A method to evaluate compliance with the new ICRP limit for eye lens dose in diagnostic and interventional radiology

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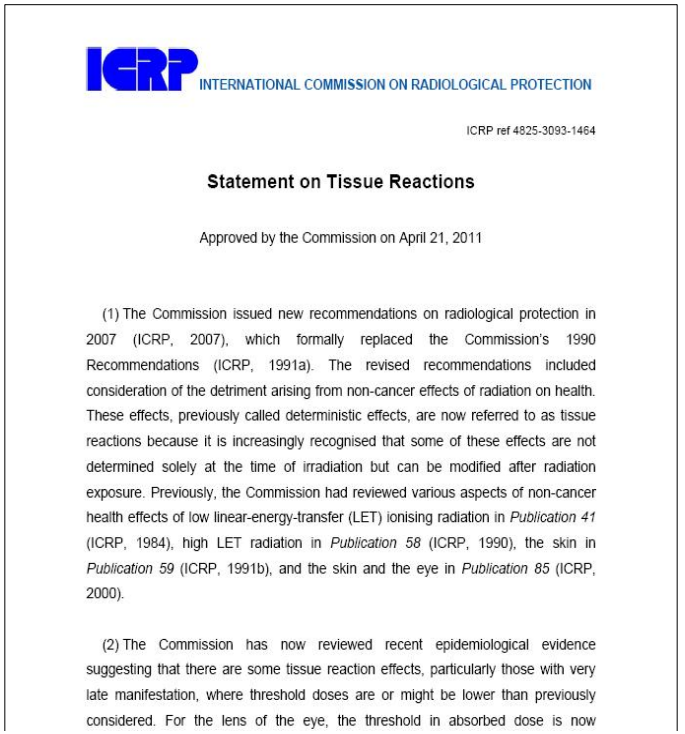
Regulation and guidelines

SSM´s dose limits concerning workers in practices involving ionising radiation

Dose Quantity	Annual Dose Limits [mSv]
Effective dose	50
Equivalent dose to the lens of the eye	150
Equivalent dose to the skin	500
Equivalent dose to extremites	500
Average effective dose over defined periods of 5 years	20



ICRP INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION

ICRP ref 4825-3093-1464

Statement on Tissue Reactions

Approved by the Commission on April 21, 2011

(1) The Commission issued new recommendations on radiological protection in 2007 (ICRP, 2007), which formally replaced the Commission's 1990 Recommendations (ICRP, 1991a). The revised recommendations included consideration of the detriment arising from non-cancer effects of radiation on health. These effects, previously called deterministic effects, are now referred to as tissue reactions because it is increasingly recognised that some of these effects are not determined solely at the time of irradiation but can be modified after radiation exposure. Previously, the Commission had reviewed various aspects of non-cancer health effects of low linear-energy-transfer (LET) ionising radiation in *Publication 41* (ICRP, 1984), high LET radiation in *Publication 58* (ICRP, 1990), the skin in *Publication 59* (ICRP, 1991b), and the skin and the eye in *Publication 85* (ICRP, 2000).

(2) The Commission has now reviewed recent epidemiological evidence suggesting that there are some tissue reaction effects, particularly those with very late manifestation, where threshold doses are or might be lower than previously considered. For the lens of the eye, the threshold in absorbed dose is now

The Commission now recommends an equivalent dose limit for the lens of the eye of 20 mSv in a year, averaged over defined periods of 5 years, with no single year exceeding 50 mSv

Karolinska University Hospital

- Geographical located at two sites, Solna and Huddinge
- 42 departments are included in the radiation safety organisation
    - Approximately 2000 employees are working in the area of X-ray
    - 9 angiography and interventions units
    - 8 operation and fluoroscopy units
    - 3 computed tomography units with supervisory staff during exams

Start up – Eye Dose Study

Type of measurements?

Dose measurements in clinical environments. For example to include staff members movement pattern and the use of radiation protection screens

In which departments should measurements be performed?

The department with the highest dose burden for different modalities where staff members are present in the X-ray room.

Type of dosimeters?

- EDD-30

- TLD
- Realtime dose monitoring system

Pro & cons for realtime dose monitoring system in dose studies

a. Active dosimeter, PDM
b. Base station
c. Dose manger, software to analyse radiation dose

Benefits

- Easy to use for clinical staff
- Dose rate information – describes the radiation environment
- Dose measurements of several staff members simultaneously
- Gives real time feed back to staff

Cons

- Radiation dose differ between eye and thorax
- Dose variations can occur between labs, because of different radiation environments and the visual effect of the monitoring system
- Time consuming to analyse dose per procedure in Dose Manager

Action levels – A screening approach

Dosimeters for large scale eye dose studies, Hp(3) are nonexistent, therefore screening dose measurements that are compared with an Action level are needed.

An action level will state when more accurate dosimetric measurements should be performed.

Determine an Action Level:

1.Identify and quantify sources of error

2.A correction factor is derived that takes into account a reasonable uncertainty, by overestimating the error.

3.Estimate the Action Level by the correction factors and the dose limit for the lens of the eye

If the approximated staff dose is higher then the action level a potential risk for exceeding the dose limit to the lens of the eye is present and additional more accurate measurements are needed

Example of correction factor - active dosimeters at thorax

Phantom measurement, with active dosimeters placed at the forehead and the thorax, will give dose differences for:

–different position in the room

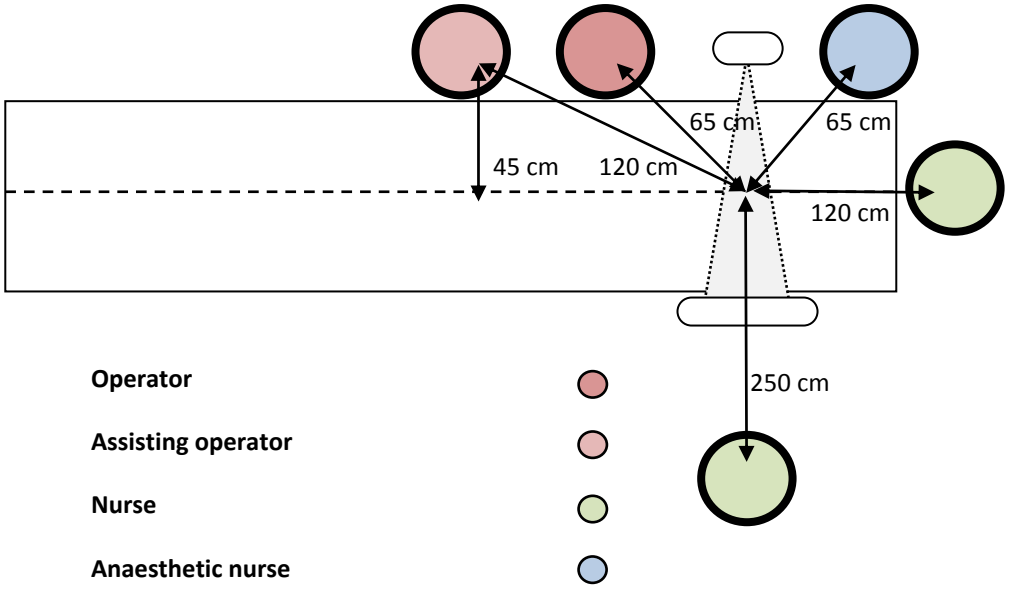
–different geometries of the c-arm

Measurements on staff, with active dosimeters placed at the forehead and the thorax, will include dose differences for:

–movement patterns

–radiation protection equipment

–various categories of staff



The phantom and staff measurements will result in one correction factor for determination of an Action level (realtime dose montioring in angiographic rooms).

Screening method – step by step

1. Perform series of dose measurements on staff and determine the action level
2. Collection of dose indicators as DAP and DLP for each type of procedure for approximately one year and determine:

- Median DAP- and DLP-values for each exam and intervention
- Number of procedures for each procedure type

3. Each staff dose measurement will be normalized to the general dose burden for each type of procedure according to equation 1

$$H_p(d)_{i,general} = H_p(d)_i \cdot \frac{DAP_{median}}{DAP_i}$$ **Equation 1**

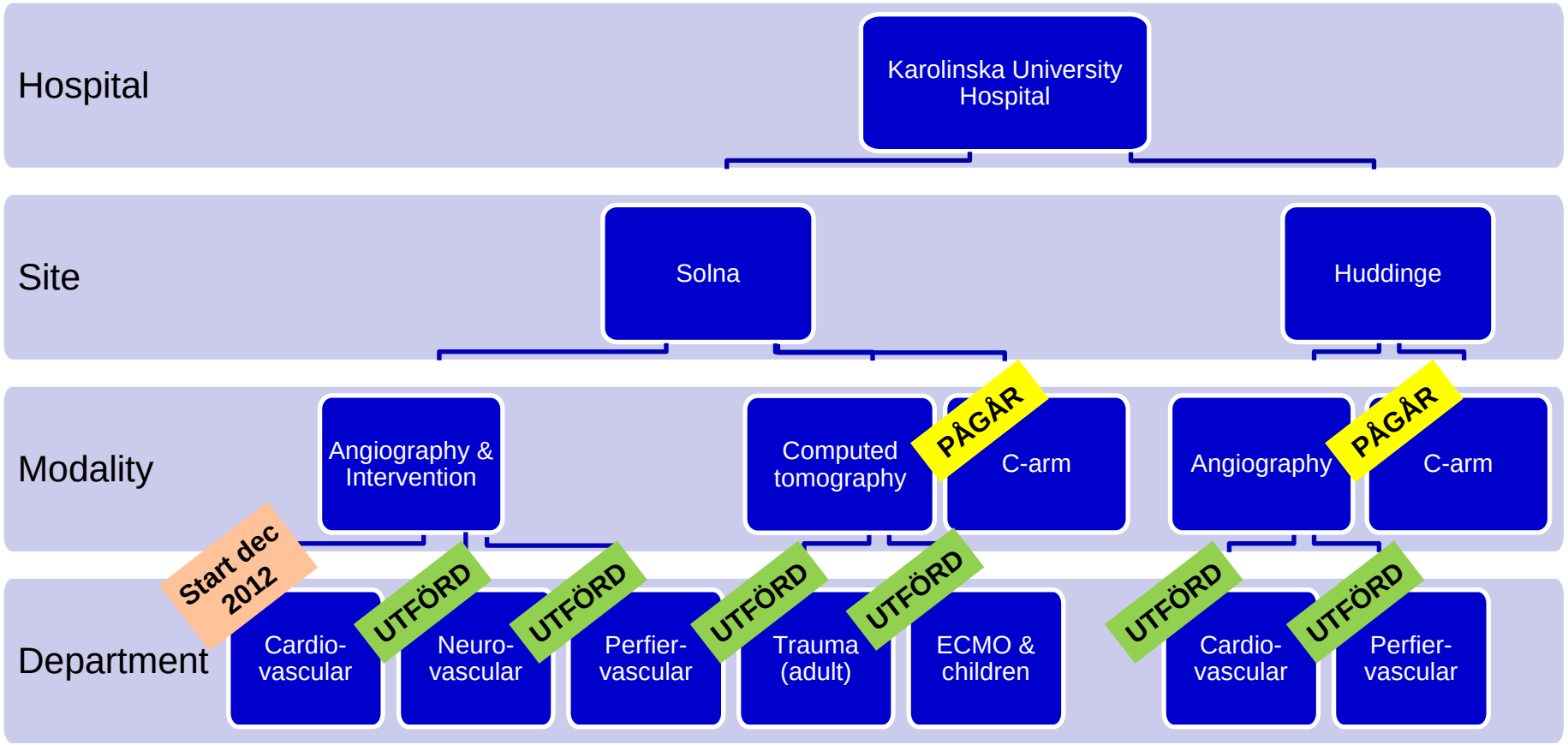
4. The 3rd quartile dose value from each series of measurement specific to a occupational group will represent the dose for one exam type and one profession
5. The yearly collective dose for each profession and compared with the Action level
6. If the yearly collective dose > Action level. Identify the worker that perform most of the procedure and estimate the individual dose. Compare again with the Action level

Suggestions of activities if Staff dose > Action level

- More accurate dosimetric measurement will be performed and compared with the dose limit to the lens of the eye before further action is taken
- Estimated the Action Level more accurate
- Radiation protection training to staff
- Introduce radiation protection screens or lead glasses

The eye dos study at Karolinska - First results

Series of measurements - Departments included



Define Action Level - First measurement on staff

During four weeks four workers at the cardiology department had active dosimeters both at the forehead and at the chest, in addition they also had TLD´s close to the left and right eye

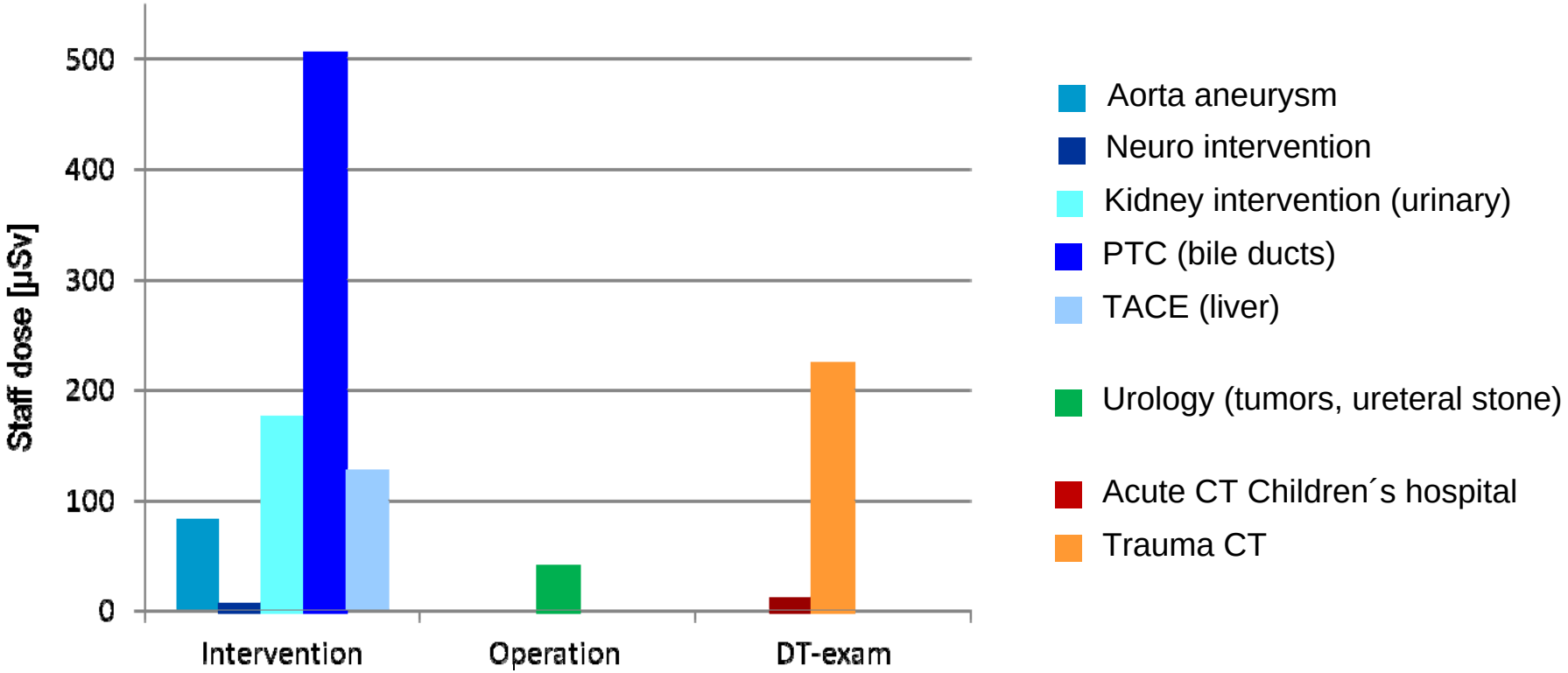
Profession	Placement	Hp (0,07) µSv	Hp (10) µSv	
Individual	Eye	TLD Forehead	PDM Forehead	PDM Thorax
Nurse 1	Left	135	152	149
	Right	130		
Nurse 2	Left	192	227	193
	Right	166		
Nurse 3	Left	134	110	164
	Right	58		
Operator	Left	1063	629	682
	Right	583		

The first result indicates that the correction factor$_{THORAX}$ for staff member is:

–1 between thorax and forehead for staff members not always working close to the patient

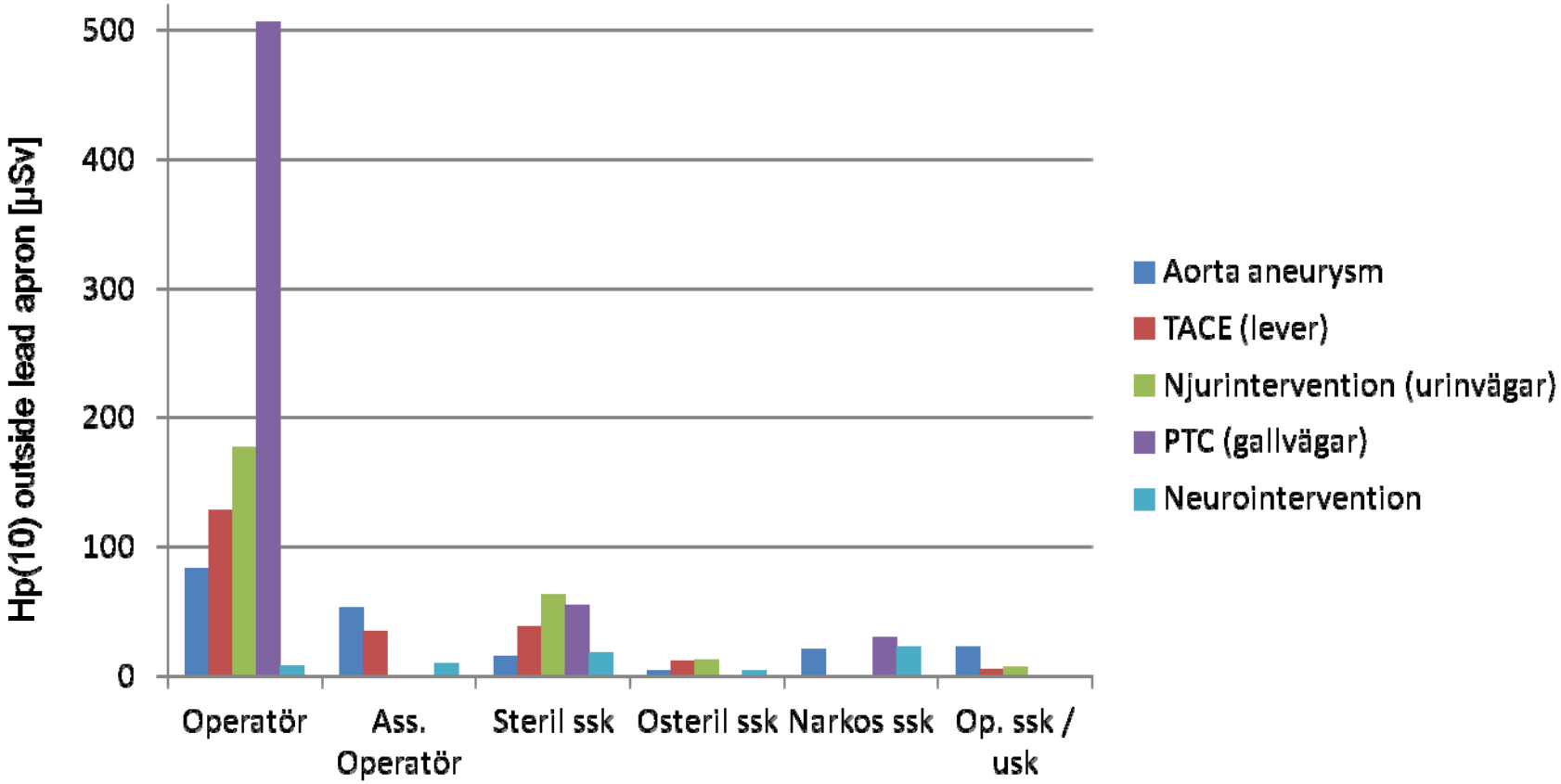
–2 between thorax and the eye closes to the scattering area for staff members standing along the patient table

Staff dose per procedure working at different modalities



- **Intervention:** Realtime monitoring system measure Hp(10) at chest outside lead apron
- **Operation**: EDD-30 measure Hp(0,07) at forehead
- **DT-exam**: Realtime monitoring system Hp(10) at forehead
  EDD-30 Hp(0,07) at forehead

Staff dose to different occupational groups in the angiographic room



There are individual dose values above 100 µSv for all occupational groups except the ass. operator

Discussion

- Staff dose measurements, Quantity or Quality?
- Is staff dose proportional to DAP/DLP?
- What is the benefits by measuring dose per procedure?
- Radiation protection screens vs. lead glasses