Radiation Doses from the ACR CT Accreditation Program:
New Diagnostic Reference Values and Pass/Fail Limits

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Reference Doses

- Have been shown to lower average dose in other modalities and/or other countries
- Represent the upper third or quartile of doses sampled from actual practice data
- *Do not represent ideal or suggested doses*
- Identify when dose is unusually high

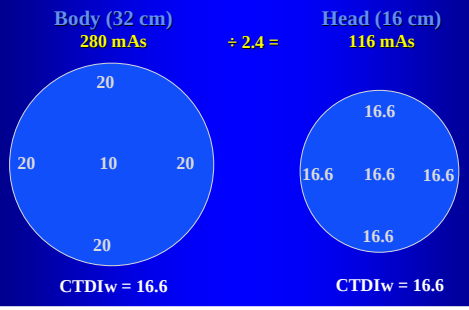
Gray JE, et al . Reference values for diagnostic radiology: application and impact. Radiology 2005; 235:354-358.
Tsapaki V, et a l. Dose reduction in CT while maintaining diagnostic confidence: Diagnostic reference levels at routine head, chest, and abdominal CT--IAEA-coordinated resea rch project. Radiology 2006; 240:828-834.
Hart D, et al. Doses to patients from medical x - -ray examinations in the UK. —1995 review. In: Chilton: NRPB -R289, 1996.
Shrimpton PC, et al. Doses from Computed Tomography (CT) Examinations in the UK - 2003 Review. In: National Radiological Protection Board, Oxon: NRPB -W67, 2005.

- **ACR CT Reference Doses**
  - Adult Head 60 mGy*
  - Adult Abdomen 35 mGy*
  - Pediatric (5 yr old) Abdomen 25 mGy
- **Currently no pass/fail dose criteria**
  - Justification or corrective action requested
    - New CTDI data and images
    - Low contrast resolution images
    - Statement that clinical image quality is acceptable

*From European Commission EUR 16262 (2000)
European Guidelines on Quality Criteria for Computed Tomography

Phantom size affects CTDI values

Same kVp, collimation, pitch



- Use of smaller phantom and lower reference value implies that a reduction in tube output by a factor of to 3 - 4 is expected for a 5 y.o. abdomen exam
- CTDIvol values displayed on the scanner console use large CTDI phantom
  - Need to address with appropriate standards, professional and manufacturer organizations, as well as clearly educate users

Materials & Methods

Site Dose Measurements

- CTDIw (mGy) for
  - Routine head (cerebrum/brain)
  - Adult abdomen
  - Pediatric abdomen (5 y.o)
- CDTI phantom images filmed to verify correct technique

Excel® "Dose Calculator" spreadsheet

Dose Calculator spreadsheet available for exposure or air kerma meters

Center			
Measurement 1 (mR)	197		
Measurement 2 (mR)	199		
Measurement 3 (mR)	199		2:9
Average of above 3 measurements (mR)		198.3	
Body CTDI at isocenter in phantom (mGy)		11.2	
12 o'clock position			
Measurement 1 (mR)	401		
Measurement 2 (mR)	422		
Measurement 3 (mR)	401		
Average of above 3 measurements (mR)		408.0	
Body CTDI at 12 o'clock position in phantom (mGy)		23.0	
CTDIw (mGy)		19.0	

$CTDIw = 2/3\ CTDI_{100}$ (edge) + $1/3\ CTDI_{100}$ (center)

CTDIw (mGy)		19.0	
Clinical exam dose estimates (using measured CTDIw and site's Adult Abdomen Protocol from Table 1)			
CTDIvol (mGy)	=CTDIw*N*T/I	25.4	
DLP (mGy-cm)	=CTDIvol*25	634.2	
Eff Dose (mSv)	=DLP*0.015	9.5	

Volume CTDI = CTDIw / pitch

Reviewer Validation

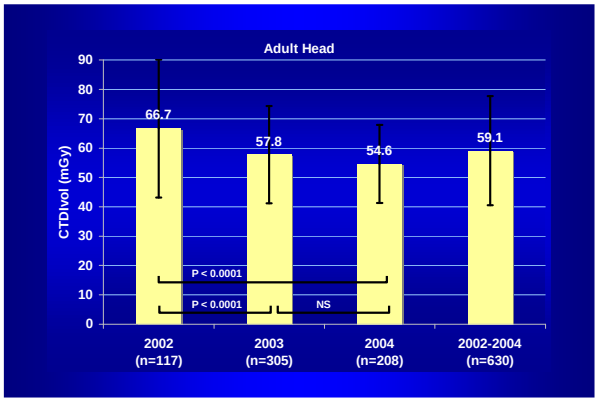
- Adult Head
  - 16 cm CTDI phantom, in head holder
- Pediatric abdomen (5 y.o.)
  - 16 cm CTDI phantom, on table
- Adult Body
  - 32 cm CTDI phantom, on table
- Axial scan mode
- Correct detector configuration
- Invalid data omitted from analysis

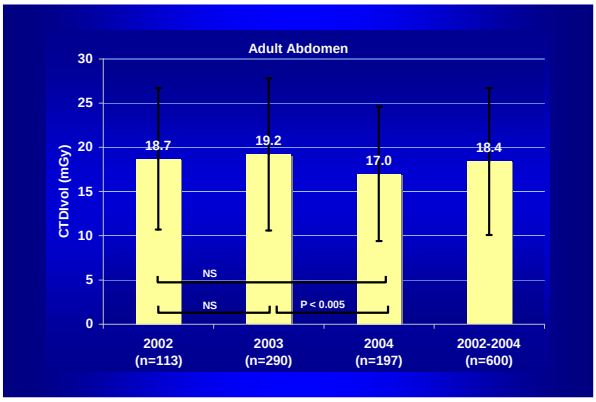
Data Analysis

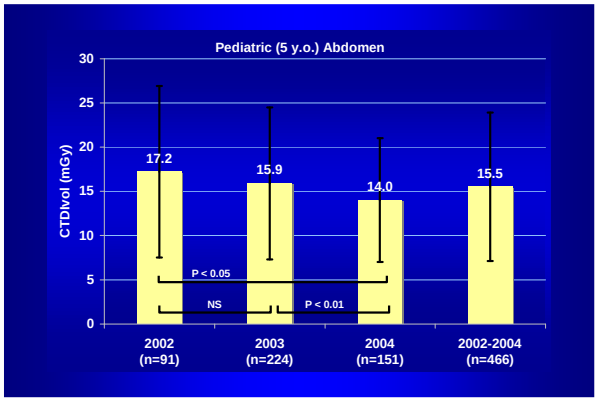
- Average, standard deviation, and histogram determined
  - By exam (head, abdomen, pediatric abdomen)
  - By year (2002, 2003, 2004, and 2002-2004)
  - By CTDIw and CTDIvol
- Statistical significance of changes in average doses by year tested using a 2-tailed t-test
- Percent of scanners above references dose determined
  - Current reference dose using CTDIw and CTDIvol
  - Proposed reference dose using CTDIvol

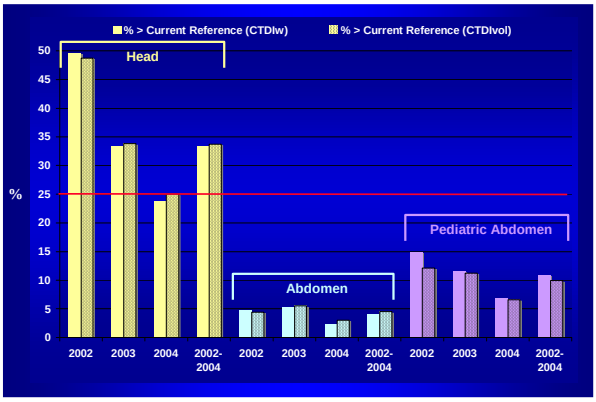
Results I
Mean ± standard deviation

Shown for CTDIvol only


Adult Head
CTDIvol (mGy)
90
80
70
60
50
40
30
20
10
0
66.7
57.8
54.6
59.1
P < 0.0001
P < 0.0001
NS
2002 (n=117)
2003 (n=305)
2004 (n=208)
2002-2004 (n=630)


Adult Abdomen
CTDIvol (mGy)
30
25
20
15
10
5
0
18.7
19.2
17.0
18.4
NS
NS
P < 0.005
2002 (n=113)
2003 (n=290)
2004 (n=197)
2002-2004 (n=600)


Pediatric (5 y.o.) Abdomen
CTDIvol (mGy)
30
25
20
15
10
5
0
17.2
15.9
14.0
15.5
P < 0.05
NS
P < 0.01
2002 (n=91)
2003 (n=224)
2004 (n=151)
2002-2004 (n=466)

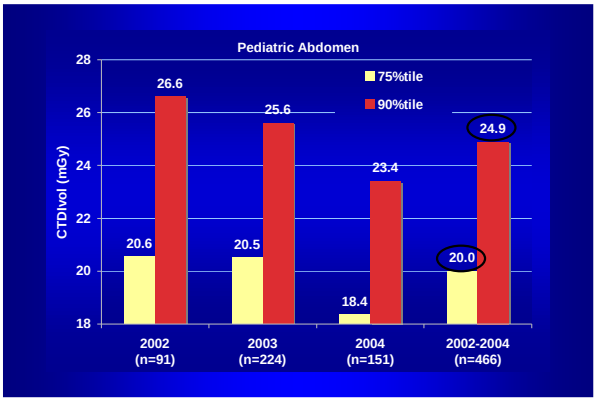

% > Current Reference (CTDIw)
% > Current Reference (CTDIvol)
Head
Abdomen
Pediatric Abdomen
%
50
45
40
35
30
25
20
15
10
5
0
2002
2003
2004
2002-2004
2002
2003
2004
2002-2004
2002
2003
2004
2002-2004

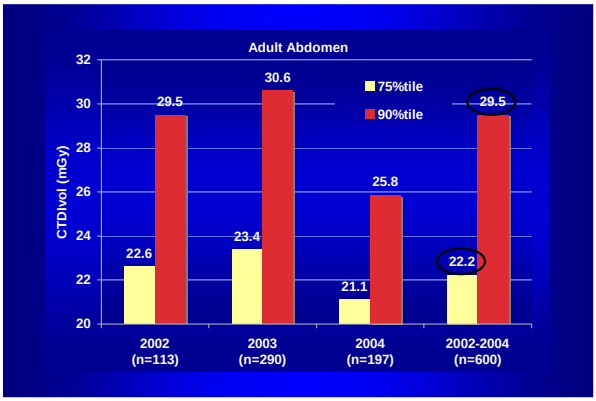
Conclusions I

- Dose for three high-use exams have decreased significantly in the U.S. since 2002
  - Adult head
  - Adult abdomen
  - Pediatric abdomen
- Sites are “dialing down” the dose for kids
  - About a factor of 3
- ACR CT Accreditation program has developed a valuable database to monitor dose trends and to establish new reference doses
- ACR will switch to CTDIvol to include the effect of pitch

Results II

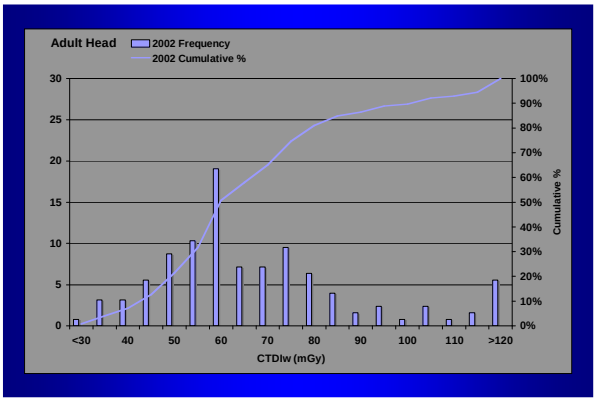
- Percent above references dose
- Establishing new reference doses
  - Maintained 5 mGy “step size”
- Mandatory dose limits

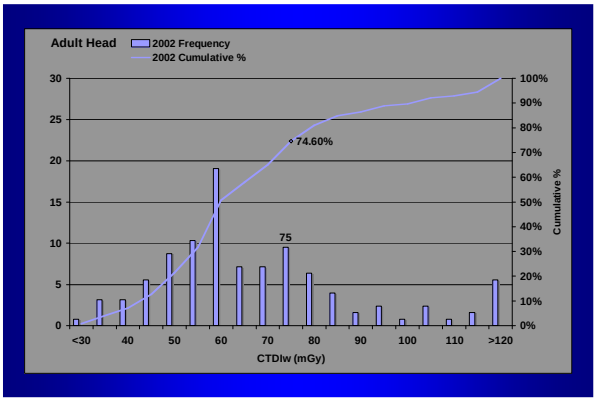


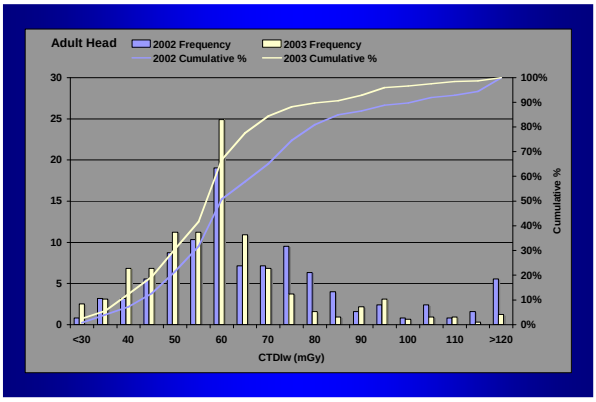


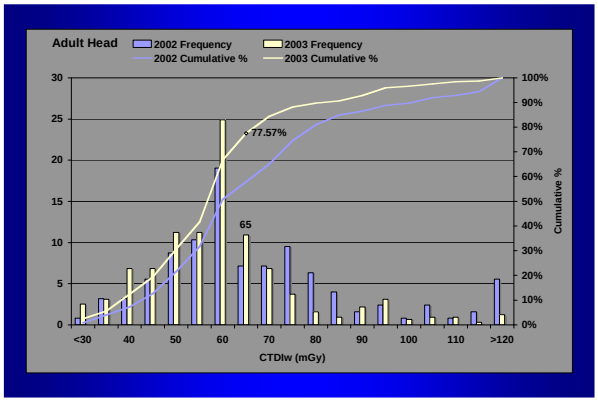
Adult Head

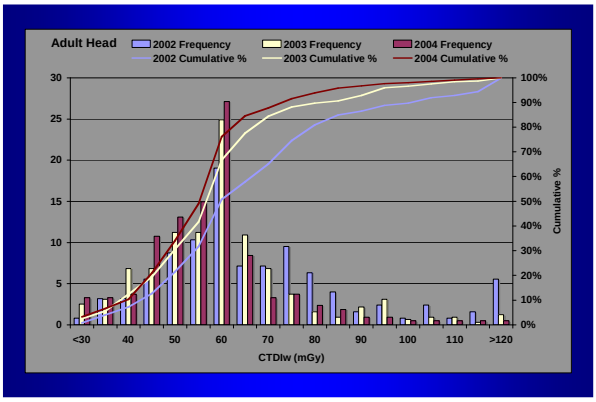
- 75%tile difficult to determine because initial reference values altered the practice distribution
- Numerous sites felt the 60 mGy was not clinically acceptable
- Multiple reports of sites increasing head dose after accreditation process completed

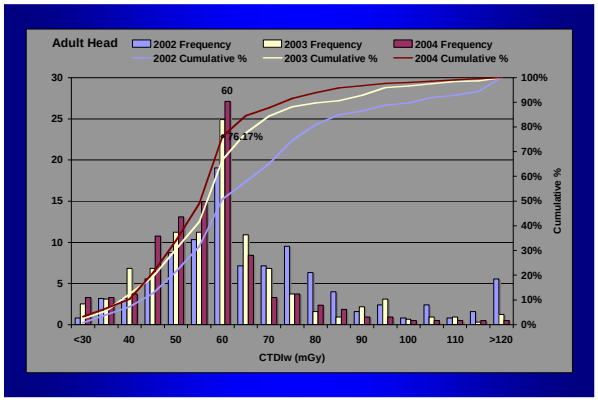


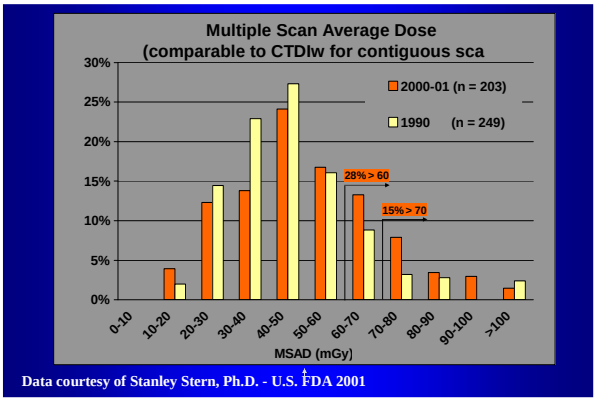












Data courtesy of Stanley Stern, Ph.D. - U.S. FDA 2001

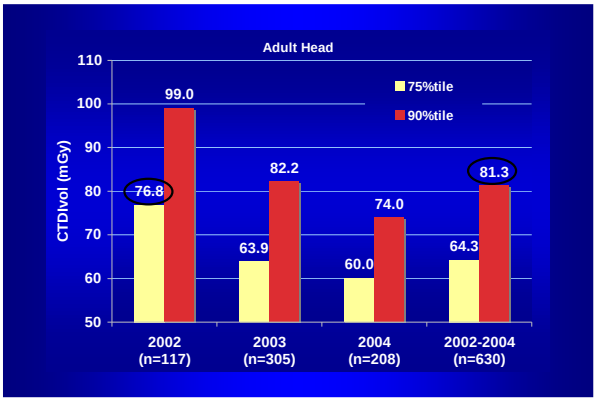
ACR vs. NEXT data (Head)

- **NEXT 1990: 45.9 mGy ± 18.1 (n=249)**
  Solid state detectors become standard, spiral CT and higher power tubes introduced, slice width begins to decrease
- **NEXT 2000: 50.3 mGy ± 19.4 (n = 203)**
  MDCT introduced in 1999, SDCT techniques used on MDCT, slice width continues to decrease
- **ACR 2002: 66.8 mGy ± 23.2 (n = 127)**
- **ACR 2003: 58.1 mGy ± 17.4 (n = 321)**
- **ACR 2004: 55.5 mGy ± 15.5 (n = 214)**

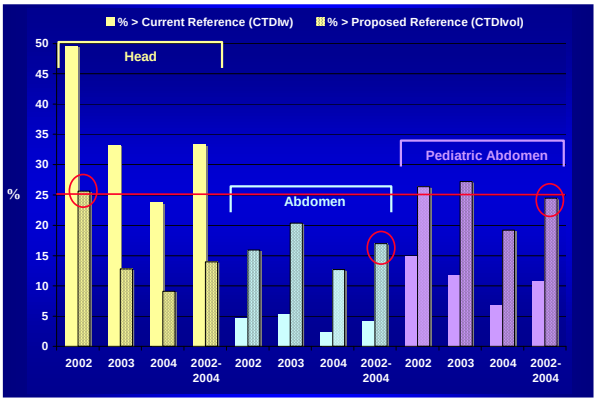
New UK Diagnostic Reference Levels

	SSCT	MSCT
Brain	65	100
Posterior Fossa	55	65

Shrimpton et al. Doses from CT Examinations in the UK – 2003 Review. NRPB-W67 (NRPB, Chilton) 2005.



- **New ACR CT Reference Doses**
  - **Adult Head** **60 → 75 mGy**
  - **Adult Abdomen** **35 → 25 mGy**
  - **Pediatric (5 yr old) Abdomen** **25 → 20 mGy**



Conclusions II

- Have sufficient data for new U.S. reference doses
- Based on CTDIvol to include the effect of pitch
- Reference doses (site given educational information)
  - Adult Head 60 → 75 mGy
  - Adult Abdomen 35 → 25 mGy
  - Pediatric (5 yr old) Abdomen 25 → 20 mGy
- Maximum allowable doses (site fails if these are exceeded)
  - Adult Head 80 mGy
  - Adult Abdomen 30 mGy
  - Pediatric (5 yr old) Abdomen 25 mGy
- Effective January 1, 2008

Additional Program Refinements

- Simplified Film Page 1
  - Elimination of need to convert spiral into axial
  - CT number of non-water rods only at 120 kVp
  - Fewer slice thickness scans
- New results database
- WIP
  - New performance limits
  - Accommodation of non-traditional CTDIvol measurements
  - Quality control manual
  - Electronic submissions

Thank you

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