

# Radiation protection of staff in cardiology and interventional radiology

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 **stuk**

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Säteilyvaara  
Strålrisk

5

Säteilyn käytön  
turvallisuus  
kardiologiassa

Material and images of this presentation are mostly from a new Finnish book "*Radiation safety in Cardiology*" (Säteilyn käytön turvallisuus kardiologiassa), Radiation and Nuclear Safety Authority in Finland (STUK), 2018.

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Google: "*säteily kardiologia*"

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# **Radiation protection of staff in cardiology and interventional radiology**

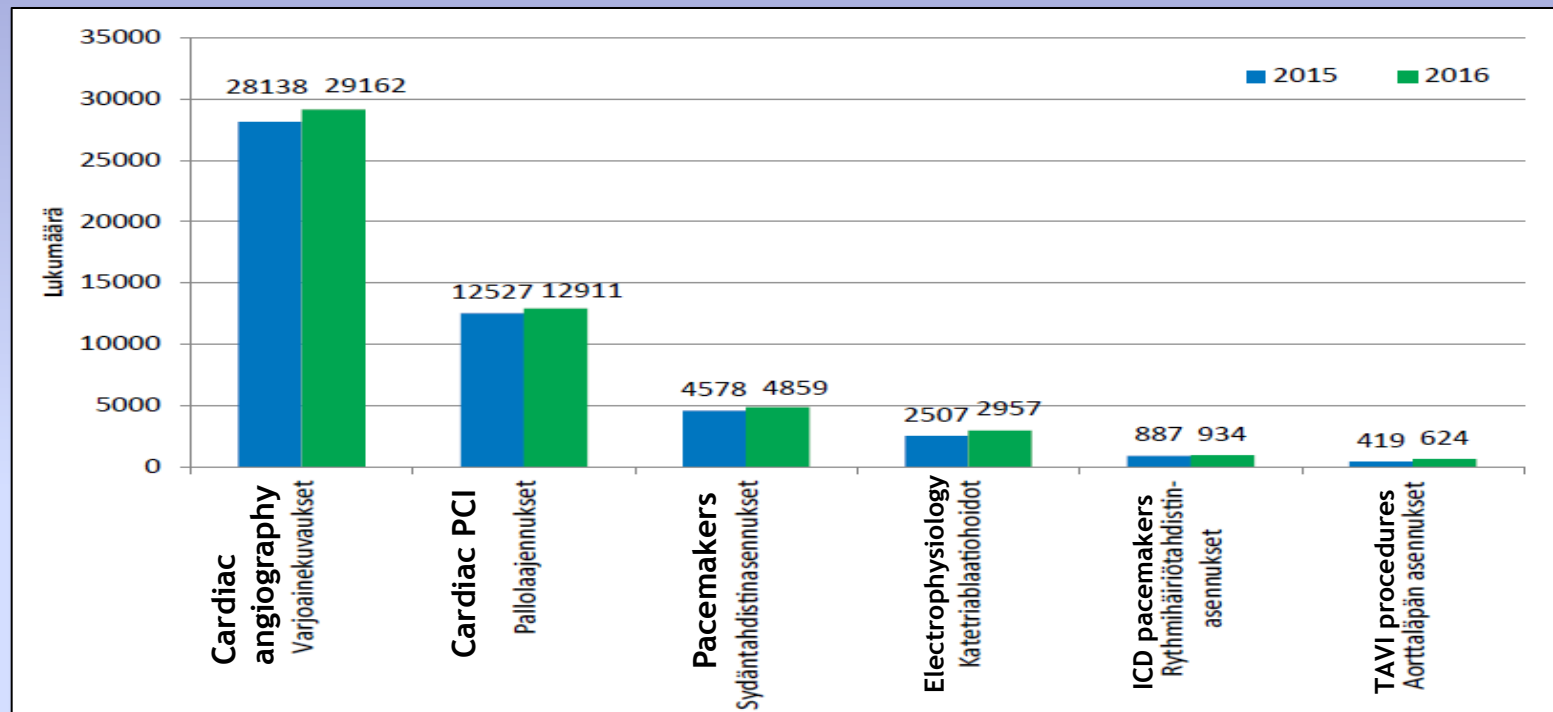
1. Problems, good news and challenges
2. Radiation doses of personnel in cardiology
3. Radiation protection of staff in angiolab
4. How to minimize the use of radiation
5. Rule of thumbs

# Problem 1. Workers are usually not able to move away from angiolaboratory during procedures



→ radiation protection of staff has an important role!  
(and has partly same principles than radiation protection of patients!)

# Problem 2. In Medical diagnostics and treatments has cardiology and interventional radiology growing demand in Finland and many other countries



→ demand of diagnostic and treatments is estimated to rise even at 5 % per year in cardiology at coming 15 years in Finland!  
(it is estimated that age group of 75+ almost doubles in 15 coming years).

# Good news 1. Modern X-ray systems are able to provide excellent image quality with lower X-ray exposure

Imaging systems equipped with enhanced filtering and software systems can significantly decrease radiation exposure to both operator and patient

→ the decrease in radiation exposure between the modern imaging systems and conventional systems can be even 40% - 70% [1]

[1] Decrease in Radiation Exposure during Cardiac Implantable Electronic Device (CIED) Implantation with Modern Imaging Platform. Chudow et al., International Journal of Clinical Cardiology & Research, 2018



**Challenge 1. Complexity of procedures and disease being treated has increased**  
(e.g. CTO procedures in cardiology)

**Challenge 2. development of novel interventional alternatives for diseases traditionally treated with surgery**  
(e.g. TAVI and MitralClip –procedures in cardiology)

→ amount of staff in the operational theatre should be “as low as possible” but may vary depending e.g. on a complexity of cardiological procedure



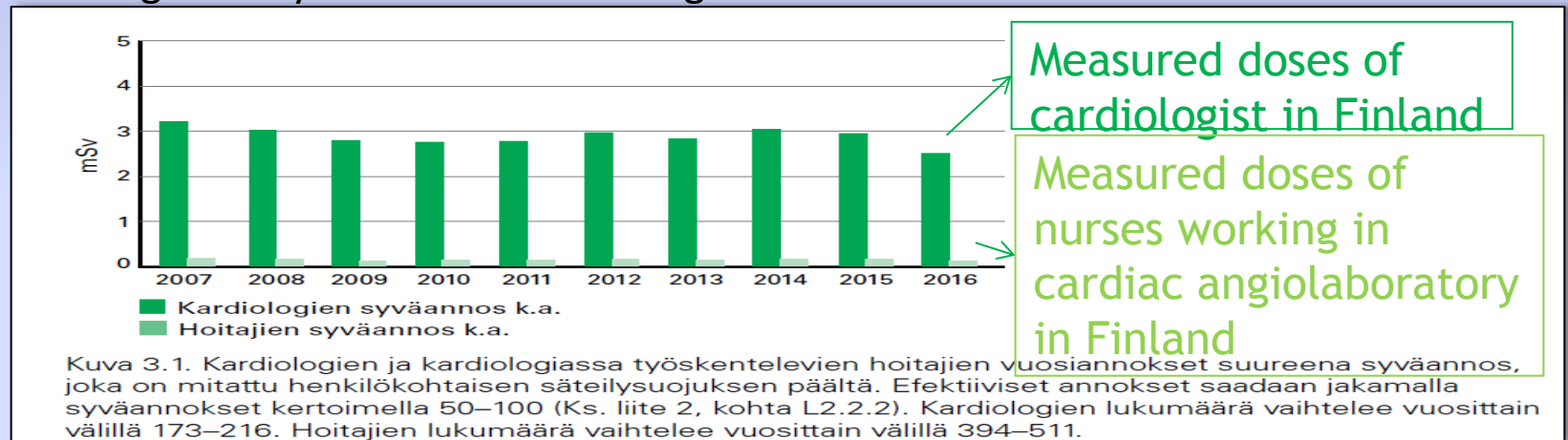
# Radiation doses of staff

- Measured radiation doses of invasive cardiologists can be yearly between 4 – 10 mSv
  - to get effective doses measured doses can be divided by 30 or even 50



(background radiation in Finland mean value is 4 mSv per year)

→ in some research this amount of extra radiation for interventional cardiologists working 20-30 years is estimated to give 1:100 extra lifetime cancer risk



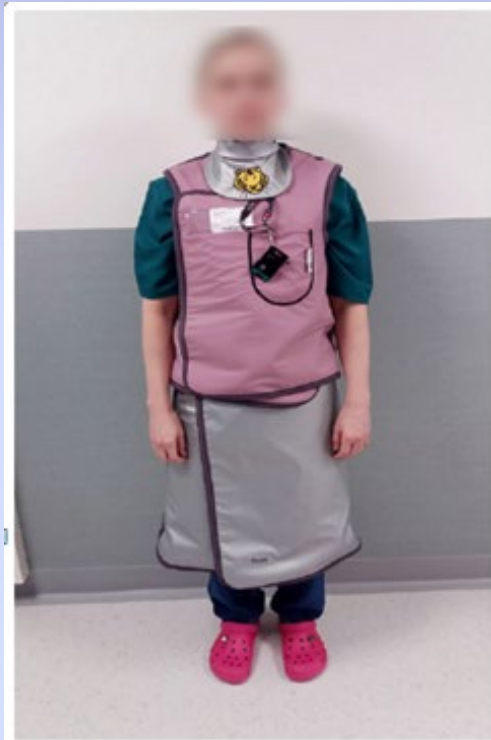
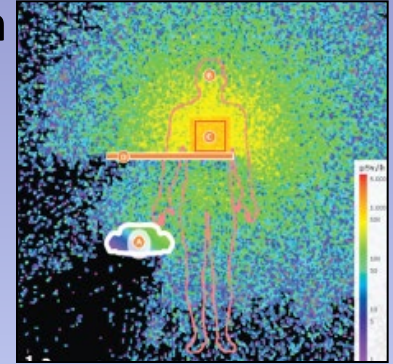
- Also a risk of cataract can be risen for cardiologists doing several hundred (e.g. 400 – 800) procedures per year



# Radiation protection of staff in angiologlab

## - scattered radiation

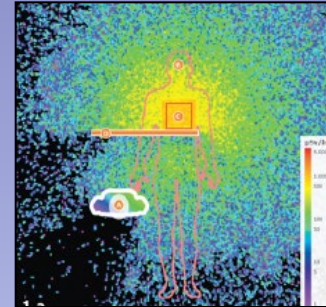
- Most important protection method from scattered radiation from patient are lead aprons:
    - X-ray vest and skirt
    - thyroid shield (with lead equivalents of 0.25 or more mmPb)
- when properly used, the effective dose of staff can be reduced at factor 1/10 or even 1/30!





# Radiation protection of staff in angiolab - scattered radiation

- Good use of time-distance-shielding (TDS) principle  
→ if a radiation worker doubles her distance from a source, her dose is now one-fourth of the original dose.



Kuva 3.9. Etäisyyden kasvattaminen säteilylähteeseen pienentää henkilökunnan annosta. Jo yksi askel taaksepäin potilaasta voi pienentää annosta neljännekseen. Kuvassa potilashoitaja, joka lääkitsee potilasta tutkimuksen kuluessa. Kuvat: Tuomas Rissanen, Siun sote.

***“take step backwards from radiation source always when possible”***

# Radiation protection of staff in angiolab - scattered radiation

## - **Operator: use angiography device in a optimal way also with radiation protection point of view!**

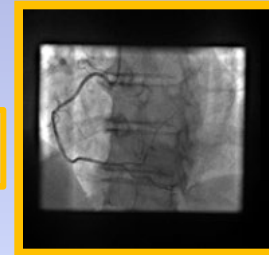
- \* Set image intensifier as close to patient as possible,
- \* Set x-ray tube as far away from patient table as possible (by rising patient table)

- \* Avoid unnecessary fluoroscopy- and image series,
- \* Avoid unnecessary zoom during fluoroscopy,

- \* Collimate imaging area as well as possible,

- \* Optimal imaging protocol

(as low amount of pulses in fluoroscopy as possible) etc.

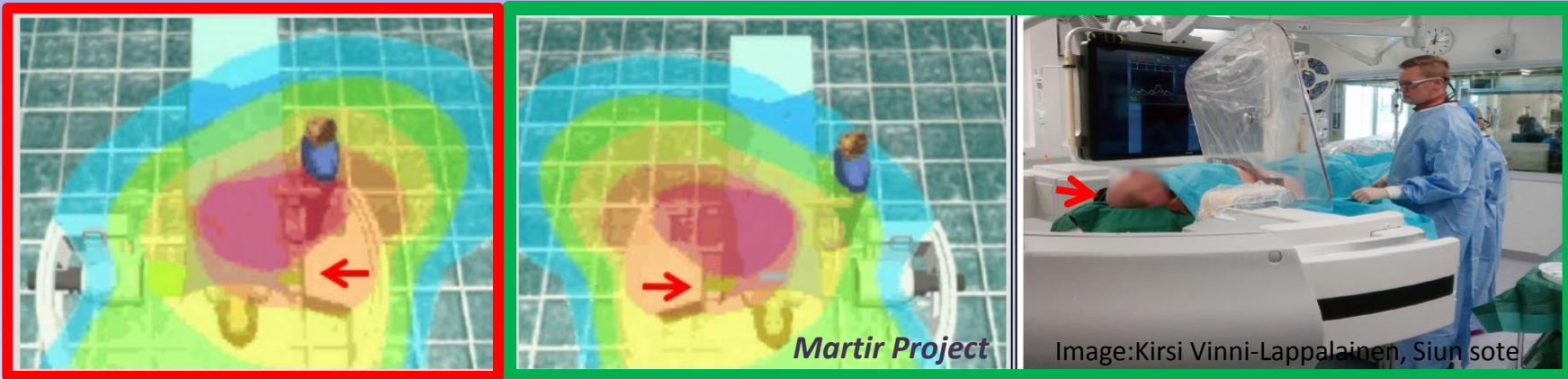


# Radiation protection of staff in angiolab - scattered radiation

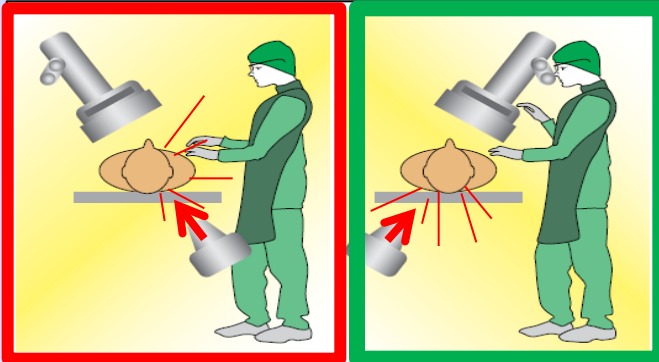
\* avoid steep angles while imaging

→ detector should rather be in operators side

(radiation is highest at x-ray tube side of patient, look images below)



\*



Use rather RAO- (right)  
(and PA-) than LAO- (left)  
projections

→ operators eye dose is  
higher at LAO projection

Kuva 3.11. RAO-kallistus (oikealla) on sekä toimenpiteen suorittajan että potilaan säteilysuojelun kannalta parempi. LAO-kallistuksessa (vasemmalla) toimenpiteen tekijän silmät altistuvat suuremmalle määrälle sironnutta säteilyä.



# Radiation protection of staff in angiolab - scattered radiation

## Use and be behind protective shields:

- Operator:

- \* Set upper shield to the surface of patient as well as possible,
- \* Use table shields,
- \* Do not use fluoroscopy or take images while e.g. nurses are giving medicine to patients etc.



Kuva 3.3. Kuvia varjoainekuvaussalista, jossa kattoon kiinnitetty lyijylasisuoja kiinni potilaassa. Alasirontasuoja suojaa potilasta pöydän alta tulevalta sironnalta. Avustaja on mahdollisimman kaukana säteilylähteestä. Oikealla olevassa kuvassa kiinteä säteilysuojaseinä, jonka taakse potilashoitaja ja tutkimusta seuraavat henkilöt voivat mennä kuvausten ajaksi.

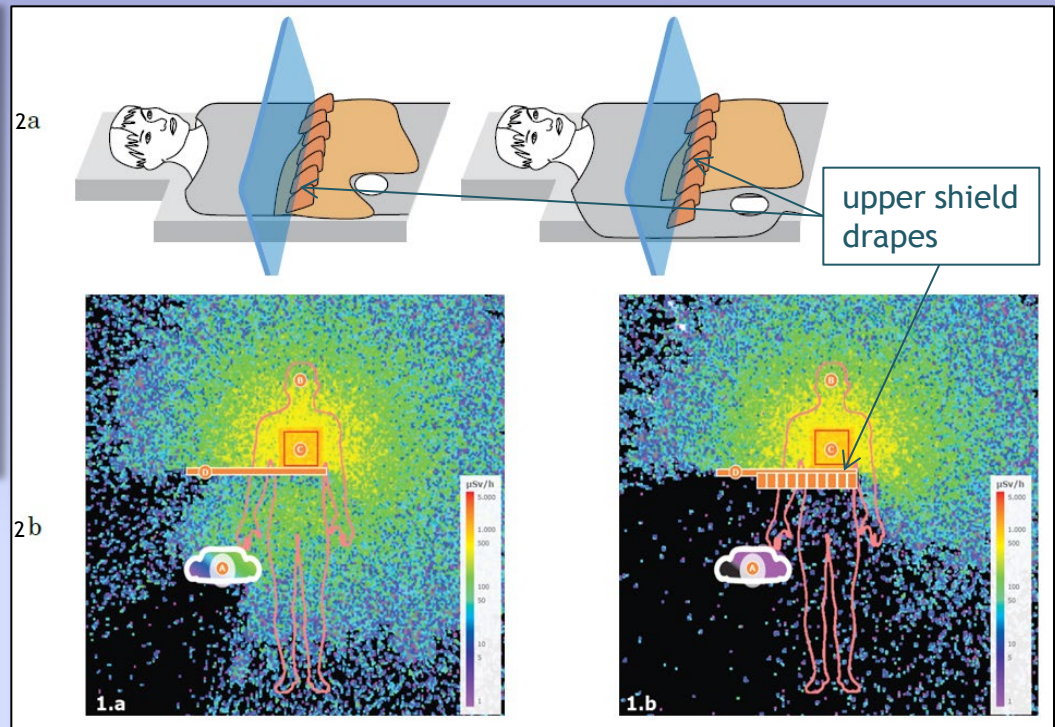
Kuva vasemmalla: Tuomas Rissanen, Siun sote. Kuva oikealla: Timo Mäkelä, OYS.

# Radiation protection of staff in angiolab - scattered radiation

- Disposable sterile radiation shields reduces operator radiation exposure during percutaneous coronary intervention even at 1/3 of original dose



Image (left). Disposable radiation shield for radialis coronary angiography



- Image 2. (right) 2a) Disposable radialis (left) and femoralis (right) drapes with upper shield with drape
- 2b) Set upper shield to the surface of patient as well as possible
- In 2b) left image the upper shield is not properly attached to the skin of the patient.
- In 2b) right there are drapes in upper shield that blocks scattered radiation



# Radiation protection of staff in angiolab

## - scattered radiation

- mobile lead barriers and e.g. table shields will minimize scattering radiation from patient and lower the staff dose (e.g. nurses)
- when possible it is good to be outside of operating room during procedure



Image. Mobile x-ray barrier in TAVI-procedure.



Image. Safe location in control room during procedure. Kuva TM, OYS.

# Radiation protection of staff in angiolab - scattered radiation

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- During CRP (cardiopulmonary resuscitation)  
the fluoroscopy and imaging are usually stopped
- resuscitation team should take care of own protection (X-ray shirt, vest etc.)
- Automatic chest compression systems like Lucas2  
or Zoll Autopulse is recommended e.g. if PCI is continued during CRP



Automatic chest compression system in demonstration situation.  
The equipment could be used only in cranial or caudal directions.  
Image: Tuomas Rissanen, Siun sote.

# Radiation protection of staff in angiolab - pacemaker implantation

Pacemakers are usually set up from left side of patient

→ use collimation

→ patient shield under head and pelvis

→ use at end of table radiation protection drapes (x-ray tube usually under table)

→ recommended to use low pulses (3,5/s tai 7,5/s) and AP direction



Image. Pacemaker implantation. Sterile vismutdrape (Radpad) lowers the scattered radiation from patient. Upper shield is often difficult to use during pacemaker implantation.

Image (left) Tuomas Rissanen, Siun sote, Image (right): Markku Eskola, TAYS Sydänsairaala, Tampere.



# Radiation protection of staff in angioblab - electrophysiology

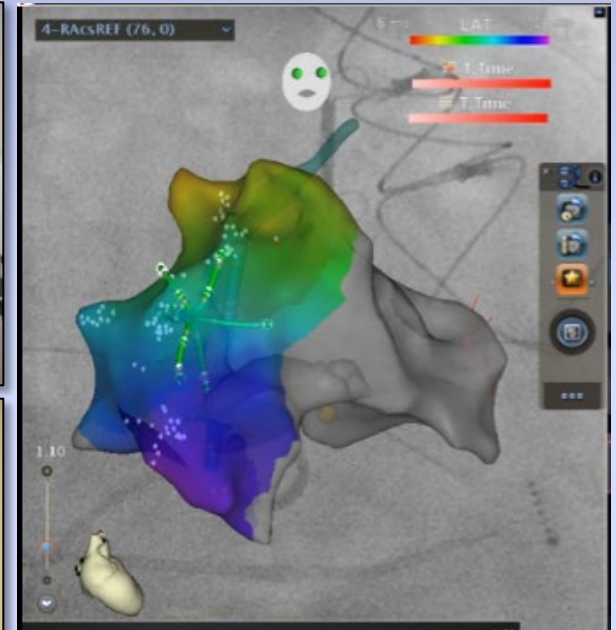
In electrophysiology lower image quality is usually needed than in angiography

→ the use of upper shield in patient table is important

→ use fluoroscopy e.g. in 3,75 p/s (usually only low quality fluoroscopy is needed)

→ mapping softwares (e.g. Carto, Ensite) lowers the need of using radiation

→ the use of magnetic navigation (Stereotaxis) lowers the scattered radiation to the staff because procedure can be performed mainly from control room



Carto 3D Mapping of cardiac arrhythmias - atrial flutter

<https://www.youtube.com/watch?v=rvvE9Ngjpo&feature=youtu.be>

# Radiation protection of staff in angiolab - TAVI

Transcatheter Aortic Valve Implantation (TAVI) and MitraClip-procedures

\* usually many people in the operating room during procedure

→ it is important to communicate clearly while using radiation

→ in TAVI and MitraClip it is recommend to use drapes in end of the table (image left)

→ there should be enough **mobile barriers** in operating room for staff

→ in MitraClip procedures it is important to protect also operator performing ultrasound (image down right)

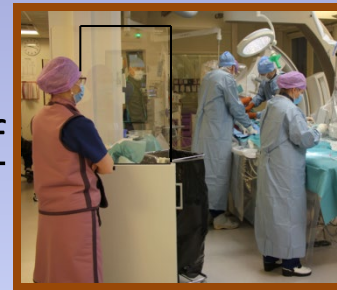
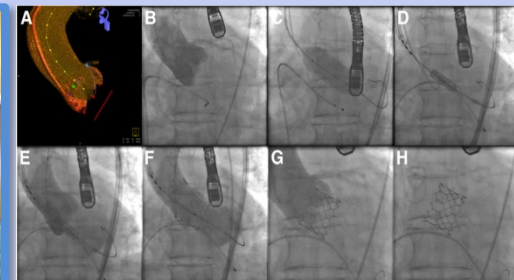


Image. Table lead-drapes in TAVI- and MitraClip procedures. Image: Markku Eskola, TAYS Sydänsairaala.



Image. Protection of operator of ultrasound in MitraClip-procedure. Image: Markku Eskola, TAYS Sydänsairaala.



JACC: CARDIOVASCULAR INTERVENTIONS  
© 2015 BY THE AMERICAN COLLEGE OF CARDIOLOGY FOUNDATION  
PUBLISHED BY ELSEVIER INC. <http://dx.doi.org/10.1016/j.jcin.2015.05.010>

## Transcatheter Aortic Valve Replacement With the SAPIEN 3

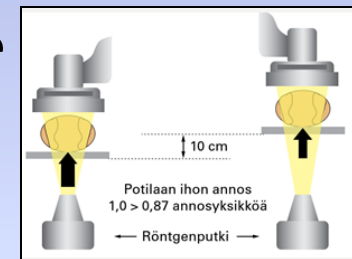
### A New Balloon-Expandable Transcatheter Heart Valve

Ronald K. Binder, MD,\* Josep Rodés-Cabau, MD,† David A. Wood, MD,\* Michael Mok, MD,† Jonathon Leipsic, MD,\* Robert De Larochellière, MD,† Stefan Toggweiler, MD,\* Eric Dumont, MD,† Melanie Freeman, MBBS,\* Alexander B. Willson, MBBS,\* John G. Webb, MD\*



# In leaflet “Radiation safety in Cardiology” the nine “rule of thumbs” mainly to operators were ...

- 1) Avoid unnecessary staying beside x-ray tube.  
Take a step backwards from imaging area (x-ray tube) whenever possible. Use and be behind protective shields.
- 2) Avoid unnecessary fluoroscopy- and image series
- 3) Set pulse and imaging frequencies as low as possible
- 4) Set x-ray tube as far away from patient table as possible (by rising patient table)
- 5) Avoid steep angles while imaging.  
Use rather RAO- than LAO-projections
- 6) Set image intensifier as close to patient as possible. Lowest scattered radiation doses are at image intensifier side of table.
- 7) Avoid unnecessary zoom during fluoroscopy and angio imaging.
- 8) Collimate imaging area as well as possible
- 9) Set upper shield to the surface of patient as well as possible.



# IAEA Radiation Protection Posters – Radiation protection of staff in fluoroscopy

<https://www.iaea.org/resources/rpop/resources/posters-and-leaflets>

## 10 Pearls: Radiation protection of **staff** in fluoroscopy

Reducing patient dose always results in staff dose reduction

### 1. Use protective devices!



Advisable skirt type lead apron to distribute weight

0.25 mm lead equivalence but with overlap on front to make it 0.5 mm on the front and 0.25 mm on the back (Provides >90% protection)



Lead glass eyewear with side protection



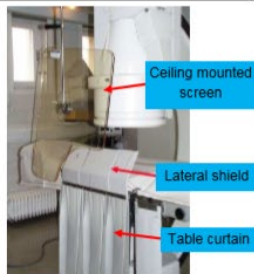
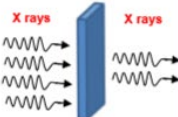
Thyroid protection

### 2. Make good use of time-distance-shielding (TDS) principle

Minimize time

Maximize distance as much as clinically possible

Use shielding



Ceiling mounted screen

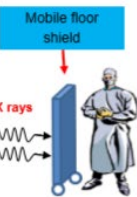
Lateral shield

Table curtain

### 3. Use ceiling suspended screens, lateral shields and table curtains

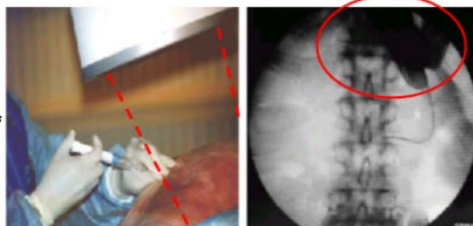
They provide **more than 90% protection** from scattered radiation in fluoroscopy

Mobile floor shielding is advisable when using cine acquisition



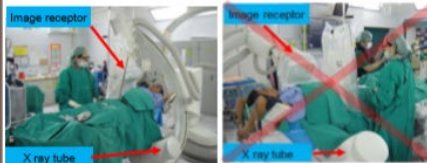
### 4. Keep hands outside the primary beam unless totally unavoidable

Hands inside the central area of the primary beam will increase exposure factors (kV, mA) and doses to patient and staff



## 10 Pearls: Radiation protection of **staff** in fluoroscopy

Reducing patient dose always results in staff dose reduction



Right!

Wrong!

5. Only 1-5% of radiation falling on the patient's body exits the other side

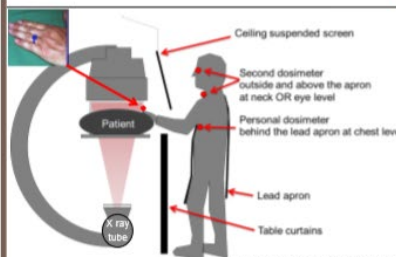
Stand on the side of the *transmitted* beam (i.e. by the *detector*), which contains only 1-5% of the incident radiation and its respective scatter



Right!

Wrong!

6. Keep X ray tube under the patient table and not over it  
Undercouch systems provide better protection from scattered dose



Ceiling suspended screen

Second dosimeter outside and above the apron at neck OR eye level

Personal dosimeter behind the lead apron at chest level

Lead apron

Table curtains

\*Image adapted from ICRP Publication 56

### 7. Use personal dosimetry

Use at least **two** dosimeters

- One **inside** the apron at chest level
- One **outside** the apron at neck or eye level
- Additional finger ring dosimeter for procedures requiring hands close to primary beam

Real time dosimetry systems are useful

### 8. Update your knowledge about radiation protection



9. Address your concerns about radiation protection to radiation protection specialists (medical physicists)

### 10. REMEMBER!

- Quality control testing of fluoroscopy equipment enables safe and stable performance
- Know your equipment! Using the equipment's features appropriately will help reduce doses to patients and staff
- Use injector devices



Related Poster!  
10 pearls! Radiation protection of patients in fluoroscopy  
<http://rpop.iaea.org/RPOP/RPOP/Content/Documents/Whitepapers/poster-patient-radiation-protection.pdf>

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Fluoroscopy

Staff Radiation Protection

<http://rpop.iaea.org>

<http://www-ns.iaea.org/tech-areas/communication-networks/norp/semir-web.htm>



Related Poster!  
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Staff Radiation Protection

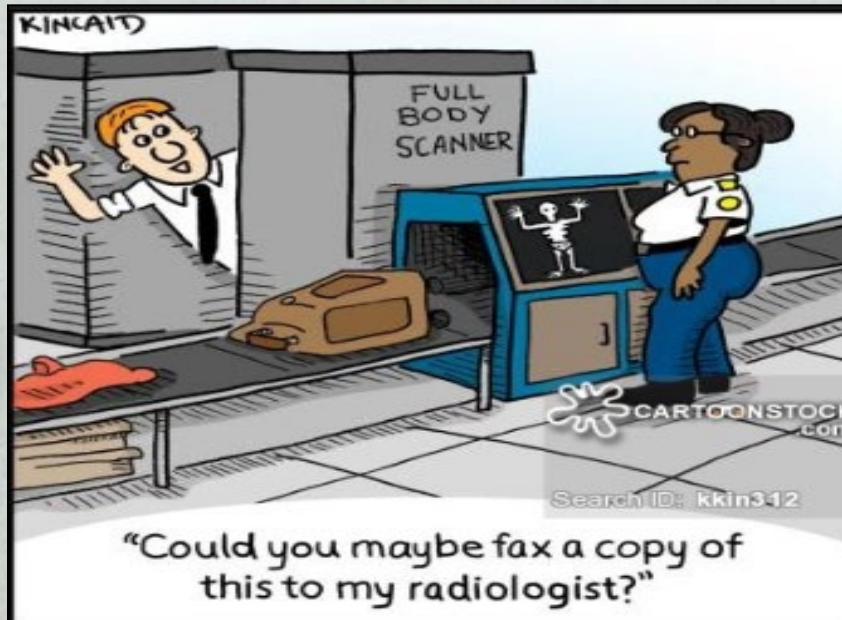
<http://rpop.iaea.org>

<http://www-ns.iaea.org/tech-areas/communication-networks/norp/semir-web.htm>

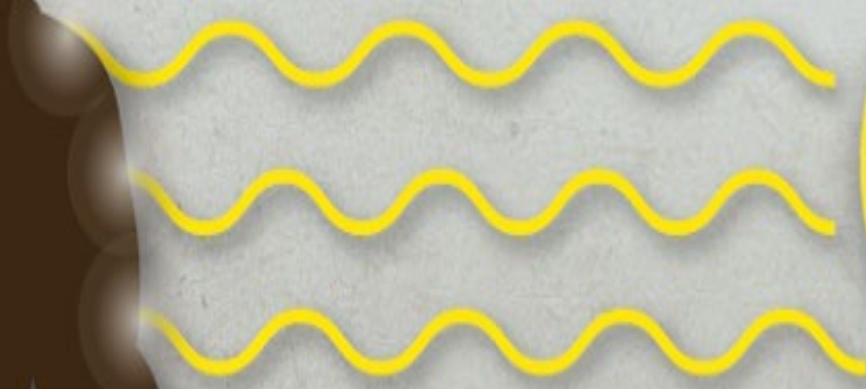
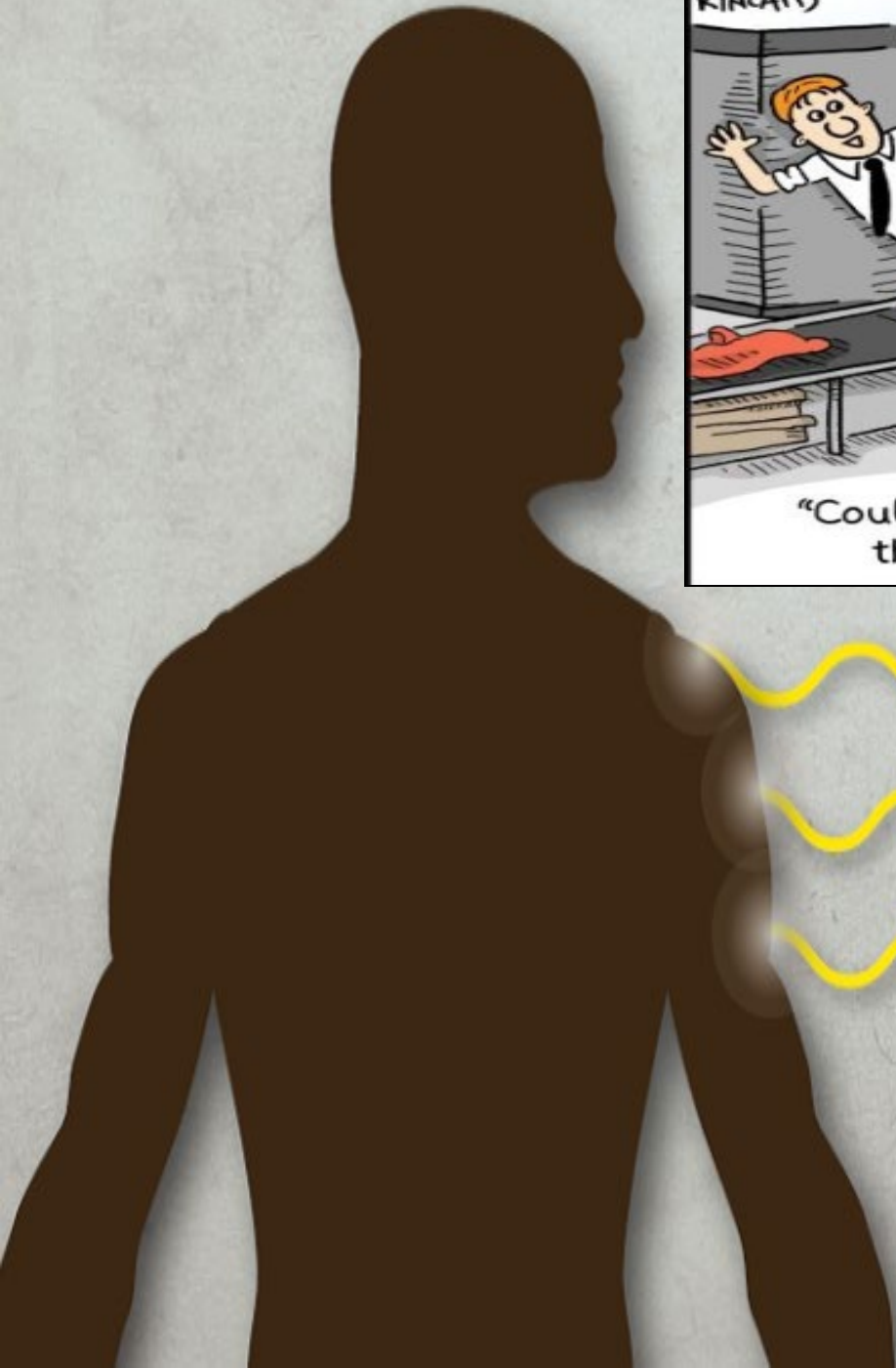


*Summer and winter  
"scattering" from Finland*





"Could you maybe fax a copy of this to my radiologist?"



Thank you!