

Radiation dose to interventional radiology staff – can it be assessed according to the exposure measurements of only one radiation badge: trunk, head or finger?

Purpose

The relations between the trunk, head and finger badge exposures for three radiologist performing similar medical procedures were analyzed in order to find a possible relation between the badges exposures.

Material and methods

A follow up during 52 months for three interventional radiologists, Dr. K, Dr. O and Dr. L, was performed, observing their trunk, head and finger badges exposures. The radiation badges were supplied and measured monthly by the Israeli monitoring service.

The wraparound protective aprons used by the staff consist of 0.25 mm lead equivalent (l.e.). A full overlapping in the apron's front side is supposed to create a 0.5 mm l.e. The thyroid protective shield consists of 0.5 mm l.e. and protective glasses of 0.5 mm l.e.

Both the trunk and head badges are worn at the chest height behind and above the lead apron, respectively. The finger badge is usually worn on the left radiologist's hand, as being closer to the radiation field.

The total follow up period was divided into three periods, according to the location of the head badges and the apron's frontal part full or partial overlapping (table 1)

Table 1 – Location of head badges and degree of apron's frontal part overlapping

Period	Location of head badges	Degree of overlapping
Aug. 2007 to Mar. 2008	Chest height	Partial overlapping*
Apr. 2008 to Jan. 2009	Attached to the thyroid shield	
Feb. 2009 to Nov. 2011		Full overlapping

*may cause trunk badge positioned behind 0.25 mm or 0.5 mm l.e. shielding

Results and Analysis

1. The ratio between trunk and head badges exposures

A part of the 52 months measurements of the radiation badges were excluded from the analyzed data for the following reasons:

- ratio between trunk and head badge above 10% (mostly caused by changing locations between the badges).
- lack of trunk or head badge report.

Some of the trunk badges exposures were not reported, being lower than 10 mrem, which is the lowest measurable dose for trunk badges. Based on the fact that radiation doses for the finger and the head badges were measured at the respective months, we have replaced these non measurable exposures reported for trunk badges by non zero values, in order to enable data analysis. We performed the analysis in two ways, assuming arbitrary exposure levels of 3 mrem or 7 mrem, instead of the unknown exposures between 0 to 9 mrem.

Table 2 – Average ratios between trunk and head badges exposures – radiologist K

Ratio between trunk and head badges exposures			No. of months Included in the analysis
	Analysis with non reported exposure of trunk badge replaced by		
Period	3 mrem	7 mrem	
Aug. 2007 to Mar. 2008*	6.0% +- 2.3%**	6.0% +- 2.3%**	8
Apr. 2008 to Jan. 2009	Single data point	Single data point	1
Feb. 2009 to Nov. 2011	1.6% +- 1.0%**	2.0% +- 0.8%**	31 (15)***

* Any not reported exposures (below detection limit of 10 mrem) of trunk badge in this period.

** Errors are 1SD.

*** Figures in parenthesis indicate no. of months with non reported trunk badge exposures (below 10 mrem).

Table 3 – Average ratios between trunk and head badges exposures – radiologist O

Ratio between trunk and head badges exposures			No. of months included in the analysis
	Analysis with non reported exposure of trunk badge replaced by		
Period	3 mrem	7 mrem	
Aug. 2007 to Mar. 2008*	4.0% +- 2.4%**	4.0% +- 2.4%**	6
Apr. 2008 to Jan. 2009	2.5% +- 1.8%**	3.2% +- 1.5%**	6 (3)***
Feb. 2009 to Nov. 2011	2.2% +- 1.8%**	2.6% +- 1.5%**	29 (13) ***

* Any not reported exposures (below detection limit of 10 mrem) of trunk badge in this period.

** Errors are 1SD.

***Figures in parenthesis indicate no. of months with non reported trunk badge exposures (below 10 mrem).

Table 4 – Average ratios between trunk and head badges exposures – radiologist L

Ratio between trunk and head badges exposures			No. of months included in the analysis
	Analysis with non reported exposure of trunk badge replaced by		
Period	3 mrem	7 mrem	
Aug. 2007 to Mar. 2008	2.7% +- 2.5%*	2.9% +- 2.3%*	7 (3)**
Apr. 2008 to Jan. 2009	2.0% +- 1.2%*	3.1% +- 1.9%*	7 (4)**
Feb. 2009 to Nov. 2011	1.9% +- 1.9%*	2.8% +- 1.6%*	30 (17)**

* Errors are 1SD

** Figures in parenthesis indicate no. of months with non reported trunk badge exposures (below 10 mrem).

A reduction in the trunk to head badge measurement ratios for the third period relative to the first period is observed for the three radiologists. This reduction is better observed when zero reports are replaced by 3 mrem. This reduction is mostly due to the change in the head badge location. Further investigation has to be made for finding the optimal value for replacing the zero results.

2. The ratio between head and finger badges exposures

Table 5 – Average ratios between head and finger badges exposures

<u>Period</u>	<u>Dr. K,</u>	<u>Dr. O,</u>	<u>Dr. L,</u>
*Aug. 2007 to Mar. 2008	51% +-16%	51% +-29%	45% +-16%
**Apr. 2008 to Nov. 2011	30% +- 15%	31% +- 17%	22% +- 16%

*head badge worn at the chest height

**head badge attached to the thyroid shield

For each period similar values of the ratio are observed for the radiologists. In addition note the same reduction of the ratio value at the second period compared to first one.

Discussion

Some previous studies found that a personal dosimeter worn outside a protective apron is a good screening device for dose to the eyes and fingers (1), that very significant correlation between finger dose and the dosimeter worn outside the lead apron was found (2) and that a linear relation between the measurements above and those under the lead apron was proved (3) The trunk radiation badge, has to be worn into the shirt pocket or hanged behind a protective apron of 0.5 mm l.e. At wraparound aprons the 0.5 mm l.e. has to be achieved by a full overlapping of two plies of 0.25 mm. According to our experience, as in our study during period 1(table 1), some radiologists use aprons which do not provide full overlapping, due to improper design or as a result of wearing aprons not adapted to their sizes. As a result, at two strips of about 10-20 cm. along the axillary lines, the radiologist is protected by only 0.25 mm l.e. Depending on its location, the trunk badge will measure the exposure behind 0.25 mm or 0.5 mm l.e. One has to be aware of the possible higher exposures of the radiologist along the strips of 0.25 l.e. protection, which obviously are not measured by the trunk badges.

The head badge, targeted for measurement of the lens of eyes exposure, is worn above the protective apron, at the chest height. The head badge may be located at different heights and left-right locations, influencing its exposure and therefore the trunk to head ratio.

The following factors influence the trunk, head and finger badges exposures and the ratios between them:

- type of fluoroscopy system
- nature of procedure performed
- radiologist's experience including ultrasound guidance
- radiologist's instruction in radiation protection
- radiologist's physique.
- improved work methods applied by proper radiography techniques
- location of the head and trunk badges
- use of sterile protecting gloves and upper protecting shielding

Conclusions

In our study the ratios of trunk to head badge exposures varies from 1.6% to 6%. For a specific radiologist it's possible to evaluate the trunk exposure based on the head badge exposure. Nevertheless, assuming the same nature of procedures performed, a gross estimation of the trunk badge exposure based on the head badge measurement is possible.

The ratios of head to finger badge exposures vary from 22% to 31% for our three interventional radiologists, which perform similar medical procedures. In our view, depending on many factors, a reliable correlation between head and finger badges exposures for interventional radiologists working in different units is difficult to be established.

References

1. E. Strandén, A. Widmark, T. Sekse; Assessing doses to interventional radiologists using a personal dosimeter worn over a protective apron
2. E. Strandén, T. Seske, A. Widmark; Indicators for the finger doses in interventional radiology
3. Gerritjan Kuipers, Xandra L. Velders et al.; Evaluation of the occupational doses of interventional radiologists