standardization



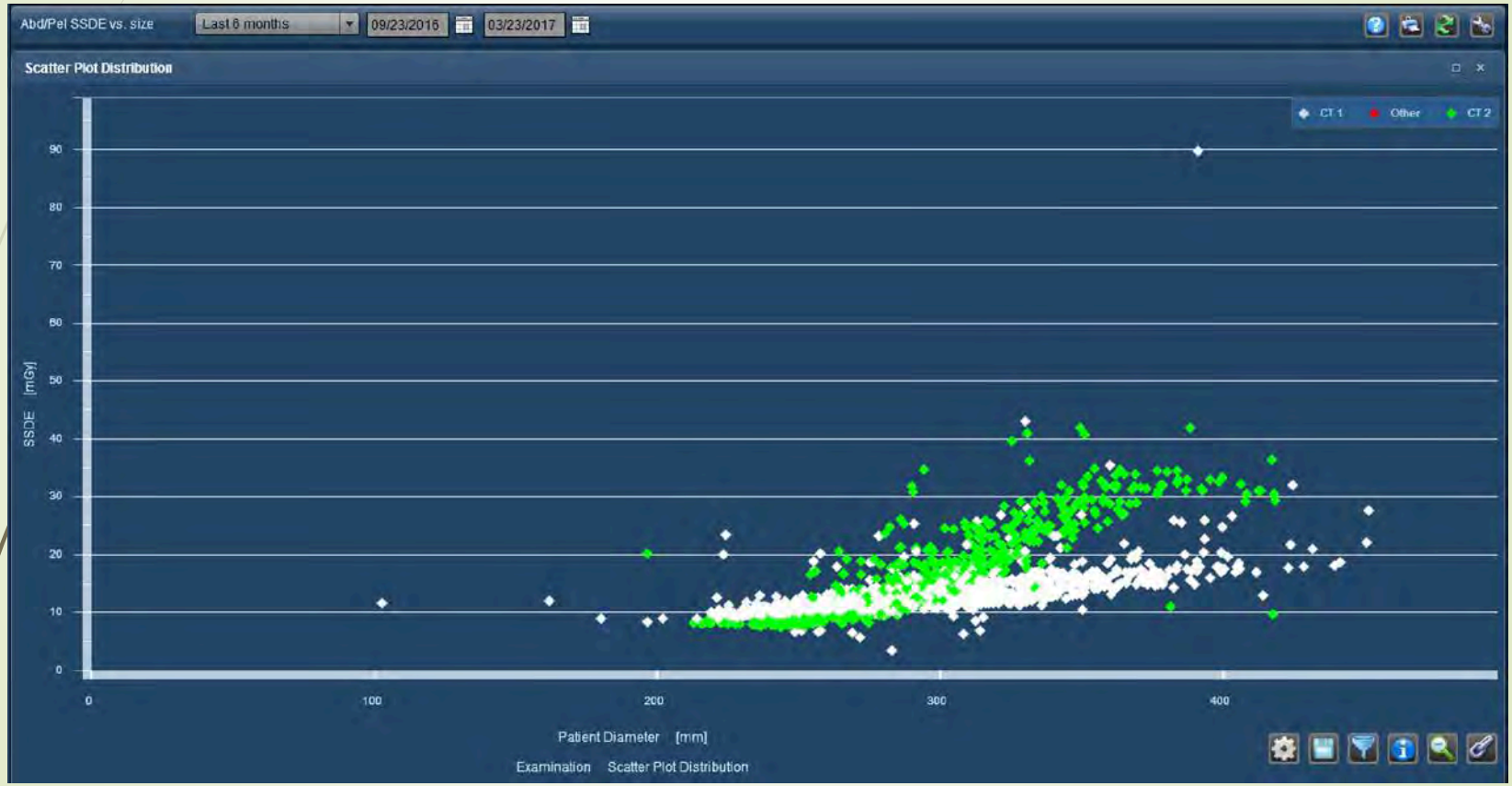
Case Study 1


Abd/Pel SSDE vs. size
Last 6 months
09/23/2016
03/23/2017
Scatter Plot Distribution
CT 1
CT 2
Other
CMC CT
SSDE [mGy]
90
80
70
60
50
40
30
20
10
0
0
100
200
300
400
Patient Diameter [mm]
Examination Scatter Plot Distribution

Case Study 1

- Clear that dose from CMC scanner is higher than other two
- Cause analysis
  - Is CMC scanner functioning properly?
  - Different technologists?
  - Different protocols?
- CMC scanner does not have iterative reconstruction
  - Iterative reconstruction allows for typically 10-60% dose reduction
  - Administrative decision: should CMC scanner be replaced?
    - Meets ACR dose limits for accreditation
    - Was “state of the art” at it’s time
    - 12 years old
    - What studies should be diverted, if any?
- Solution
  - Scanner was due to be replaced in 6 months anyway

Case Study 2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CT 1
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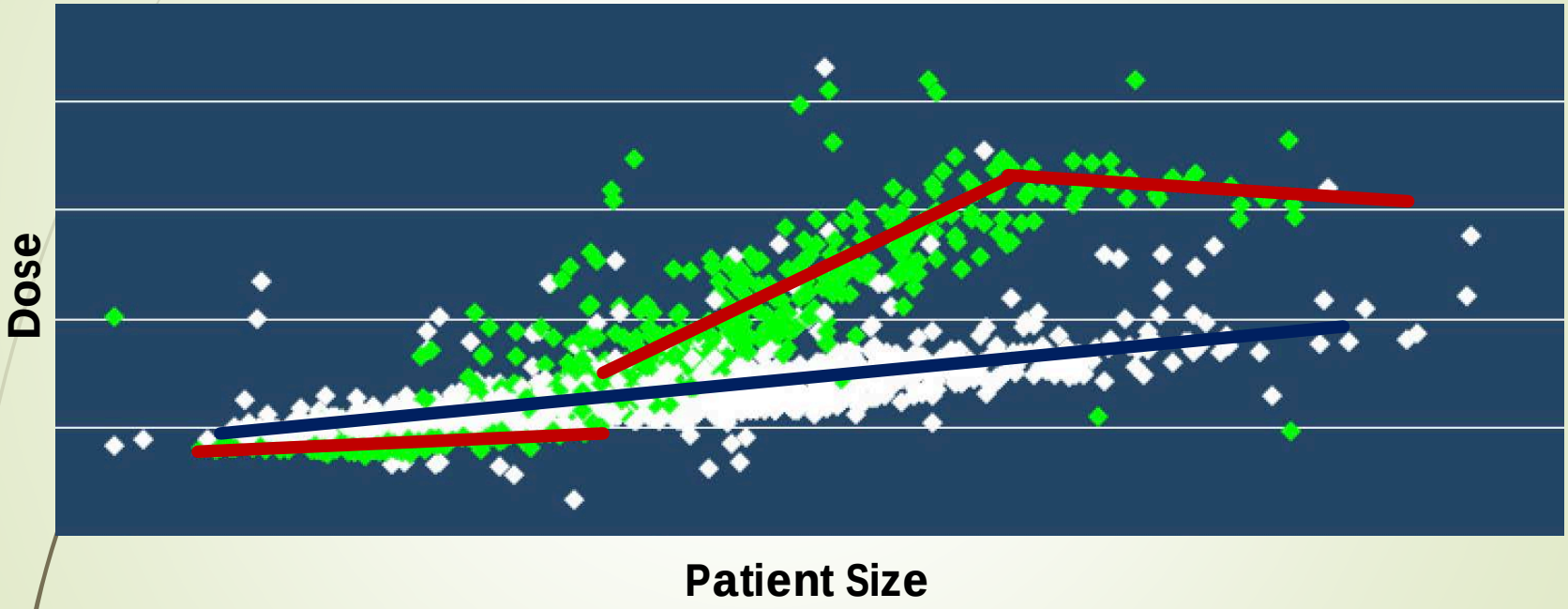
80
70
60
50
40
30
20
10
0
0
100
200
300
400
Patient Diameter [mm]
Examination Scatter Plot Distribution

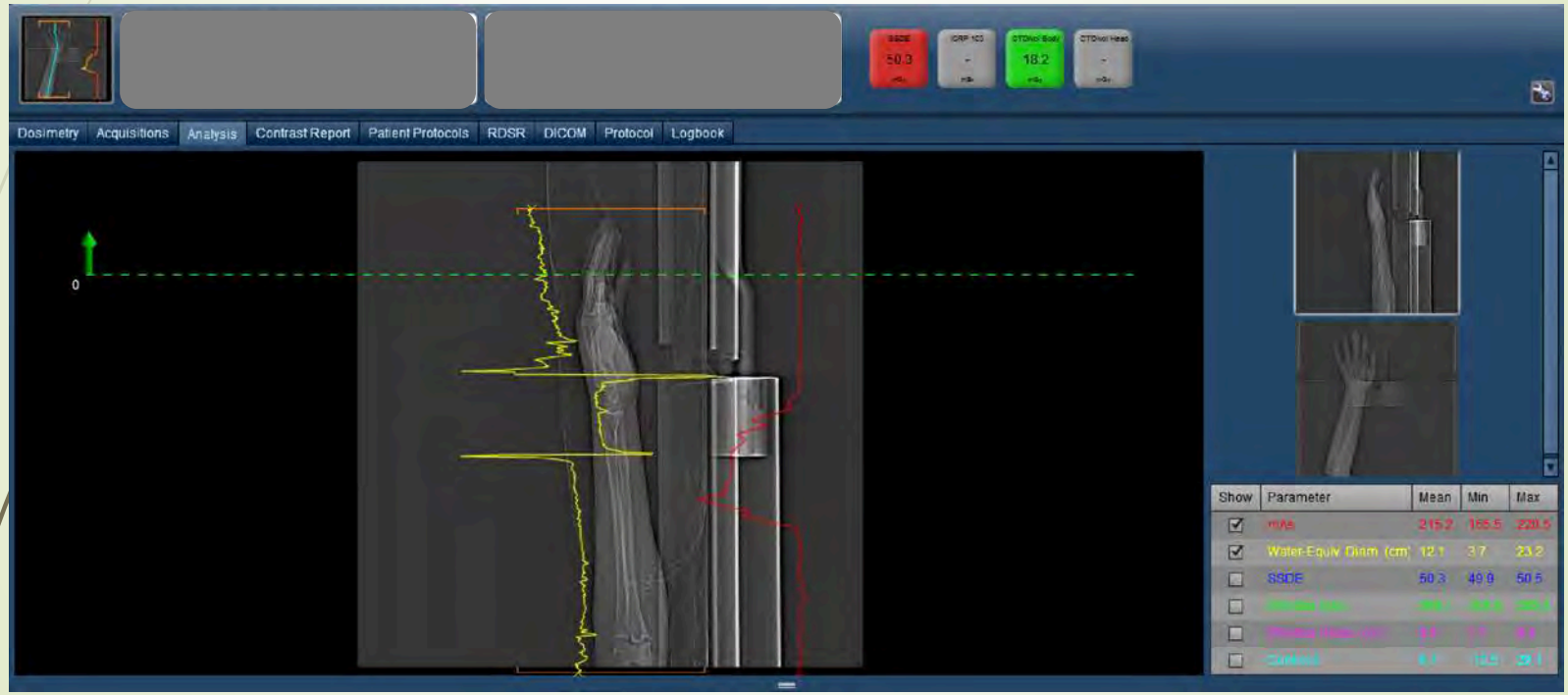
Case Study 2



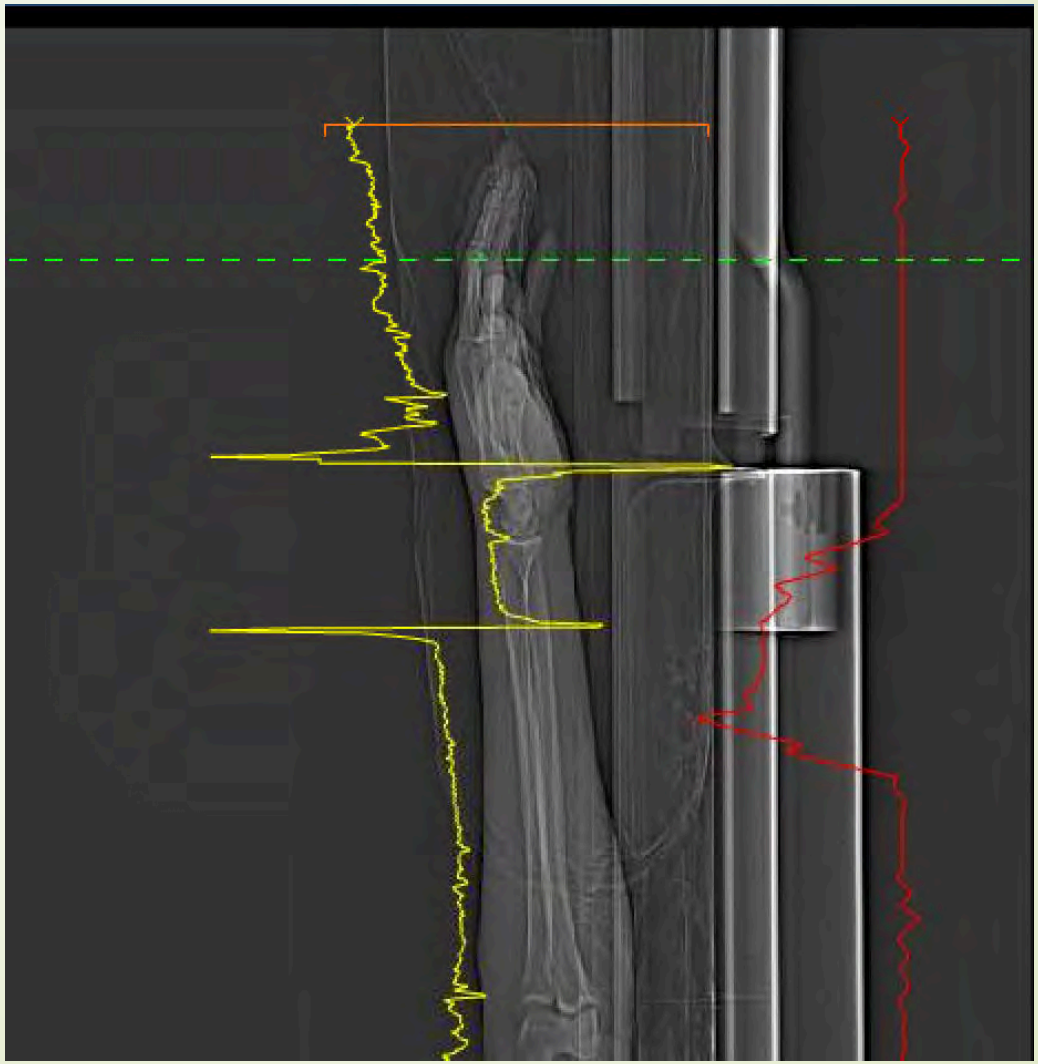
Case Study 2

- CT 1 dose varies dose with patient size smoothly
- CT 2 dose change with patient size is not smooth
- Is scanner functioning properly?
- Are protocols correct?
  - Not really
    - GE approach to mA modulation tends to underdose small patients and overdose large patients
    - Must create separate protocols for patient size ranges
    - GASP! Increase pediatric dose!
      - Image quality rules
- Solution
  - Reviewed data and determined new noise index values based on patient size

Case Study 3


50.3
18.2
Dosimetry
Acquisitions
Analysis
Contrast Report
Patient Protocols
RDSR
DICOM
Protocol
Logbook
0
Show
Parameter
Mean
Min
Max
mAs
215.2
165.5
220.5
Water-Equiv Diam (cm)
12.1
3.7
23.2
SSDE
50.3
49.9
50.5

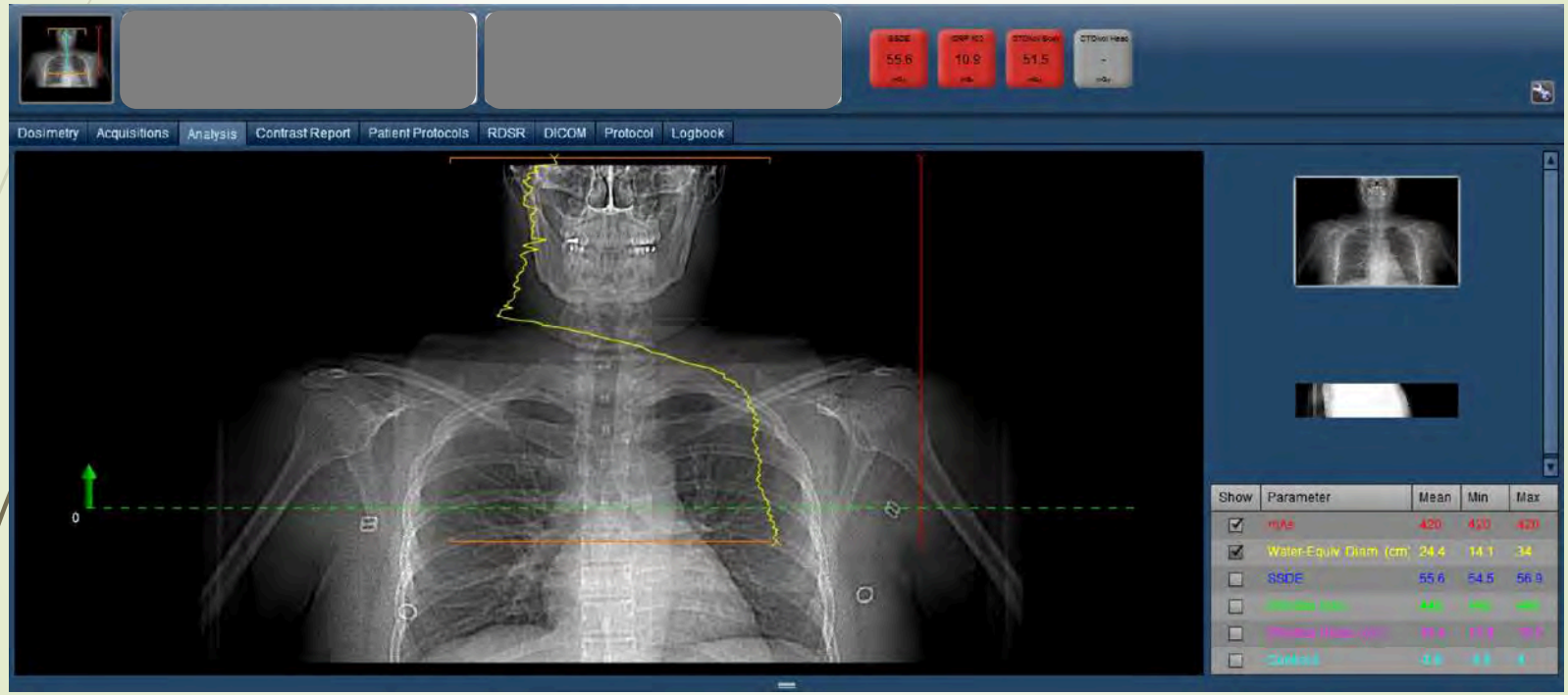
Case Study 3



Case Study 3

- Table has discontinuity where foot extender attaches to main cradle
- Upper extremities scanned in “superman” position
- Wrist (area of interest?) at position of discontinuity
- mA, and therefore image quality, impacted by positioning
- Solution
  - Technologists instructed to make sure region of interest located in uniform section of table

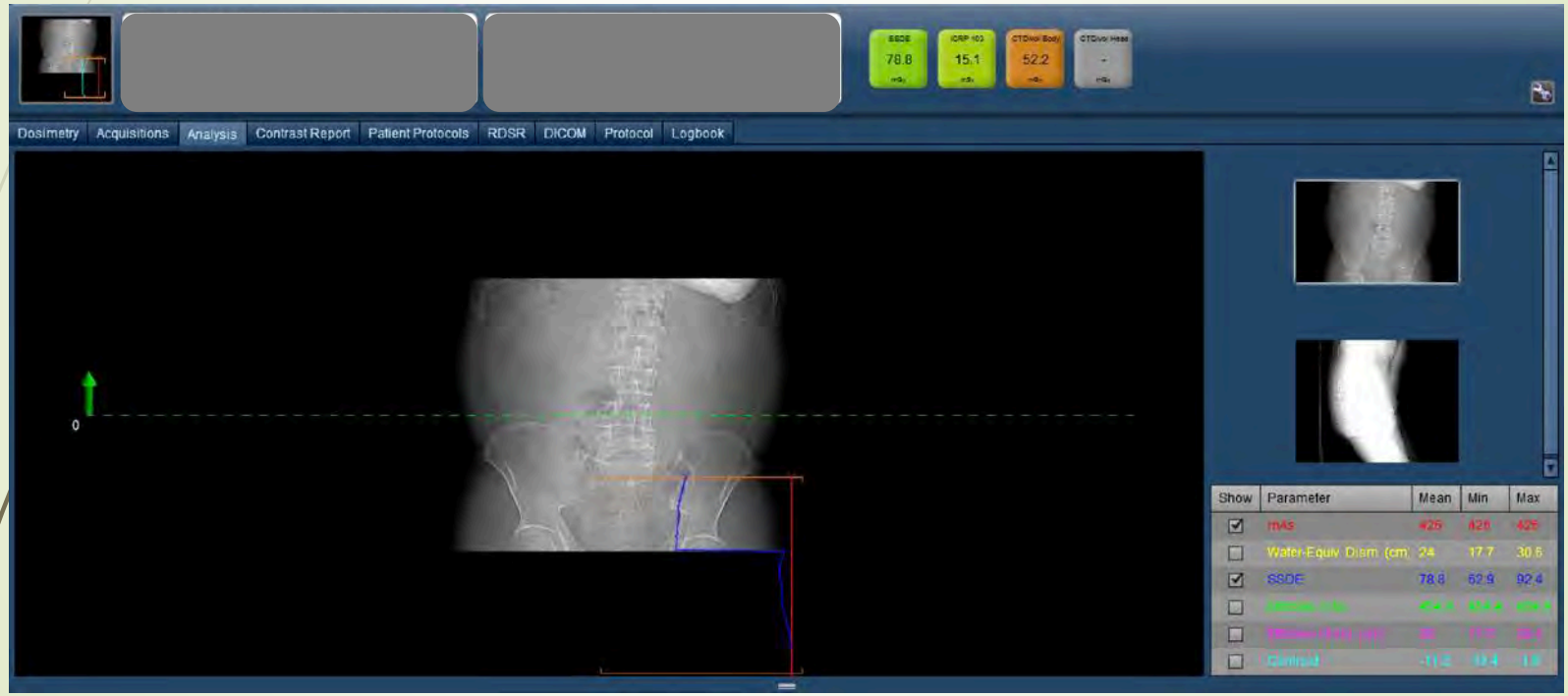
Case Study 4


55.6
10.9
51.5
Dosimetry
Acquisitions
Analysis
Contrast Report
Patient Protocols
RDSR
DICOM
Protocol
Logbook
0
Show
Parameter
Mean
Min
Max
mAs
420
420
420
Water-Equiv Diam (cm)
24.4
14.1
34
SSDE
55.6
54.5
56.9

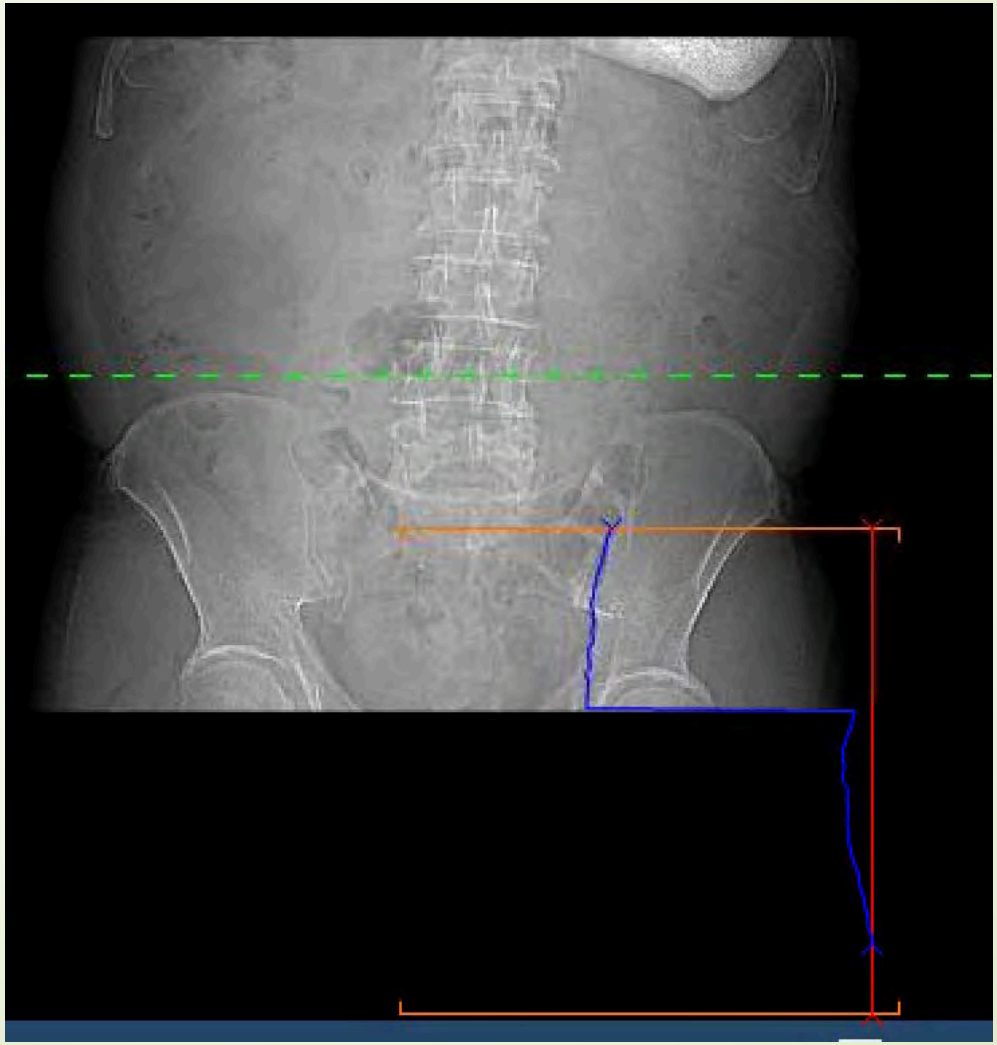
Case Study 4

- C-spine imaging is very difficult due to large attenuation difference between neck and shoulders
- Radiologists often complain about image quality
- Technologist over-rode scanner settings and set a fixed mA value
  - Shoulder region ok
  - Neck, thyroid much higher than necessary
- Solution
  - Instructed technologists not to over-ride settings without documentation
  - Revisited c-spine protocol and modified to better use scanner capabilities to improve image quality

Case Study 5


78.8
15.1
52.2
Dosimetry
Acquisitions
Analysis
Contrast Report
Patient Protocols
RDSR
DICOM
Protocol
Logbook
0
Show
Parameter
Mean
Min
Max
mAs
Water-Equiv Diam (cm)
24
17.7
30.6
SSDE
78.8
62.9
92.4

Case Study 5



Case Study 5

- Technologist cut the scout image too short
- mA modulation system did not have enough information to properly determine mA
- System defaults to protocol maximum mA
- Solution
  - Technologists educated that scout scan must fully encompass the scan volume
  - Scout contributes comparatively miniscule dose to the scan
  - If miss, redo the scout

Conclusion

- Protocol optimization includes all aspects of the protocol
  - Protocol optimization does not mean dose reduction
  - Not even just dose
- Radiologists, Technologists, Medical Physicists play vital roles in optimizing protocols
  - Standard consultative medical physics agreements often do not include such support
- ACR DICOE gives positive impetus to excel
- TJC mandates protocol optimization (at least dose)
- Many resources for guidance
- Dose monitoring software can be a valuable tool