# Pediatric CT Physics: A Radiologist's Perspective

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## Dr. McKinstry's Disclosures

- Siemens Healthcare:
  - Acting & Modeling Fees, Honoraria, Travel, Meals related to the PET/MR.
- Guerbet LLC:
  - Consulting Fee related to gadoterate meglumine IV MR contrast agent
- No disclosures related to the content of this lecture

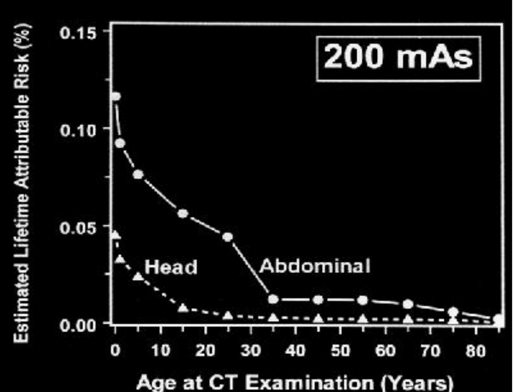
# Pediatric CT Physics:
# A Radiologist's Perspective

- Background
- Objective
- Reducing CT Utilization
- Reducing CT Dose
- Monitor our Results
- Summary

# Children are at Greater Risk than Adults

## Kids are up to 15 more vulnerable than adults

- Children are considerably more sensitive to radiation than adults
- Children also have a longer life expectancy than adults, resulting in a larger window of opportunity for expressing radiation
- Children receive a higher dose than necessary when adult CT settings are used for children




Estimated lifetime attributable cancer mortality risk, as a function of age at examination, for a single CT examination

Brenner Pediatric Radiology
Apr 2002 pg 230

# Radiation Dose Units

Energy deposited is expressed in units of Gray (Gy)

1 mGy = 100 mrads

Biological risk is expressed in unit of Sieverts (Sv)

1 mSv = 100 mrem

Note that for Diagnostic Radiation (X-ray)

1 rem = 1 rad

## Average annual radiation effective dose (mSv)

| | | | | | |
|---|---|---|---|---|---|
| | UNSCEAR | | Princeton | Wa State | MEXT |
| | Average | Range | USA | USA | Japan |
| Natural | 2.40 | 1.0-13.0 | 2.95 | 2.95 | 1.50 |

Take home point: You receive

~3 mSv (300mrad)

from natural background radiation

# CT Dose Descriptors

- $CTDI_{vol}$

Specifies the average dose absorbed in the scanned volume of the phantom (or patient of the same size). It is reported in *mGy* (milligray).

- DLP (Dose Length Product)

This is merely the $CTDI_{vol}$ multiplied by the length of the actual scan, in centimeters. It is reported in *mGy cm*. If the scan length is identical, one can use this to compare doses.

- Effective Dose

This describes the radiation risk for the entire human body, but can only be measured with whole body phantoms or calculated with very sophisticated software. It can be estimated using the DLP and conversion factors. It is reported in *Sv* or *mSv* (millisievert).

# Calculation of Effective Dose Estimates: AAPM #96

**Table 3.** Normalized effective dose per dose-length product (DLP) for adults (standard physique) and pediatric patients of various ages over various body regions. Conversion factor for adult head and neck and pediatric patients assume use of the head CT dose phantom (16 cm). All other conversion factors assume use of the 32-cm diameter CT body phantom[78,79]

| *Region of Body* | *k* ($mSv\ mGy^{-1}\ cm^{-1}$) | | | | |
|---|---|---|---|---|---|
| | *0 year old* | *1 year old* | *5 year old* | *10 year old* | *Adult* |
| Head and neck | 0.013 | 0.0085 | 0.0057 | 0.0042 | 0.0031 |
| Head | 0.011 | 0.0067 | 0.0040 | 0.0032 | 0.0021 |
| Neck | 0.017 | 0.012 | 0.011 | 0.0079 | 0.0059 |
| Chest | 0.039 | 0.026 | 0.018 | 0.013 | 0.014 |
| Abdomen ≈& pelvis | 0.049 | 0.030 | 0.020 | 0.015 | 0.015 |
| Trunk | 0.044 | 0.028 | 0.019 | 0.014 | 0.015 |

$$E\,(\mathrm{mSv}) \approx k \times DLP. \qquad \text{(Eqn. 12)}$$

# Estimating Effective CT Head Dose (mSv) (20 year old)

Total mAs 4718 Total DLP 836 mGycm

| | Scan | kV | mAs / ref. | CTDIvol* mGy | DLP mGycm |
|---|---|---|---|---|---|
| Patient Position H-SP | | | | | |
| Topogram | 1 | 120 | 36 mA | 0.30 S | 8 |
| Head | 2 | 100 | 503 / 513 | 48.15 S | 828 |

Effective Dose (mSv) = k x DLP
= (0.0021 x 836)
= 1.8 mSv

## 7 months of background

## Risk from Pediatric CT

**Estimated Risks of Radiation-Induced Fatal Cancer from Pediatric CT**

David J. Brenner[1]

**RESULTS.** The larger doses and increased lifetime radiation risks in children produce a sharp increase, relative to adults, in estimated risk from CT. Estimated lifetime cancer mortal-

RE: Brenner 2001 … controversial article, … criticism of Brenner's model used for risk estimate from high doses

Whether it's 1/1,000 or 1/5,000 is not the point. The point is there *is a risk.*

risks for children undergoing CT are not negligible may stimulate more active reduction of CT exposure settings in pediatric patients.

AJR February 2001

## Update on Cancer Risk

*BMJ* 2013;346:f2360 doi: 10.1136/bmj.f2360 (Published 22 May 2013) Page 1 of 18

**Cancer risk in 680 000 people exposed to computed tomography scans in childhood or adolescence: data linkage study of 11 million Australians**

Overall cancer incidence was 24% greater for exposed than for unexposed people, (95% confidence interval 1.20 to 1.29); P<0.001)

Observed a dose-response relation, and the incidence rate ratio increased by 0.16 (0.13 to 0.19) for each additional CT scan

BMJ May 2013

## Pediatric CT Physics:
## A Radiologist's Perspective

- Background
- Objective
  - To implement a CT radiation dose program at a major US children's hospital
  - Track our results
- Reducing CT Utilization
- Reducing CT Dose
- Monitor our Results
- Summary

## Pediatric CT Physics:
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## CT Utilization is on the Rise in the US

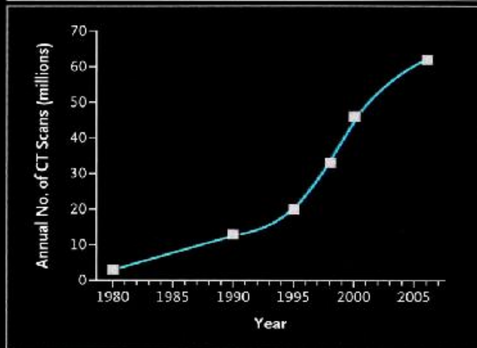



**Figure 2.** Estimated Number of CT Scans Performed Annually in the United States.
The most recent estimate of 62 million CT scans in 2006 is from an IMV CT Market Summary Report.[3]

NEJM Nov 2007 Brenner and Hall

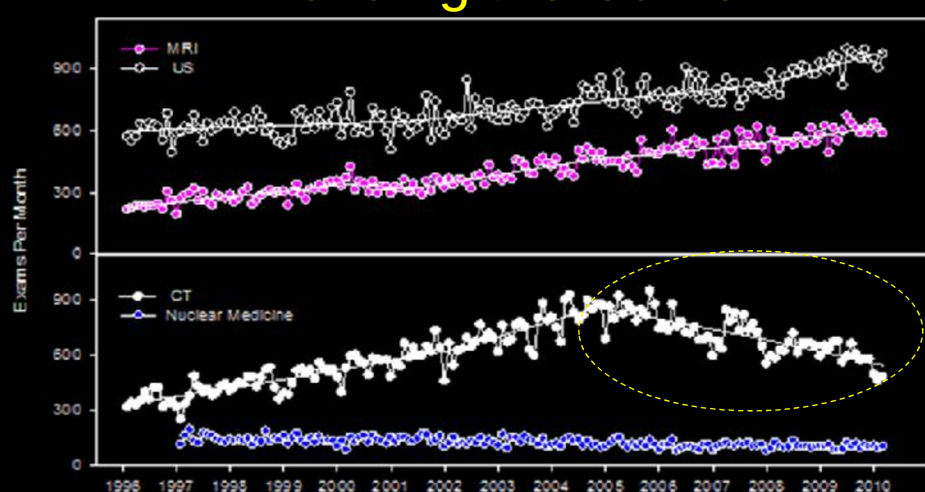
## Reducing CT Utilization at SLCH

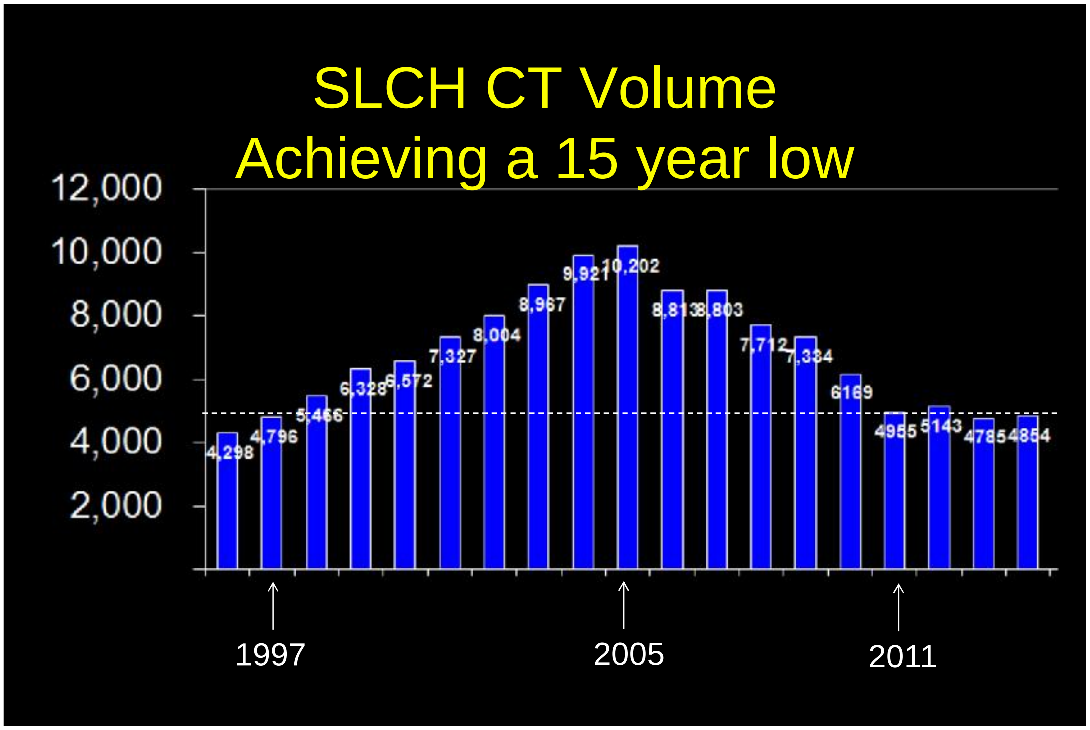
- EDUCATION:
  - Get the word out about the risks and benefits of CT
- ALTERNATIVES:
  - We used "Lean" methodology to streamline access to MRI
  - We expanded the access to ultrasound
  - We offered interpretation of outside hospital CTs
- AUDIT:
  - Track exams, dose and adherence to protocol
  - We compared our practice to published guidelines

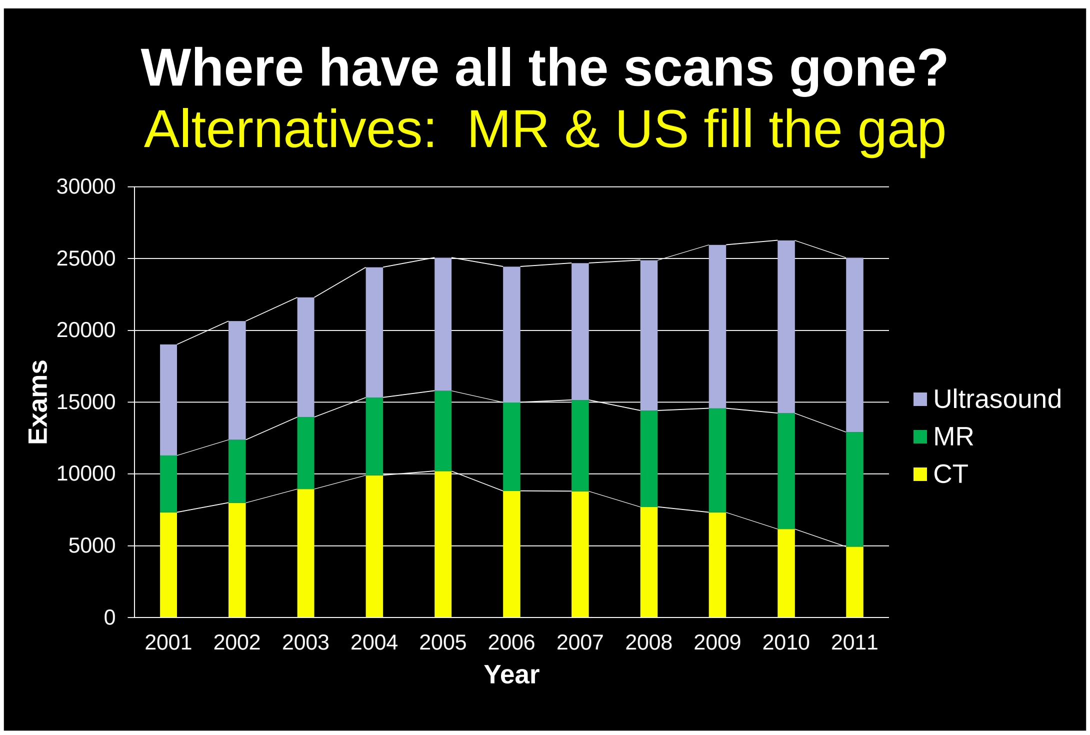
## Education

- Educate residents/fellows on CT Dose
- Offer community CME to elevate awareness among ER physicians and pediatricians
- Present grand rounds at regional hospitals
- Attend pediatric subspecialty divisional meetings to elevate awareness
- Present status updates at General Medical Staff Meetings for the hospital

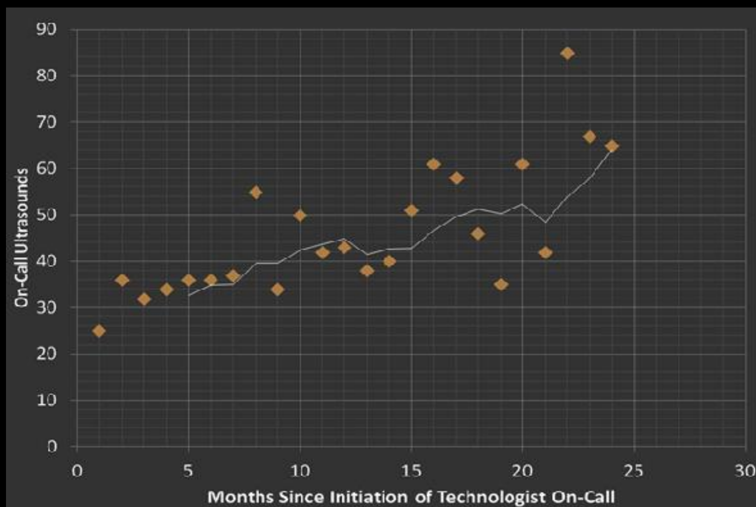
## Reducing CT Utilization at SLCH Bending the Curve



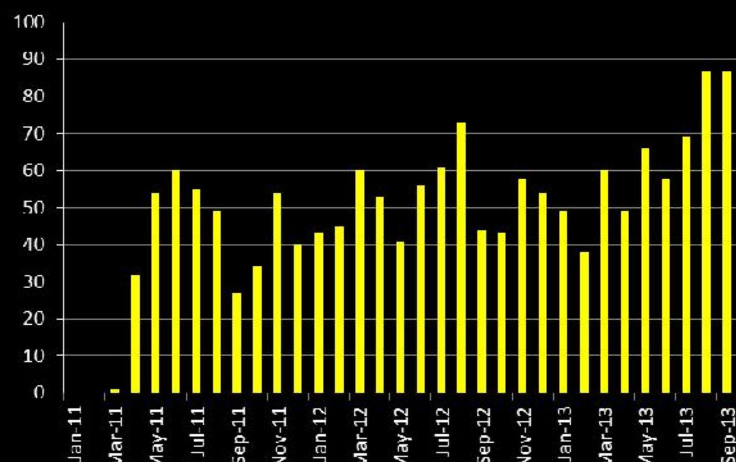

SLCH CT Volume
Achieving a 15 year low
12,000
10,000
8,000
6,000
4,000
2,000
4,298
4,796
5,466
6,328
6,572
7,327
8,004
8,967
9,921
10,202
8,813
8,803
7,712
7,334
6169
4955
5143
4785
4854
1997
2005
2011


Where have all the scans gone?
Alternatives: MR & US fill the gap
30000
25000
20000
15000
10000
5000
0
Exams
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
Year
Ultrasound
MR
CT

# Alternatives: Improve On-Call Ultrasound Availability




# Alternatives: Offer Official Consultation for Outside Hospital CT Exams



# SLCH Outside Hospital Uploads June 2013 – March 2014

| Entity | Total References | Total Consults |
|---|---|---|
| SLCH | 5872 | 1566 |

| References | Totals |
|---|---|
| Body CT | 211 |
| Neuro | 2563 |
| Plain Film | 2366 |
| **Total References** | **5872** |

| Consults | Totals |
|---|---|
| Body CT | 263 |
| Neuro | 497 |
| Plain Film | 761 |
| **Total Consults** | **1566** |

# Audit: Compare our Practice to Published Guidelines

**CT for pediatric, acute, minor head trauma: clinician conformity to published guidelines.**
Linscott LL, Kessler MM, Kitchin DR, Quayle KS, Hildebolt CF, McKinstry RC, Don S.
AJNR Am J Neuroradiol. 2013 Jun-Jul;34(6):1252-6. doi: 10.3174/ajnr.A3366. Epub 2012 Dec 6.

**CONCLUSIONS:**
Clinician conformity to published guidelines for use of head CT in acute, minor head trauma (at SLCH) is better than suggested by a 2001 informal poll of pediatric radiologists.

# SLCH CT Utilization

Total Exams

| SLCH Exams | 91,000 |
|---|---|
| Total Exams | 850,000 |

10.7% of Exams

CT Exams

| Equipment | Number of Examinations | Percent |
|---|---|---|
| Barnes-Jewish Hospital | 44368 | 80.7% |
| Barnes-Jewish West County Hospital | 6557 | 11.9% |
| St. Louis Children's Hospital | 2623 | 4.8% |
| Barnes-Jewish South County | 1109 | 2% |
| Total | 54993 | |

4.8% of CTs

50% Lower CT Utilization in Children

# Pediatric CT Physics: A Radiologist's Perspective

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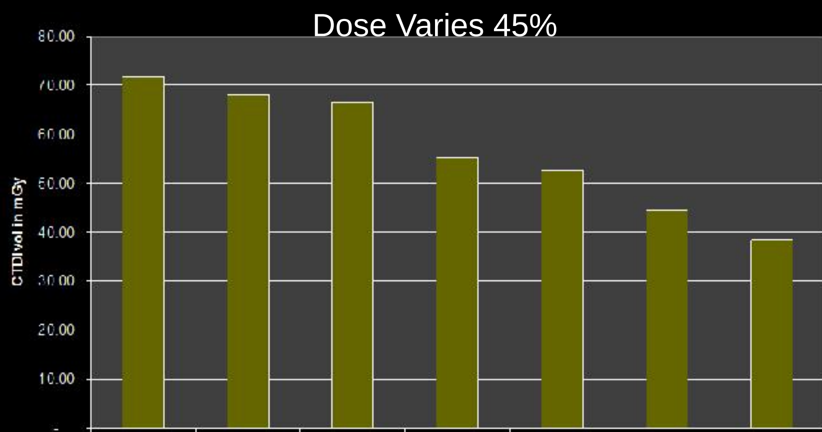
## CT Head $CTDI_{vol}$ Variation for St. Louis Regional Hospitals using Same Scanner




## Worst Case Scenario

8 year old scanned at a regional community hospital

| | Scan | kV | mAs / ref. | CTDIvol | DLP |
|---|---|---|---|---|---|
| Patient Position H-SP | | | | | |
| Topogram | 1 | 120 | | | |
| Head WO | 2 | 120 | 420 | 58.40 | 1165 |

= k x DLP
= 0.0057 x 1165
= 6.6 mSv!!!!

2 years, 2 months of background

SLCH Case Scenario

8 year old scanned with full dose technique

"at what percentage of BG radiation is pediatric CT dose considered reasonably achievable?"

&

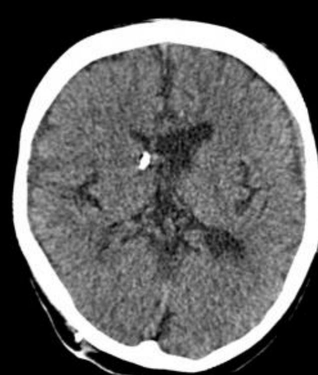
"why not image quality is the indicator for image acceptability?"

6 months of background

How much dose is enough to detect shunt malfunction?

Community Hospital

2 years, 2 month of background



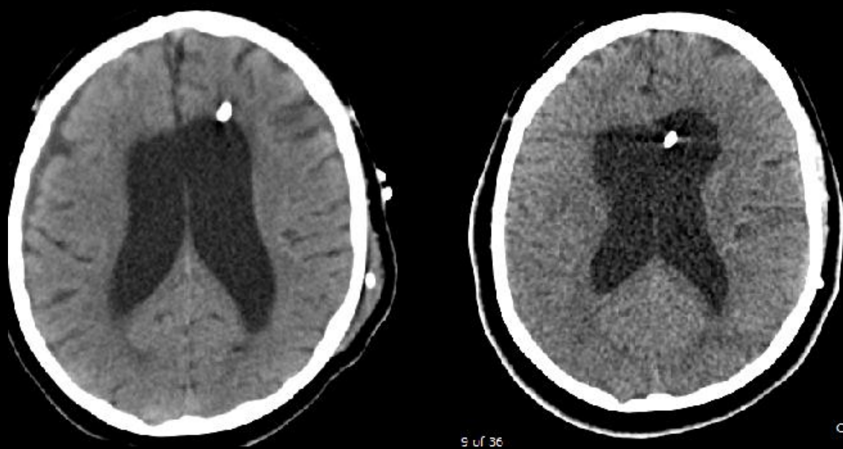
SLCH

6 month of background

Community Dose is 4.7 times higher!

## We Introduced a Low Dose Option

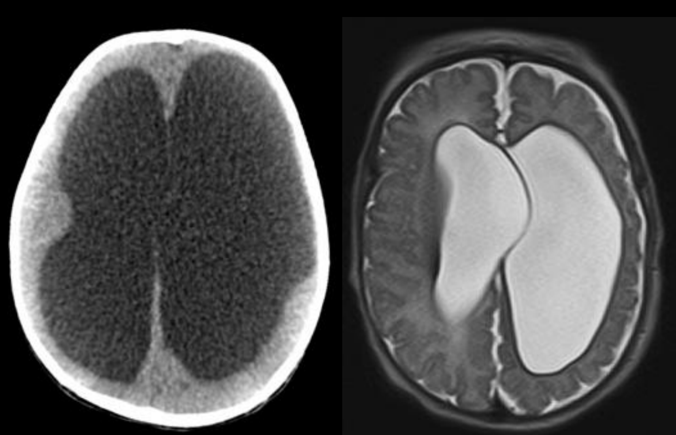
Shunt/Ventriculomegaly Protocol



Full Dose 1/3 Dose

## We Introduced a No Dose Option

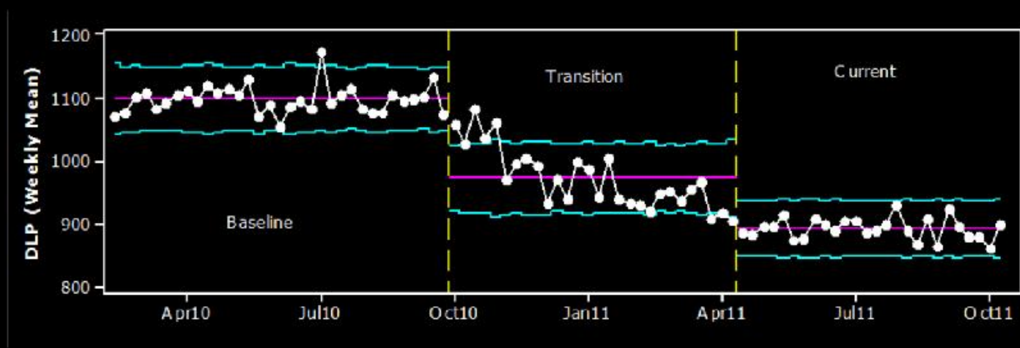
Rapid MRI using Ventriculomegaly Protocol



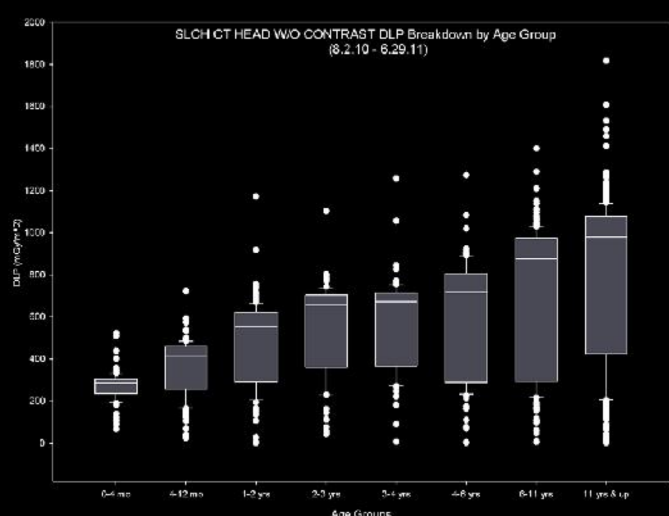
5-10 minutes without sedation

# Process Control: CT Head

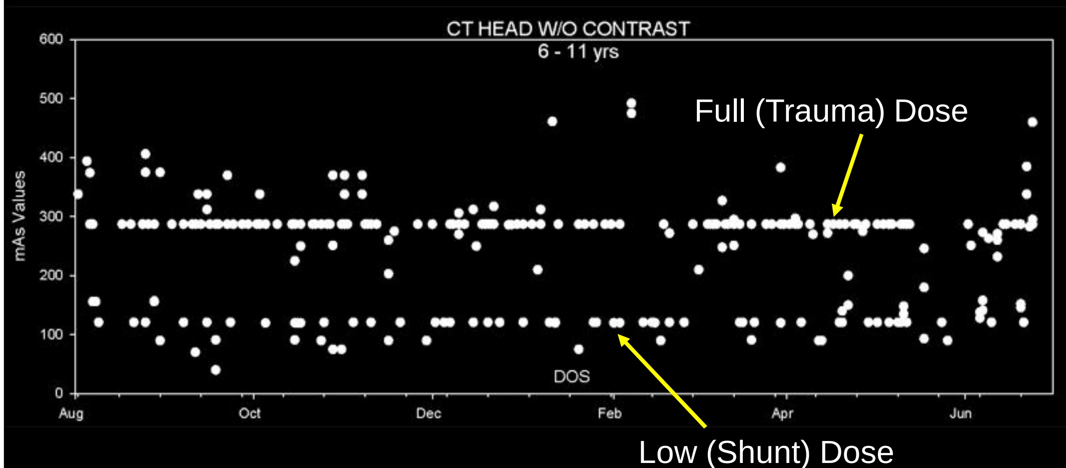
CT Head without IV Contrast



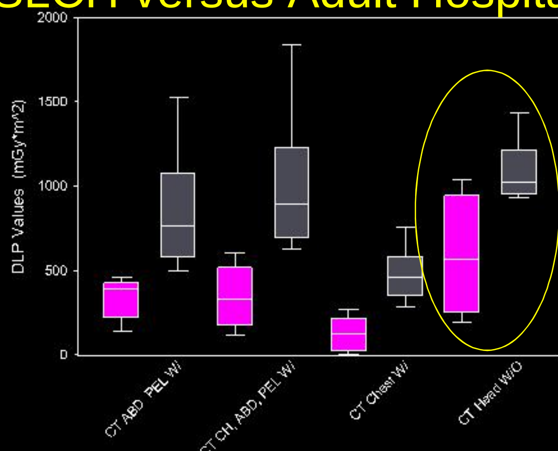

# SLCH Age Adjusted Protocols (for Scanners without AEC)



# Audit Your Practice
## SLCH Ongoing QI




# Audit: Teenagers Scanned
## SLCH versus Adult Hospital

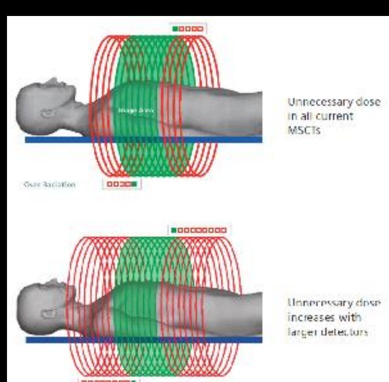



You can deliver consistently lower dose if you follow a program

## Recent Advances

- Upgrade our scanners
- Let the scanner do the work!
- Make the low dose (Shunt) protocol the standard
- Reserve full dose for trauma and kids who can't get MRI (e.g., Cardiac ICU patients on ECMO)
- DICOM SR sent to a central dose monitoring database for improved tracking and reporting

## Strategy #2: Upgrade Old Scanners

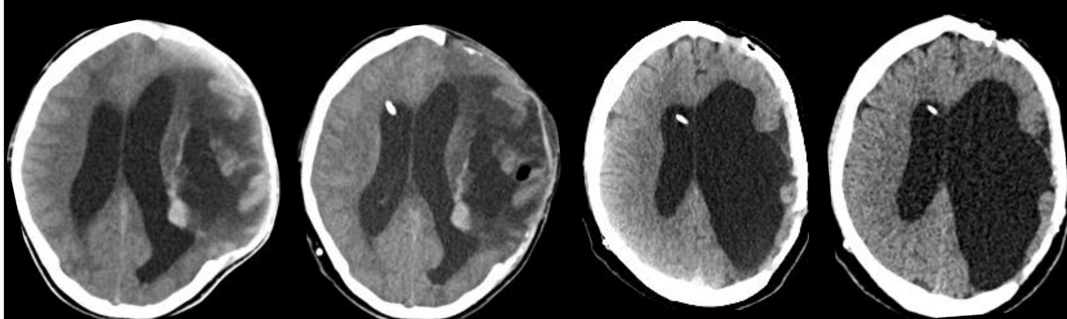



- Adaptive Shielding
- Automatic tube current modulation
- Patient specific tube voltage selection
- Iterative reconstruction
- Dual Energy

# Ongoing Dose Reduction
## 19 yo with 14 CT Heads in 5 years

| | | Scan | kV | mAs / ref. | CTDIvol (mGy) | DLP (mGycm) | |
|---|---|---|---|---|---|---|---|
| 2011 | 120 kV | 2 | 120 | 313 | 59.39 | 1158 | 59.39 |
| 2011 | 100 kV, AEC | 2 | 100 | 445 / 513 | 43.64 S | 778 | 43.64 |
| 2014 | Iterative Recon | 2 | 100 | 363 / 484 | 35.11 S | 614 | 35.11 |
| 2015 | Dual Energy | 2A<br>2B | 80<br>Sn140 | 204 / 300<br>109 / 150 | 17.90 S | 395 | 17.90 |

# Ongoing Dose Reduction
## 19 yo with 14 CT Heads in 5 years



| 2011<br>120 kV<br>Fixed mAs | 2011<br>100 kV, AEC | 2014<br>Iterative Recon | 2015<br>Dual Energy |
|---|---|---|---|
| 59.39 | 43.64 | 35.11 | 17.90 |

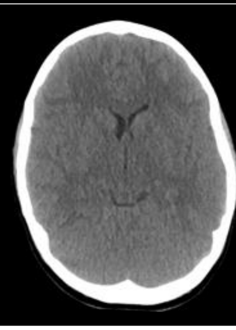
# Trauma (Full) Dose

Total mAs 1339    Total DLP 415 mGycm

| | Scan | kV | mAs / ref. | CTDIvol* mGy | DLP mGycm |
|---|---|---|---|---|---|
| Patient Position H-SP | | | | | |
| Topogram | 1 | 120 | 34 mA | 0.25 S | 6 |
| Head | 2 | 100 | 238 / 403 | 23.03 S | 409 |

Est. Dose = 0.0032 x 415

= 1.3 mSv



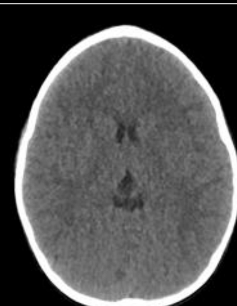
# Standard (Low) Dose

Total mAs 510    Total DLP 146 mGycm

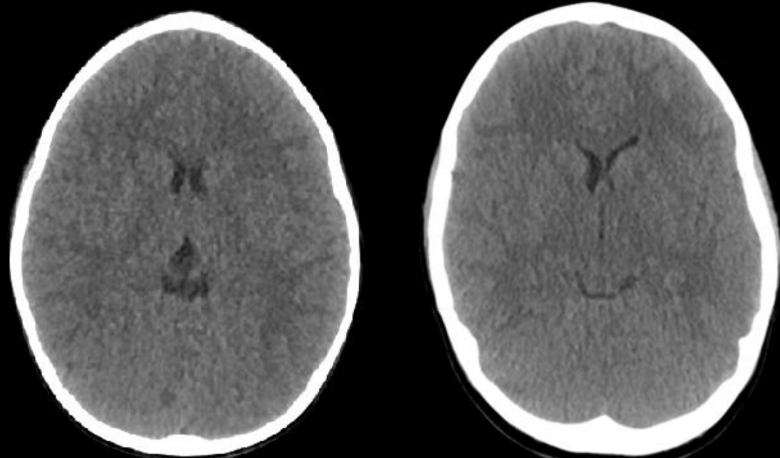
| | Scan | kV | mAs / ref. | CTDIvol* mGy | DLP mGycm |
|---|---|---|---|---|---|
| Patient Position H-SP | | | | | |
| Topogram | 1 | 120 | 34 mA | 0.25 S | 6 |
| Head | 2 | 100 | 91 / 150 | 8.86 S | 140 |

Est. Dose = 0.0032 x 146

= 0.47 mSv

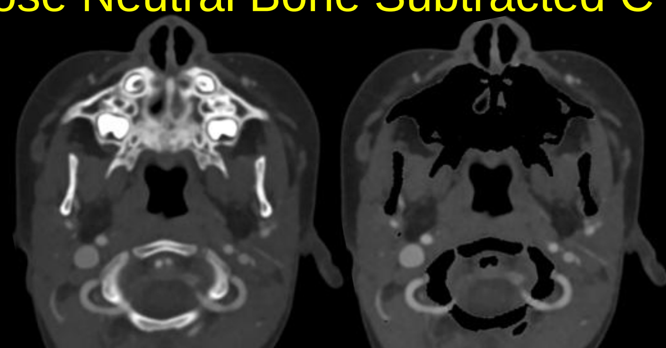


# Low Versus Full Dose Scans



0.47 mSv 1.3 mSv

# Dual Energy CT: Early Applications
## Dose Neutral Bone Subtracted CTA

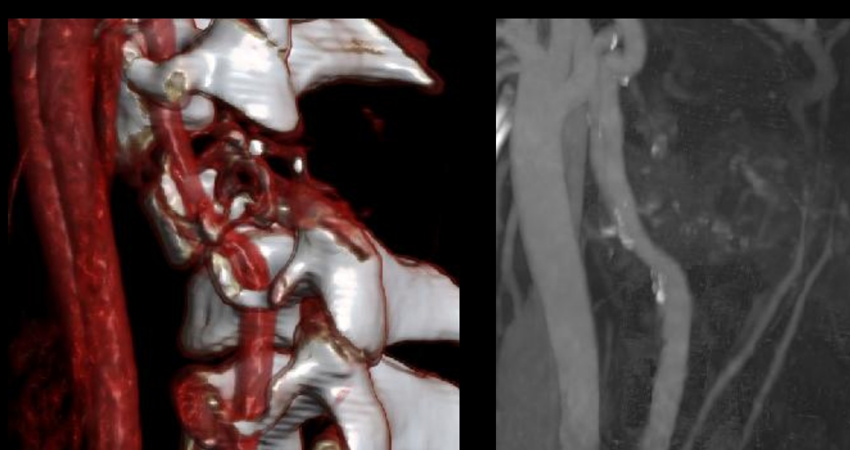


DLP 159 mGycm

| Scan | kV | mAs / ref. | CTDIvol* mGy | DLP mGycm |
|---|---|---|---|---|
| 4A | 100 | 83 / 114 | | |
| 4B | Sn140 | 85 / 114 | 5.19 L | 152 |

## Dual Energy Contrast Enhanced CT


## Dual Energy Bone Removal



# DE CT: Metal Artifact Reduction by Monoenergetic Extrapolation

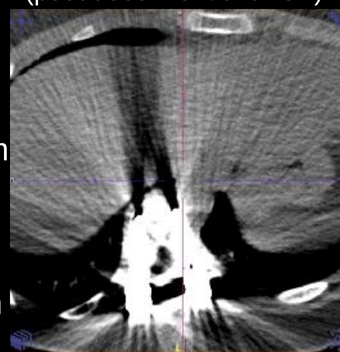
Dual-Energy CT
100/140 kV +Tin filter

Dose Neutral

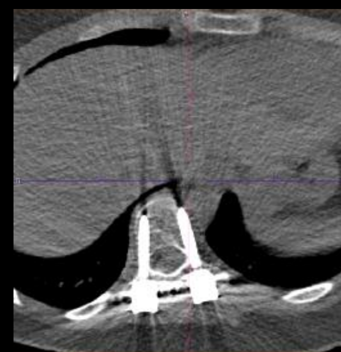
Dual Energy
CTDI = 18.6 mGy
DLP = 1120 mGy cm

Routine Protocol
CTDI = 20.1 mGy
DLP = 1217 mGy cm

Monoenergetic
70 keV
(pseudoconventional CT)



Monoenergetic
120 keV

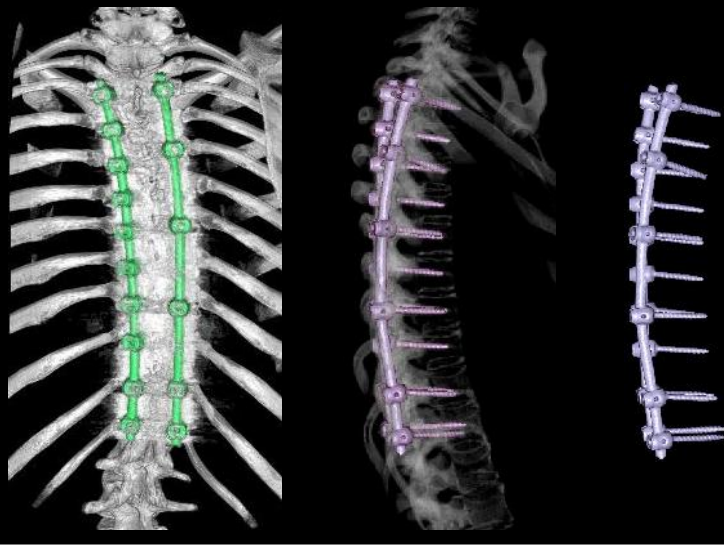


# Dual Energy CT:
## Metal Artifact Reduction

Monoenergetic 70 keV
(Equivalent to conventional CT)

Monoenergetic 120 keV

# Dual Energy CT:
## Metal Artifact Reduction



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## Initial Experience with Enterprise Wide Dose Monitoring at BJC Healthcare

Robert McKinstry, MD, PhD, FACR
James Duncan, MD, PhD
Mandie Street, RT(R)(MR),CSSGB
Bruce Hall, MD, PhD, MBA

## Joint Commission Recommendations

"Effective" July 2015

Areas addressed in the new and revised standards include:

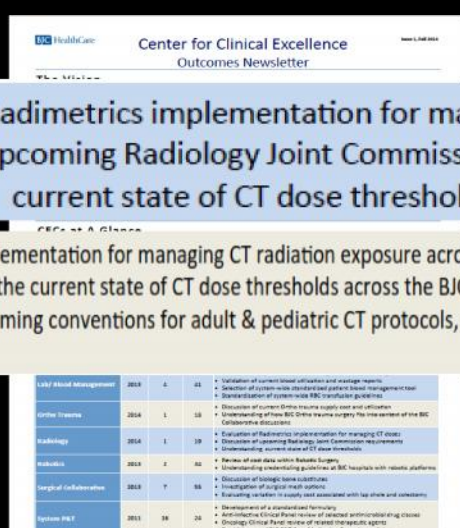
- Minimum competency for radiology technologists, including registration and certification by July 1, 2015
- Documentation of CT radiation dose in the 'patient's clinical record
- Collection of data on incidents where pre-identified radiation dose limits have been exceeded

# BJC Healthcare
# Net Revenues of $4 billion

1. Alton Memorial Hospital
2. *Barnes-Jewish Hospital
3. *Barnes-Jewish St. Peters Hospital
4. *Barnes-Jewish West County Hospital
5. Boone Hospital
6. Christian Hospital
7. Missouri Baptist Hospital
8. Missouri Baptist Sullivan Hospital
9. Northwest HealthCare
10. Parkland Health Center
11. *Progress West Hospital
12. *St. Louis Children's Hospital
13. The Rehabilitation Institute of St. Louis

*Covered by Mallinckrodt Institute of Radiology

# BJC Enterprise Excellence Efforts




- Evaluation of Radimetrics implementation for managing CT doses
- Discussion of upcoming Radiology Joint Commission requirements
- Understanding current state of CT dose thresholds

- Evaluation of SOFTWARE implementation for managing CT radiation exposure across 11 BJC hospitals.
- Exploration and evaluation of the current state of CT dose thresholds across the BJC Healthcare system.
- Standardization of protocol naming conventions for adult & pediatric CT protocols, reducing unique protocol names from 3209 to 2463.

# Dose Monitoring Implementation

| Item | Target Date | Completion Date |
|---|---|---|
| Funding Approved | | May-2013 |
| BJH, SLCH, BJWC CT/ IR Implementation | | Feb-2014 |
| Mapping Training with Mandie Street | April 4, 2014 | Apr-2014 |
| Set Up West Server | April 7, 2014- April 21, 2014 | Apr-2014 |
| CT Modality Set Up and Testing | April 21, 2014- May 5, 2014 | Apr-2014 |
| CT Modality Mapping and Customer Training | May 5, 2014- May 19, 2014 | May-2014 |
| CT Final Testing and Site Training | May 19, 2014- June 6, 2014 | May-2014 |
| MBMC, MBS, SNE/W, BJSP, PW, Parkland, Alton, Boone | July 2014 | May-2014 |
| IR Implementation West Server | Nov 2014 | |
| Academic Dose Integration | Dec 2014 | |
| West Server Dose Integration | June 2015 | |
| C-Arms/ Fluoro Units | Late 2015 | |

We Are Here

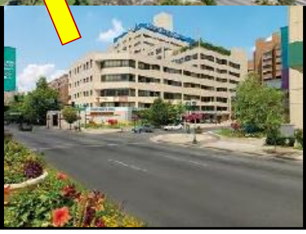
# Dose Metric in Medical Record

- Our solution has the ability to send the dose metric to the RIS (Radiology Information System)
  - Update: Sending to RIS but not yet populating the report
- Deployed at SLCH November 2012
- Deployed at BJH March 2013
- Deployed on the West Server in 2014
- Goal – all of BJC will have dose metrics in the radiology report by July 2015

# Current State

- Academic Server
  - All CT
  - All compatible IR Units
- West/Community Server
  - All CT

# Washington University Academic Medical Campus



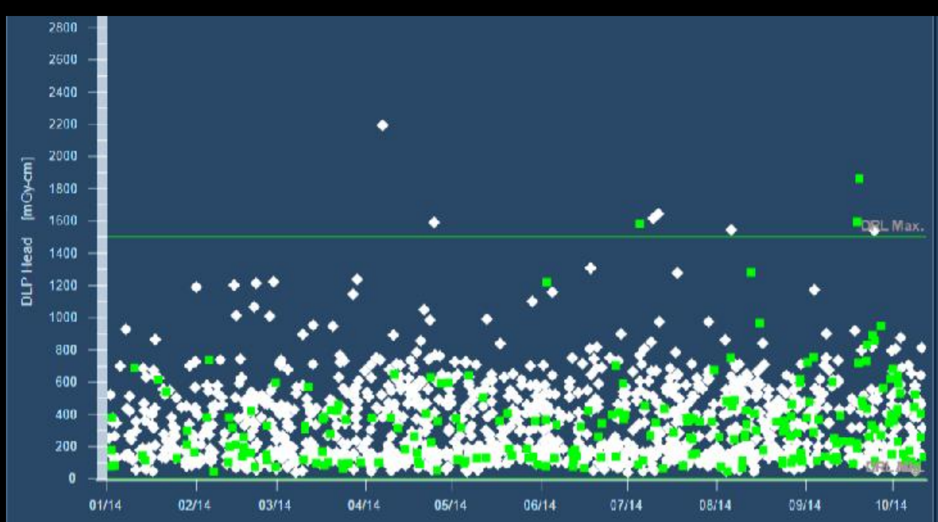
St. Louis Children's Hospital

# DLP Head vs DLP Body

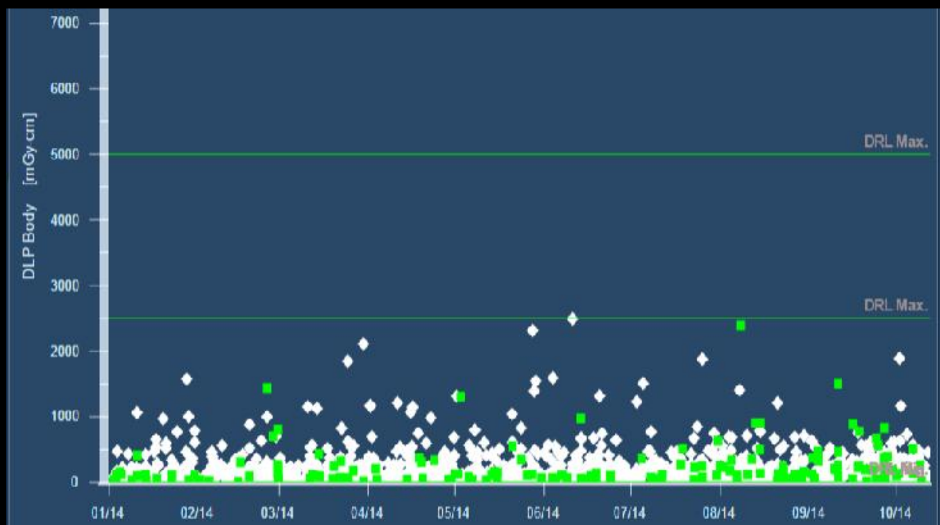
- All scanners use a
  - head (16cm) or
  - body (32cm) phantom to create a dose estimate

If the scanner used the head phantom to create the dose estimate then it would fall under the DLP head alerts – necks for example typically use the head phantom.

# Dashboard SLCH CT Head

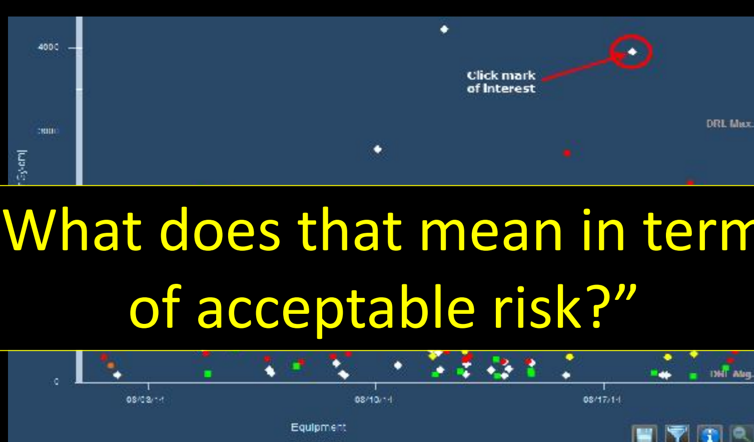


# Dashboard SLCH CT Body




# Dashboards

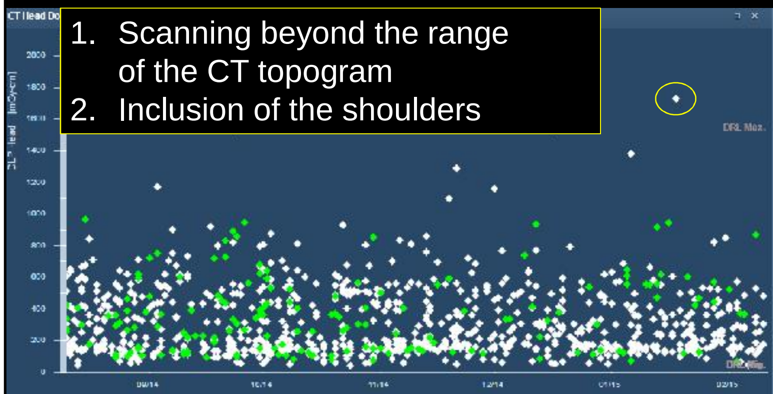
If you see an event above your threshold, in this case 3000 DLP, click it to learn about the exam.

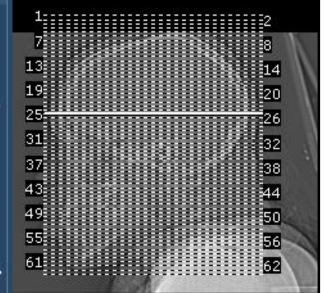



“What does that mean in terms of acceptable risk?”

# Auditing our Practice

1. Scanning beyond the range of the CT topogram
2. Inclusion of the shoulders





| | kV | mAs / ref. | CTDIvol* mGy | DLP mGycm |
|---|---|---|---|---|
| Hd_Orbit_Facial | 120 | 425 / 250 | 65.04 S | 1729 |

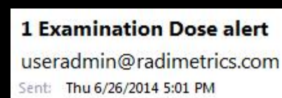
# Alerts

1. Global alerts – set per server
   a. CT
      i. Body DLP 5000
      ii. Head DLP 3000
      iii. Peds (0-18yrs) Body DLP 2500
      iv. Peds (0-18yrs) Head DLP 1500
2. Protocol alerts – set per protocol name
   a. None currently set

# Alert Notification

All alerts are set on an individual user basis

- Email Alerts

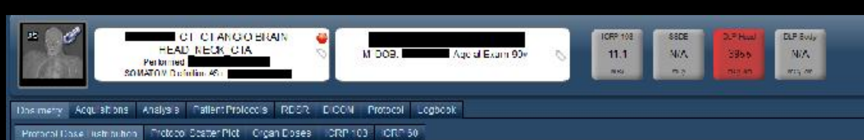



- System Alerts


  – Viewable only once you login to the system

- Alert Icon

## Exam Information

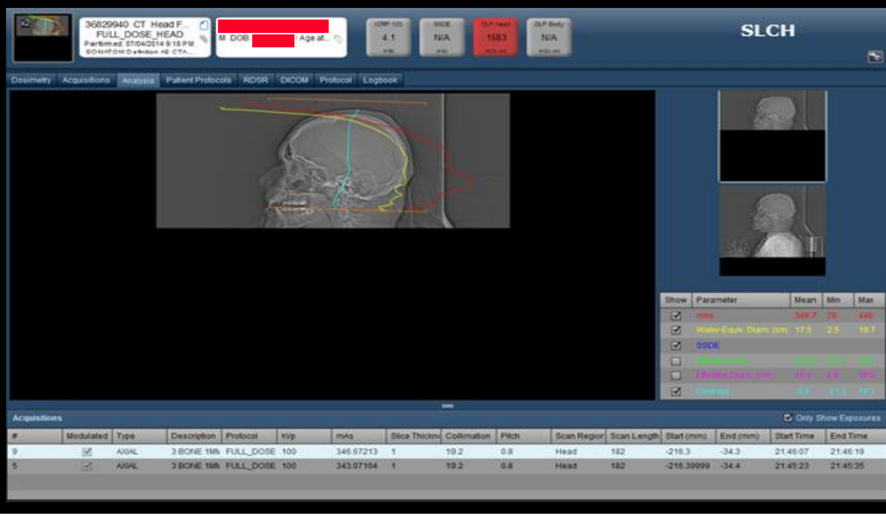


Tabs

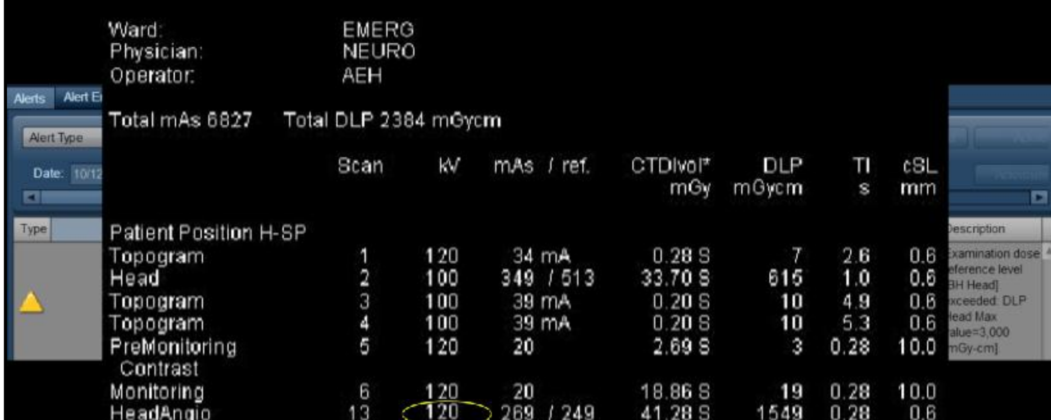
- Dosimetry: Graphs/Organ doses
- Acquisitions: List of all acquisitions and parameters
- Analysis: Topogram with acquisitions displayed
- Patient Protocol: Dose information sheet from equipment

## SLCH High Dose Analysis

Pediatric Head Alert Trigger-1500 DLP




## SLCH Notifications and Investigation



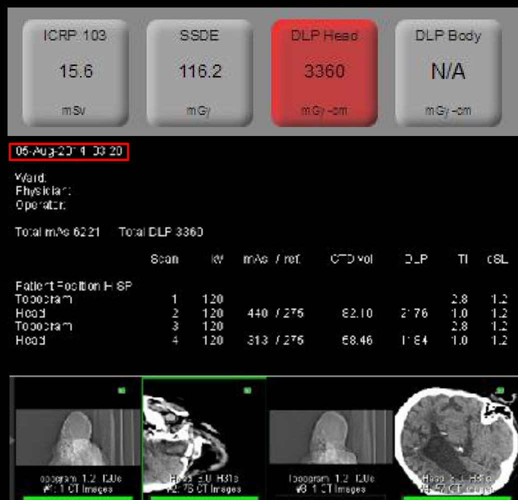
Ward: EMERG
Physician: NEURO
Operator: AEH

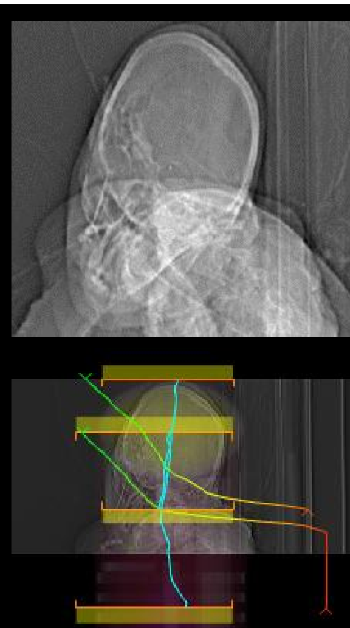
Total mAs 6827 Total DLP 2384 mGycm

| | Scan | kV | mAs / ref. | CTDIvol* mGy | DLP mGycm | TI s | cSL mm |
|---|---|---|---|---|---|---|---|
| Patient Position H-SP | | | | | | | |
| Topogram | 1 | 120 | 34 mA | 0.28 S | 7 | 2.6 | 0.6 |
| Head | 2 | 100 | 349 / 513 | 33.70 S | 615 | 1.0 | 0.6 |
| Topogram | 3 | 100 | 39 mA | 0.20 S | 10 | 4.9 | 0.6 |
| Topogram | 4 | 100 | 39 mA | 0.20 S | 10 | 5.3 | 0.6 |
| PreMonitoring Contrast | 5 | 120 | 20 | 2.69 S | 3 | 0.28 | 10.0 |
| Monitoring | 6 | 120 | 20 | 18.86 S | 19 | 0.28 | 10.0 |
| HeadAngio | 13 | 120 | 269 / 249 | 41.28 S | 1549 | 0.28 | 0.6 |

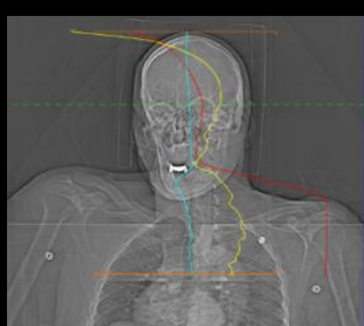
Identified a Protocol with the Wrong kV setting

# BJH Event Investigation



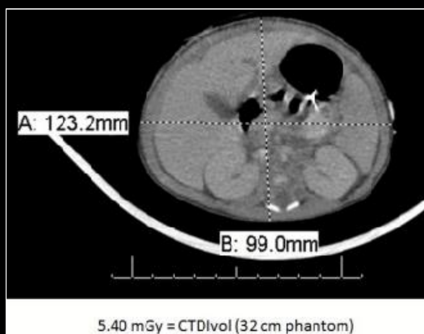
# Analysis Tab



| Show | Parameter | Mean | Min | Max |
|---|---|---|---|---|
| ☑ | mAs | 200.4 | 87 | 285 |
| ☑ | Water-Equiv. Diam. (cm) | 18.5 | 2.9 | 21.9 |
| ☑ | SSDE | | | |
| ☐ | Effective mAs | 167 | 72.5 | 237.5 |
| ☐ | Effective Diam. (cm) | 18.1 | 3 | 23.8 |
| ☑ | Centroid | 3.9 | -13.7 | 10.4 |

# Size Specific Dose Estimate

$$SSDE = f_{size}^{32X} \times CTDI_{vol}^{32}$$

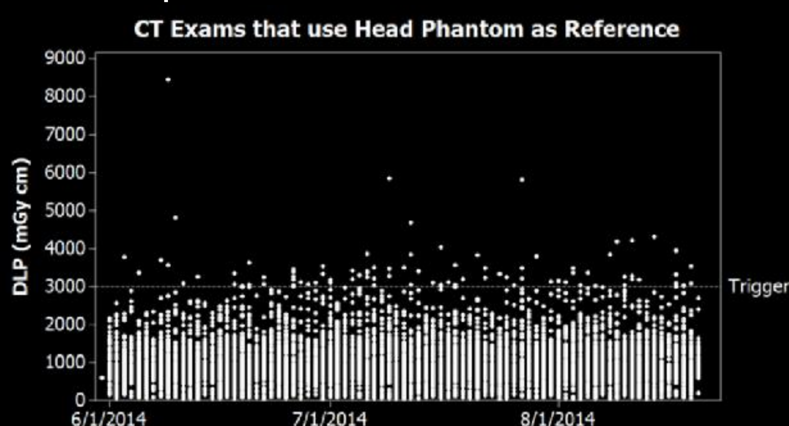



| Lat+AP Dim (cm) | Effective Dia (cm) | Conversion Factor |
|---|---|---|
| 16 | 7.7 | 2.79 |
| 18 | 8.7 | 2.69 |
| 20 | 9.7 | 2.59 |
| 22 | 10.7 | 2.50 |
| 24 | 11.7 | 2.41 |
| 26 | 12.7 | 2.32 |
| 28 | 13.7 | 2.24 |

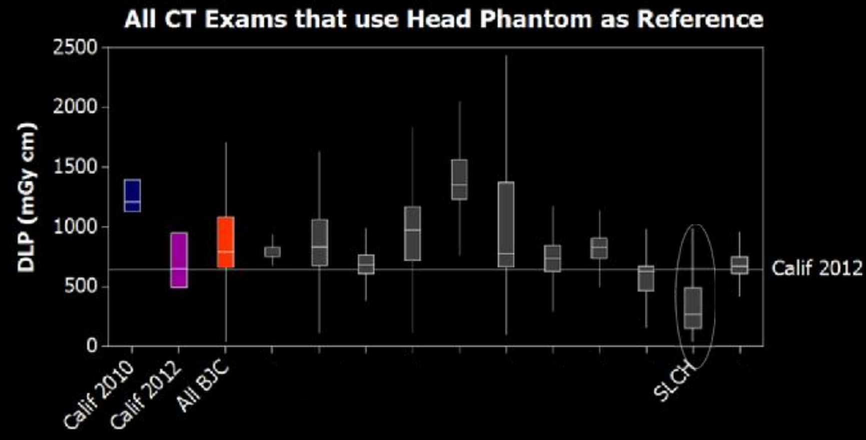
$$5.40\, mGy \times 2.50 = 13\, mGy$$

# System-Wide Progress

- Capturing CT dose metrics via
- Enterprise Software Solution

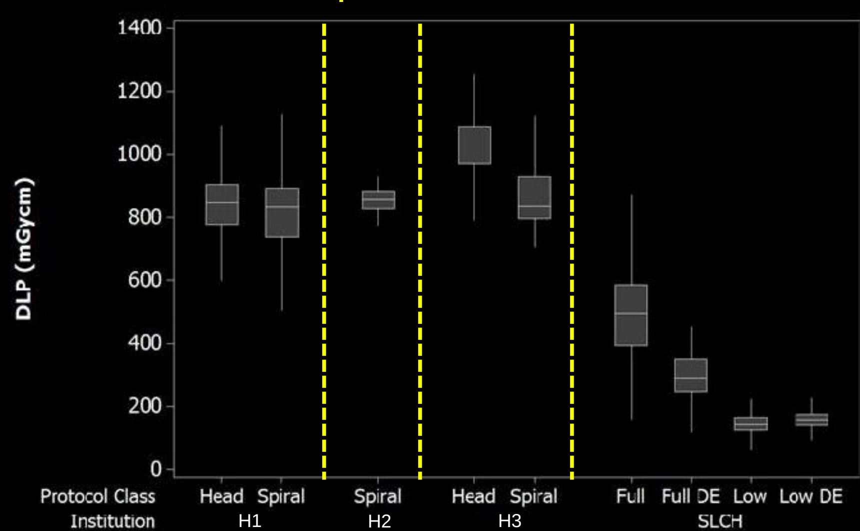


# Benchmarking our System with California

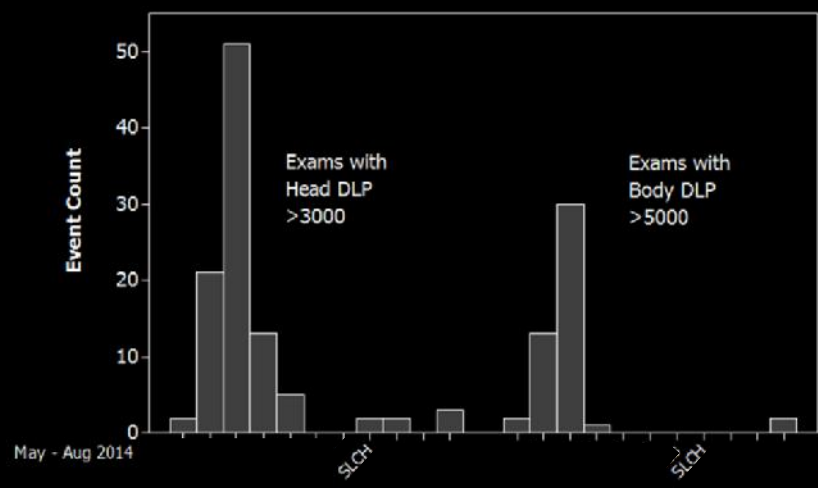



# CT Head Academic Server

## Sept 1 – Feb 11



## Trigger Frequency




## Future State

**All sites:**

- West Interventional
- C-Arms
- Fluoro units (RF)
- Plain Film (CR/DR)
- Mammography

**Ultimate Goal:**

- All imaging equipment within each hospital (Cath Lab - etc.)
- Common Database for all of BJC

## Summary

- Through our combined efforts at MIR and SLCH, we were able to cut CT utilization in children roughly in half over a 7-year period.
- We provide diagnostic CT image quality at lower dose while substantially reducing the estimated risk associated with excess medical radiation exposure

Children's HOSPITAL • ST. LOUIS | Washington University in St. Louis SCHOOL OF MEDICINE | MIR Mallinckrodt Institute of Radiology Pediatric Radiology

Why are children at greater cancer risk from CT scan exposure than adults?

| | |
|---|---|
| 20% | 1. They have hyperactive DNA repair |
| 20% | 2. They develop more cancers |
| 20% | 3. They have more CT scans |
| 20% | 4. They need more dose to maintain SNR |
| 20% | 5. They are more radiosensitive |

10

## Why are children at greater cancer risk from CT scan exposure than adults?

- Children are more radiosensitive than adults because of ongoing cell division and proliferation
- Kids have longer to live with risk after exposure
- Cancer is actually relatively rare in children
- You can decrease kV and mAs and maintain image quality in smaller children
- CT utilization is greater in adults than kids

Ref: Mathews JD, et al., BMJ. 2013 May 21;346:f2360

For the estimated effective dose equation:
E (mSv) = k x DLP

20% 1. k is dependent on the patient age
20% 2. k is independent of the body part
20% 3. E is an accurate measure of the dose
20% 4. DLP is independent of the $CTDI_{vol}$
20% 5. E is accurate for the phantom selected

For the estimated effective dose equation: E (mSv) = k x DLP

- k is dependent on age
- k is tabulated by body region
- E is an estimate, it is not accurate
- DLP is dependent on $CTDI_{vol}$
- E is an estimate for the patient, not the phantom

Ref: AAPM Report No. 96

Effective dose estimates are only valid for

| | |
|---|---|
| 20% | 1. Retrospective dose assessments |
| 20% | 2. Prospective radiological protection |
| 20% | 3. Standard 16 cm and 32 cm phantoms |
| 20% | 4. Comparison with different modalities |
| 20% | 5. Estimation of an individual's risk |

## Effective dose estimates are only valid for

Effective dose estimates are only valid for

- Prospective radiological protection purposes

E can be of some value for

- Comparing doses from different diagnostic/therapeutic procedures
- For comparing the radiation risks for different technologies.

E should not be used for

- Retrospective dose assessments or
- Detailed estimation of a specific individual's risk. Absorbed dose to irradiated tissues is the more appropriate quantity.

Ref: AAPM Report No. 96

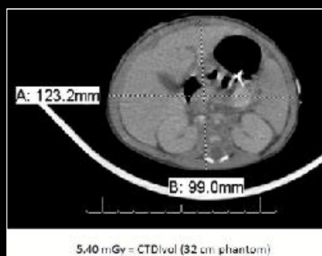
## To convert CT scanner output to SSDE, one needs

| | |
|---|---|
| 20% | 1. DLP and k-factor from AAPM #96 |
| 20% | 2. Tube Voltage kVp and effective mAs |
| 20% | 3. $CTDI_{vol}$ & cross sectional dimensions |
| 20% | 4. Scan Length (L) and $CTDI_{vol}$ |
| 20% | 5. DLP and patient width from the CT |

10

## To convert CT scanner output to SSDE, one needs

$$SSDE = f_{size}^{32X} \times CTDI_{vol}^{32}$$




| Lat+AP Dim (cm) | Effective Dia (cm) | Conversion Factor |
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| 18 | 8.7 | 2.69 |
| 20 | 9.7 | 2.59 |
| 22 | 10.7 | 2.50 |
| 24 | 11.7 | 2.41 |
| 26 | 12.7 | 2.32 |
| 28 | 13.7 | 2.24 |

Ref: AAPM Report No. 204

## Why is SSDE important for pediatric patients?

20% 1. $CTDI_{vol}$ is not an accurate measure

20% 2. AEC is not effective in children

20% 3. $CTDI_{vol}$ cannot account for lower kV

20% 4. $CTDI_{vol}$ may underestimate dose

20% 5. DLP does not account with AEC

10

# Why is SSDE important for pediatric patients?

The dose received by a patient from a CT scan is dependent on both patient size and scanner radiation output. $CTDI_{vol}$ provides information regarding *only* the scanner output. It does not address patient size, and hence does not estimate patient dose (McCollough 2011). This is a concern, *because for smaller pediatric patients, interpreting the displayed $CTDI_{vol}$ (or DLP) as patient dose—without recognizing the distinction between the two—could lead to underestimating patient dose levels by a factor of 2–3 if the 32 cm PMMA phantom was used for reference.*

Interpreting $CTDI_{vol}$ (or DLP) as dose could … lead to underestimating patient dose ….

Ref: AAPM Report No. 204

# Thanks for your attention!

Questions?

Comments?