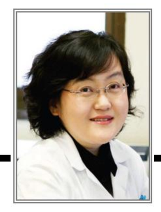
Awareness and Efforts to Decrease CT Radiation Dose and Resultant CT Protocol Changes & Dose Reduction

Seung Eun Jung, MD  (sejung@catholic.ac.kr) & Jin Hee Jang, MD
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Introduction

•Multi-detector row CT (MDCT) is one of the major progresses in medical imaging. Increasing concerns about the radiation hazard are accepted substantially, not only to radiologists, but to the physicians and patients. Steeply increased numbers of CT scans made the radiation of CT scans to be majority of medical radiation exposure.

•Reduction and optimization of radiation exposure from CT is a very important and challenging issue.

• In Korea, Korean Society of Radiology founded a special committee for radiation dose control in radiology by educated members of the KSR. This committee has been arousing the awareness of high radiation doses from MDCT and educating hospitals on the important of CT radiation dose optimization since the year 2009.

Objectives

•To compare CT dose data between the two time points and assess the changes of CT protocols and radiation doses

•To evaluate the awareness of radiation hazard and degree of efforts of radiologists

Study design

- 12 hospitals and 32 MDCT machines
- 11 CT protocols in 3 body parts
- Collected questionnaires with mails and e-mails in two time points and compare data
- Two time points
  - –1st point: just after introduction of 64ch MDCT : ***2007***
  - –2nd point: after 3 year clinical experience for applications of MDCT and introduction of late CT machines : ***2010***
- Two types of Questionnaires
  - –Questionnaire 1: about parameters of CT scan acquisition
  - –Questionnaire 2: Dose data for adult patients

• We collected two sets of questionnaires in two time points; 2007 and 2010.

• Each sets include Questionnaire 1s for each CT protocol and CT machines and 10 Questionnaire 2s for each CT protocols and CT machines.

• Questionnaire 2 was acquired from randomly collected adult patients.

• Four hospitals did not have CT dose report of each CT exams on PACS data base in 2007.

* 11 protocols

Body part	Protocol
Abdomen	Liver dynamic CT
	Routine abdomen CT
	CT Urography
	Non enhanced CT for urinary stone
Chest	Routine chest CT
	HRCT
	Low dose CT
	Coronary CT angiography
Head	Nonenhanced Brain CT
	CT Angiography of brain
	Perfusion CT of brain

* 12 hospitals and 32 CT machines

		2007	2010
Detector row	4	3	3
	16 – 40	8	10
	≥64	9	15
	Dual source	0	4
Vender	GE	5	9
	Philips	4	5
	Siemens	10	17
	Toshiba	1	1
Total number		20	32

* Two types of questionnaires

Example

Questionnaire 1.

Scan parameters for each CT protocols

Item	Results	
Year of data	2010	
Hospital name	Seoul St. May Hospital	
Machine name	Definition AS+	
Vender name	Siemens	
Year of manufacture	2008	
CT protocol	Liver	
Number of phase	4	
kVp	100 kVp in Precontrast scan, 120 kVp in other phases	
mAs	CAREdose 4D reference mAs 140	
Beam collimation	128x0.6mm	
Pitch	0.7	
Rotation time	500msec	
Scan range (according to each phase)	Phase 1	Hepatic dome ~ liver lower margin
	Phase 2	Hepatic dome ~ liver lower margin
	Phase 3	Hepatic dome~ pelvis
	Phase 4	Hepatic dome ~ liver lower margin
Monitoring for contrast enhancement timing	yes	
Convolutional Kernel	B30f	
Usage of ASIR or IRIS	no	

Questionnaire 2.

CT Radiation dose

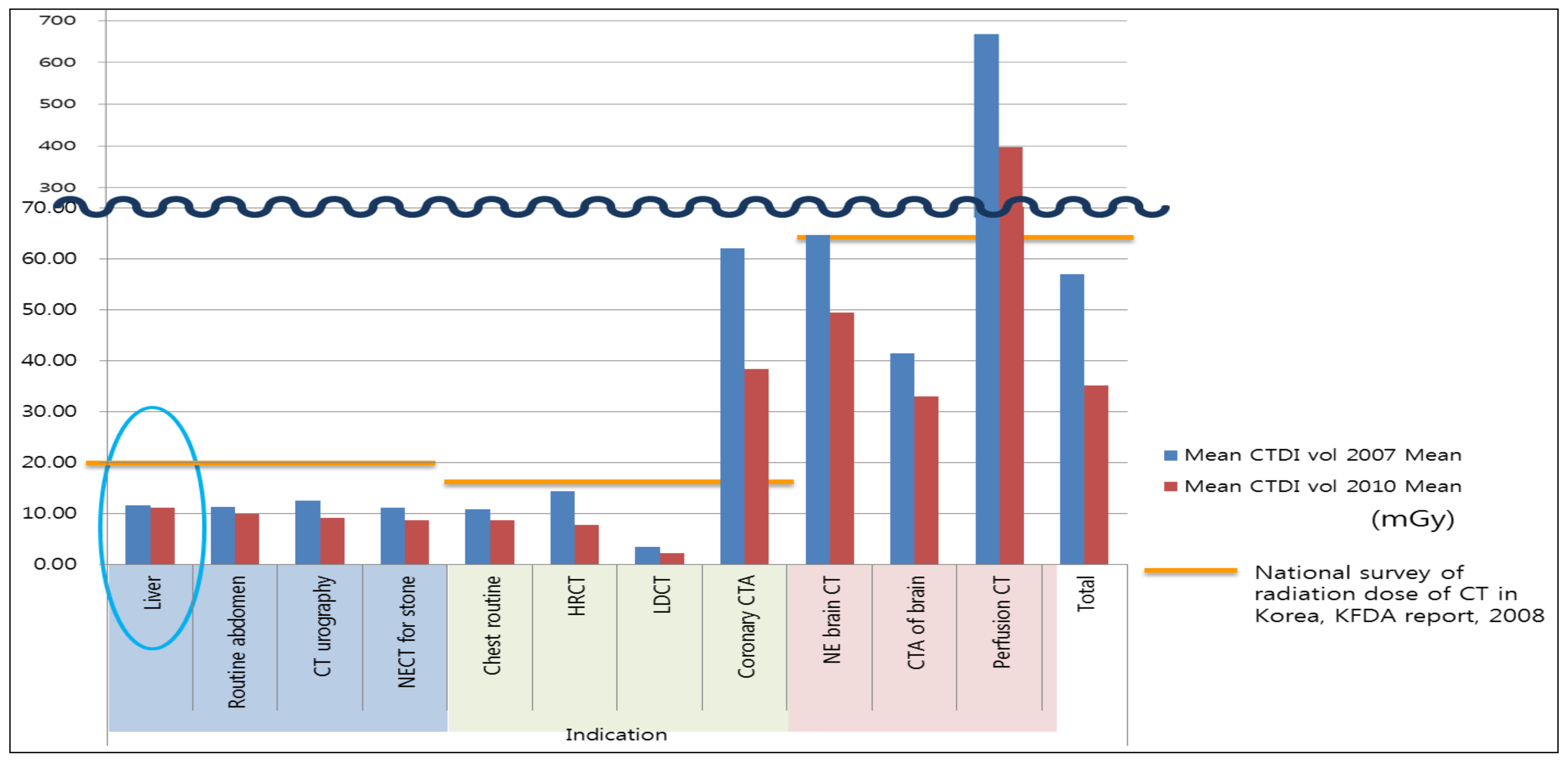
Item	Results	
CT protocol	A1-1	
Year of data	2010	
Hospital name	Seoul St. Mary hospital	
Machine name	Definition AS+	
age/sex	80/F	
Dose Parameter	CTDIvol (mGy)	DLP (mGy*cm)
Phase 1	5.29	143
Premonitoring	1.13	1
Monitoring	9.01	9
Phase 2	7.17	194
Phase 3	7.17	379
Phase 4	7.03	188

* Numbers of collected questionnaires:

	2007	2010
CT protocols (Questionnaire 1)	260	381
CT dose data (Questionnaire 2)	1,111	2,401
Mean age of CT dose data	56.14±15.42	54.74±15.08

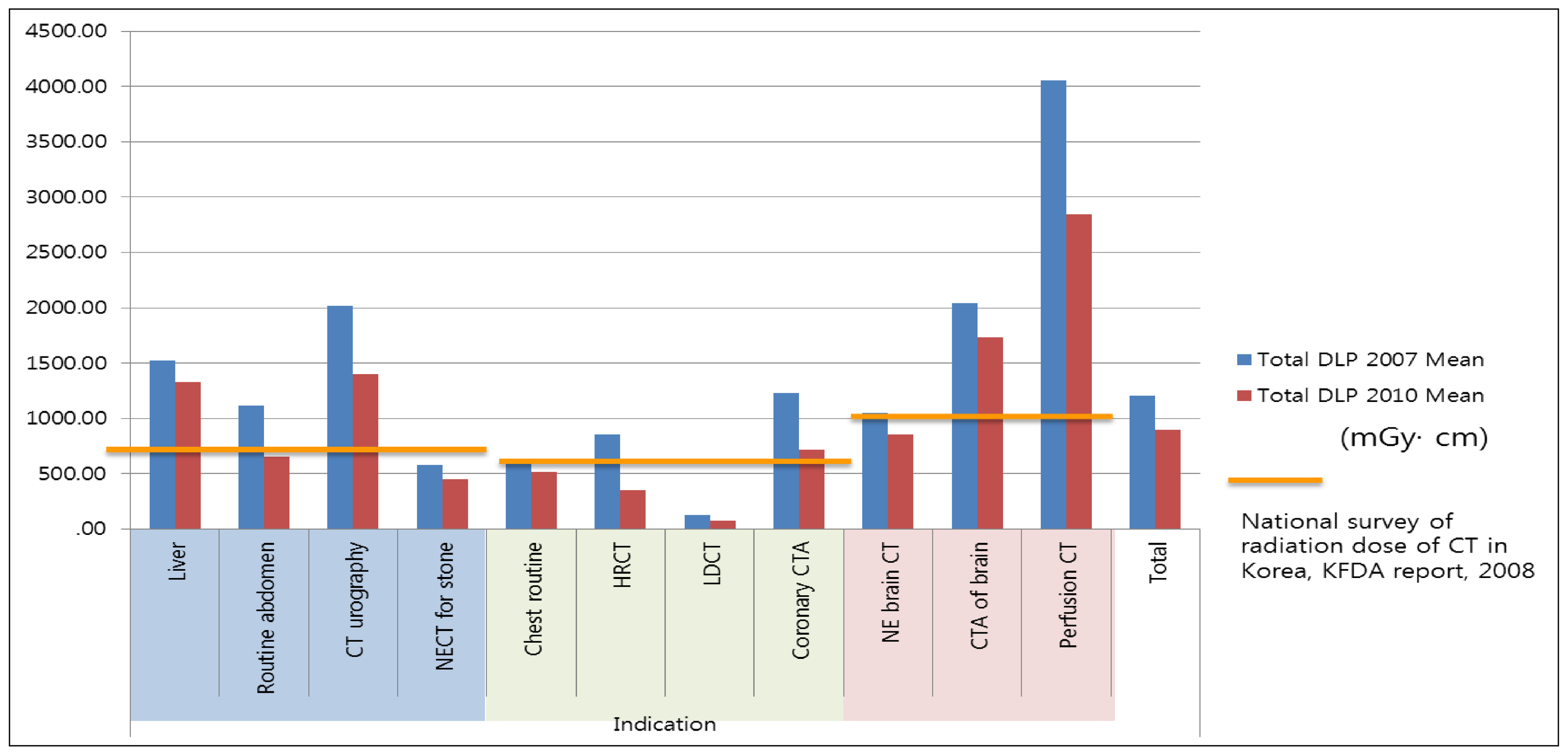
Results

Mean CTDIvol: 2007 vs 2010



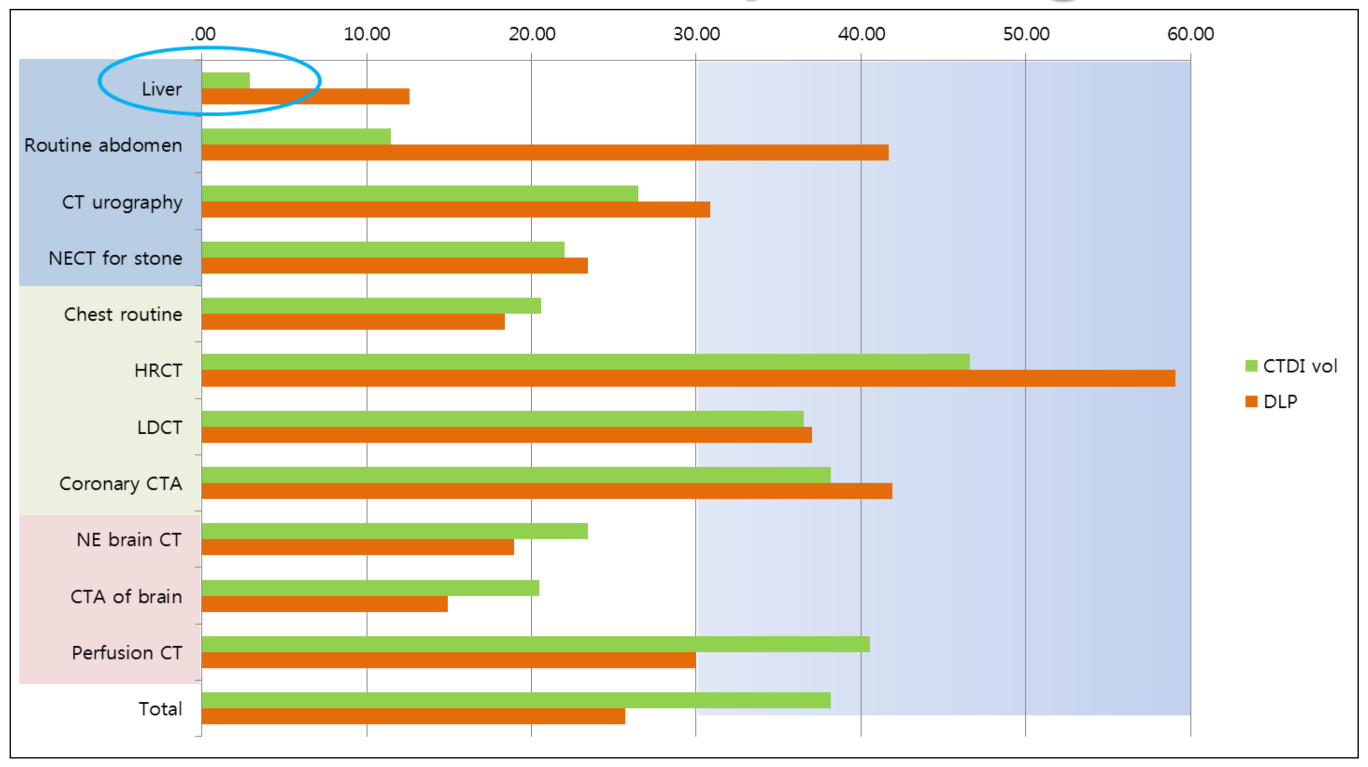
As compared with mean CTDI between 2007 and 2010, 10 CT protocols, except of liver CT, CTDI has been decreased significantly, from 2007 to 2010. There is insignificant decrease of CTDI in liver CT (blue circle).

Mean total DLP: 2007 vs 2010



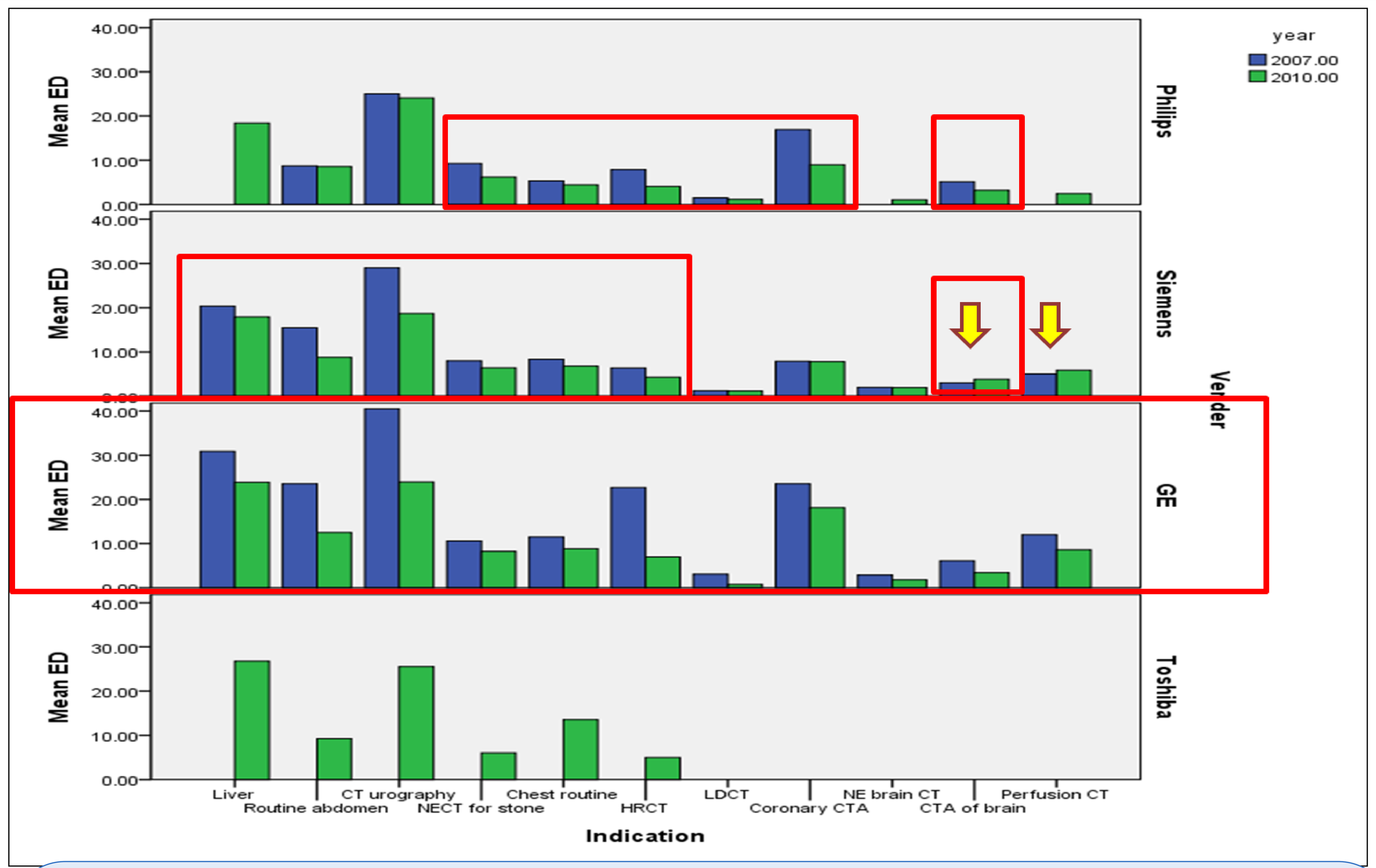
DLP of all protocols have been significantly decreased in 2010, as compared with 2007. Interestingly, CTDIvol was lower than DRL of single phase images, but DLP were higher than single phase DRL. We thought this is due to excessive phase and scan range.

Differences in percentage



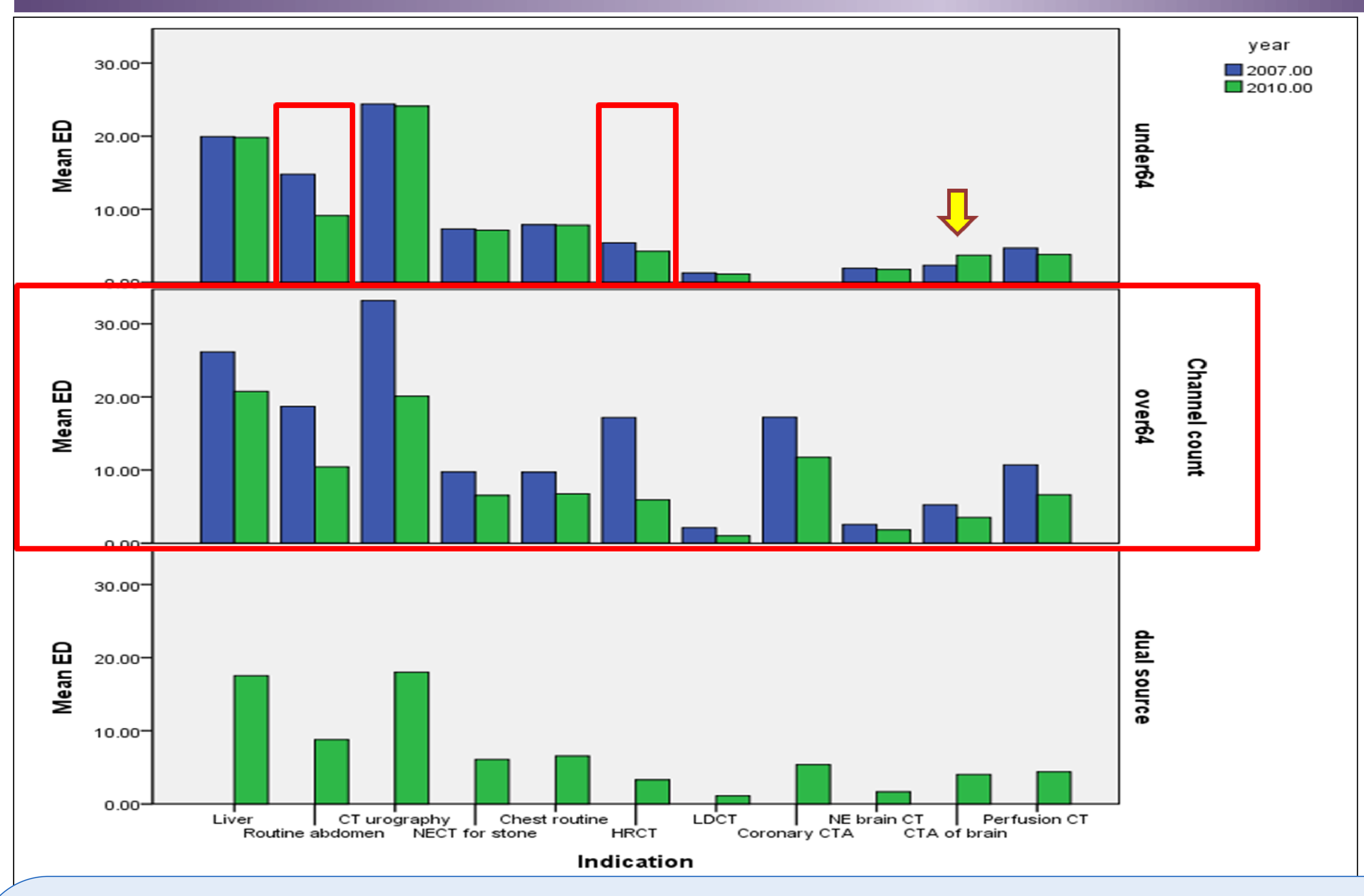
This graph shows percentage of decrement of CTDI green bars, and DLP the yellow bars, of each CT protocols, from 2007 to 2010.

Mean ED according to Vender



This graph shows the mean effective doses of each protocol at 2007 and 2010, according to the venders. The mean effective doses of each protocol were variable in 2007. In 2010, the EDs become similar, regardless of venders. Generally GE machines showed highest mean ED in 2007, and significantly decreased in 2010. Also, CT of Siemens and Philips showed some level of decrement in some protocols (red boxes).

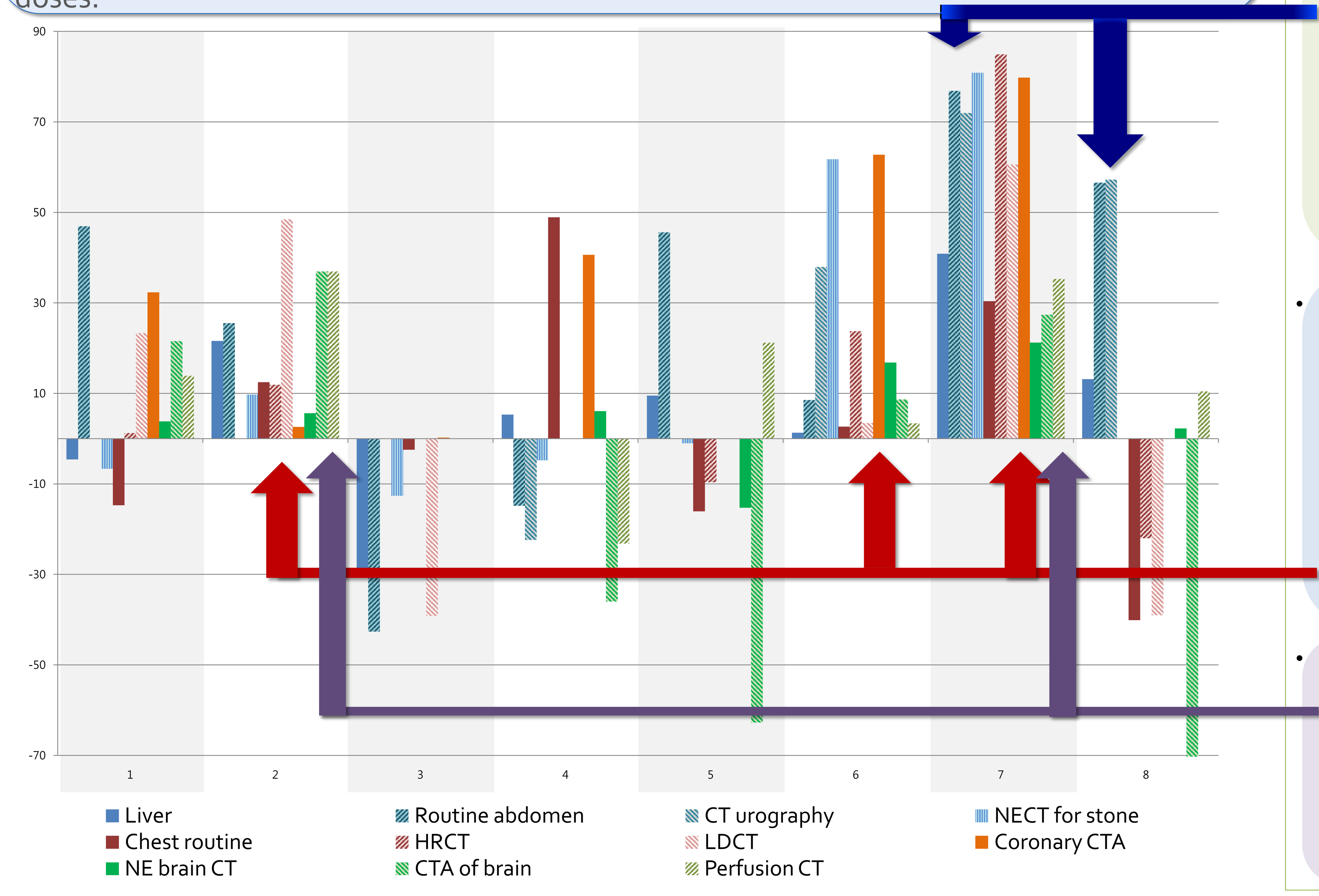
Mean ED according to CT type



We divided CT machines into three types, CT with fewer than 64 detector rows, CT with 64 or over detector row and dual source CTs. At 2007, CT with 64 or more detector rows showed higher ED than CT with fewer than 64 detector rows. But at 2010, the EDs of each protocol become similar in variable CT machines. Generally dual source CT shows lowest ED in all protocols. In all protocols, CT with 64 or more detector rows showed significantly decreased radiation dose (red boxes).

Total DLP gap(percentage): hospitals and CT protocols

We compared the average of total DLP between 2007 and 2010 in each protocol in 8 hospitals. 4 hospitals did not have individual CT dose data of 2007 CT exams in PACS database, so excluded. We transformed the differences into percentage. These 8 hospitals have generally variable degree of differences of DLP. Some hospital markedly decreased radiation dose, whereas some hospital showed little change or even increased effective doses.



Which CT parameters are mostly attributing to dose reduction?

- Abdomen Protocols
  - Modulation of kVp
    - According to BMI or body weight
    - Decreased kVp in precontrast scan
    - Increased usage of AEC: 61% -> 87%
    - Decreased level of noise index (GE machine) : 5 -> 28.2 (hospital 7)
    - Decreased reference mAs level
      - 200 mAs -> 175-200 mAs
  - Decreased numbers of phase
- Chest Protocols
  - Little usage of AEC: 19% -> 25%
  - Decreased mean mAs
    - Routine chest CT: 177.43 -> 122.75
    - HRCT: 207.67 -> 162.86
    - LDCT: 51.9 -> 25
  - Coronary CT in hospital 6 : same machine
    - Modulation of kVp according to BMI: 80 < BMI 25.0 < 120
    - Usage of cardiac specific image acquisition and dose modulation
- Brain Protocols
  - Modulation of kVp
    - Decreased kVp in perfusion CT of brain
  - Decreased mean mAs
    - NE brain CT: 320.4 -> 278.17
    - CTA of brain: 240.33 -> 218.57
    - Perfusion CT of brain: 212.5 -> 172.5

Conclusion

- We thought these were mainly due to the variation of awareness and efforts of radiologists. And the byproducts of 3 year clinical experience and efforts of radiologists and physicists are also very variable. Radiologists who concern about the medical radiation hazard, especially CT, would monitor radiation exposure from CT and do something with ALARA principle. They could cut off the radiation to as lowest level with acceptable level of image quality as possible. On the other hand, some radiologists merely ignore the potential problems from medical radiation and may put more importance on the image qualities and amount of information rather than cutting radiation off. These attitude finally resulted sub-optimization of CT scans, not reasonably low as achievable level.
- These results reflect radiologists' awareness of radiation hazard and their active efforts of radiologists for CT dose optimization.