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Radiation protection for patient and staff during routine EVAR and TEVAR procedures

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Disclosure of Interest

Speaker name: **Miltos Matsagkas**

- I have the following potential conflicts of interest to report:
- Consulting
- Employment in industry
- Shareholder in a healthcare company
- Owner of a healthcare company
- Other(s)

✓ **I do not have any potential conflict of interest**

Vascular Society

Radiation exposure during endovascular aneurysm repair

R. A. Weerakkody[1], S. R. Walsh[1], C. Cousins[2], K. E. Goldstone[3], T. Y. Tang[1] and M. E. Gaunt[1]

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Table 1 Screening time and median radiation dose during endovascular aneurysm repair based on an irradiated area of 243 cm^2

	Dose area product ($cGy\ cm^2$)	Screening time (min)	Entrance skin dose (Gy)	Effective dose (mSv)	% exceeding 2-Gy threshold for skin damage
All patients (*n* = 96)	150 (90–659)	21 (16–31)	0·85 (0·51–3·74)	27 (16–117)	29
Branched grafts excluded (*n* = 5)		21 (16–31)	0·55 (0·34–2·60)	26 (16–124)	28
Iliac disease excluded (*n* = 23)		20 (16–29)	0·52 (0·34–1·99)	25 (16–95)	25

Conclusion: Radiation doses administered during EVAR were higher than previously thought, with a potential risk of radiation-induced skin damage and later malignancy.

Weerakkody et al, Br J Surg 2008

Radiation exposure and EVAR

62 consecutive EVAR patients between May 2006 and December 2007

- The **mean effective dose** per procedure, **6.2 mSv**, was between that from a planar coronary angiography and a coronary angioplasty
- The **peak skin dose** was linearly correlated with cumulative dose in air and **did not exceed 1.0 Gy**, ie, it was less than the threshold for any acute skin reaction

CLINICAL RESEARCH STUDIES

Radiation burden of patients undergoing endovascular abdominal aortic aneurysm repair

John A. Kalef-Ezra, PhD,[a] Stratos Karavasilis, MSc,[a] Dimosthenis Ziogas, MD,[b] Dimitris Dristiliaris, MSc,[a] Lampros K. Michalis, MD,[c] and Miltiadis Matsagas, MD,[b] *Ioannina, Greece*

Introduction: Endovascular repair of abdominal aortic aneurysm (EVAR) requires the patient's extended exposure to x-rays, before, during, and after the intervention. The aim of this study was to determine the radiation exposure of patients undergoing EVAR and to assess the probability for the induction of both late and early radiation-related effects.
Methods: During the period of May 2006 to December 2007 EVAR was carried out in 62 patients using a mobile C-arm unit. The following dosimetric quantities were assessed: fluoroscopy time, cumulative dose in air, dose-area product, field area, and peak skin dose.
Results: The duration of fluoroscopy and the body mass index were found to be the main factors that influence the radiation burden in our hospital. The mean effective dose per procedure, 6.2 mSv, was between that from a planar coronary angiography and a coronary angioplasty. Taking into account the computed tomography (CT) procedure-related angiographies carried out during the first year, patients receive a total effective dose of about 62 mSv within the first year. In vivo dosimetry showed that the peak skin dose was linearly correlated with cumulative dose in air and did not exceed 1.0 Gy, ie, it was less than the threshold for any acute skin reaction.
Conclusion: Repair of abdominal aortic aneurysm results in substantial radiation burden. Radiation-related risks for carcinogenesis and skin injuries are factors that have to be taken into account in the selection of the strategy of each facility. (J Vasc Surg 2009;49:283-7.)

Kalef-Ezra et al, J Vasc Surg 2009

Radiation exposure and EVAR

Endovascular abdominal aortic aneurysm repair: methods of radiological risk reduction

J. A. KALEF-EZRA [1], S. KARAVASILIS [1], G. KOUVELOS [2]. D. DRISTILIARIS [1], L. K. MICHALIS [3], M. MATSAGKAS [2]

- ✓ **97 consecutive EVAR patients** between December 2007 and August 2009
- ✓ Using a **mobile** low-power Philips Pulsera fluoroscopic **C-arm unit**
- ✓ Patients underwent **CTA** pre-operatively and at 1^{st}, 6^{th} and 12 months after EVAR (**4 scans in a year**)

Kalef-Ezra et al, J Cardiovasc Surg (Torino) 2011

Radiation exposure and EVAR

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- ✓ The **patient mean effective dose** was **5.5mSv** and was linearly correlated with fluoroscopy time and BMI
- ✓ **Much lower** than the **22mSv** dose of a **usual CTA**
- ✓ The potential of **radiation related carcinogenesis** in AAA EVAR patients is **primarily due to CTAs** and not to the repair itself

Kalef-Ezra et al, J Cardiovasc Surg (Torino) 2011

Radiation exposure and EVAR

Endovascular abdominal aortic aneurysm repair: methods of radiological risk reduction

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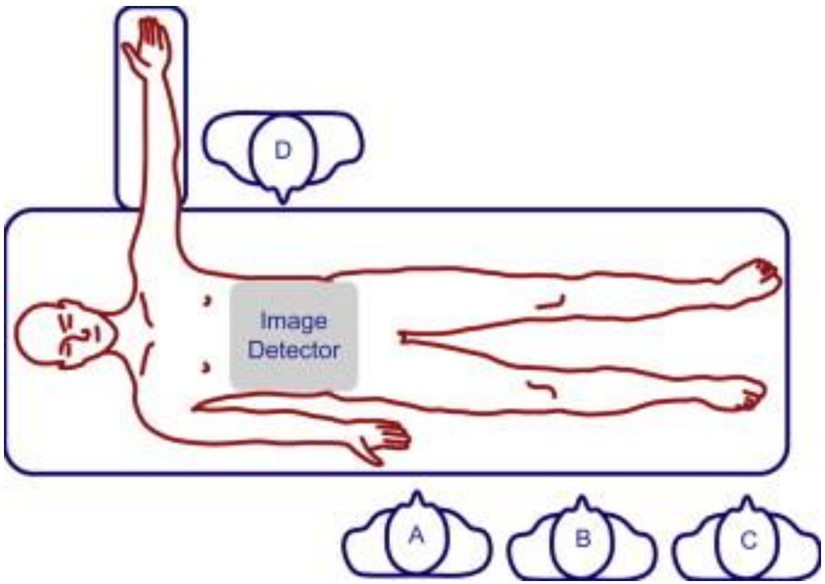
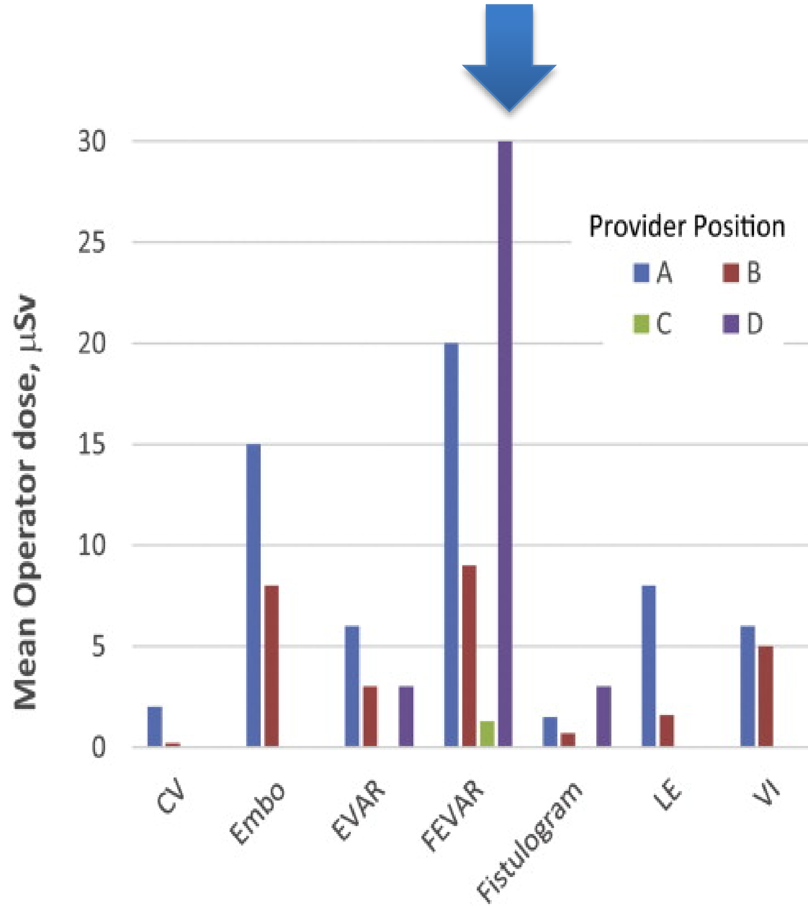
- ✓ The **collective effective dose of the staff** that carried out repairs using the mobile unit was 5.5 and 8 μSv per repair using an **angiographic** and a **surgical table** respectively

- ✓ **58%** of the collective radiation burden corresponded to the **chief surgeon**, **24% to the surgeon** stood at the **opposite side**, and **18% in the remaining stuff** present in the room

Kalef-Ezra et al, J Cardiovasc Surg (Torino) 2011

Set-up during EVAR





Kirkwood et al, J Vasc Surg 2015

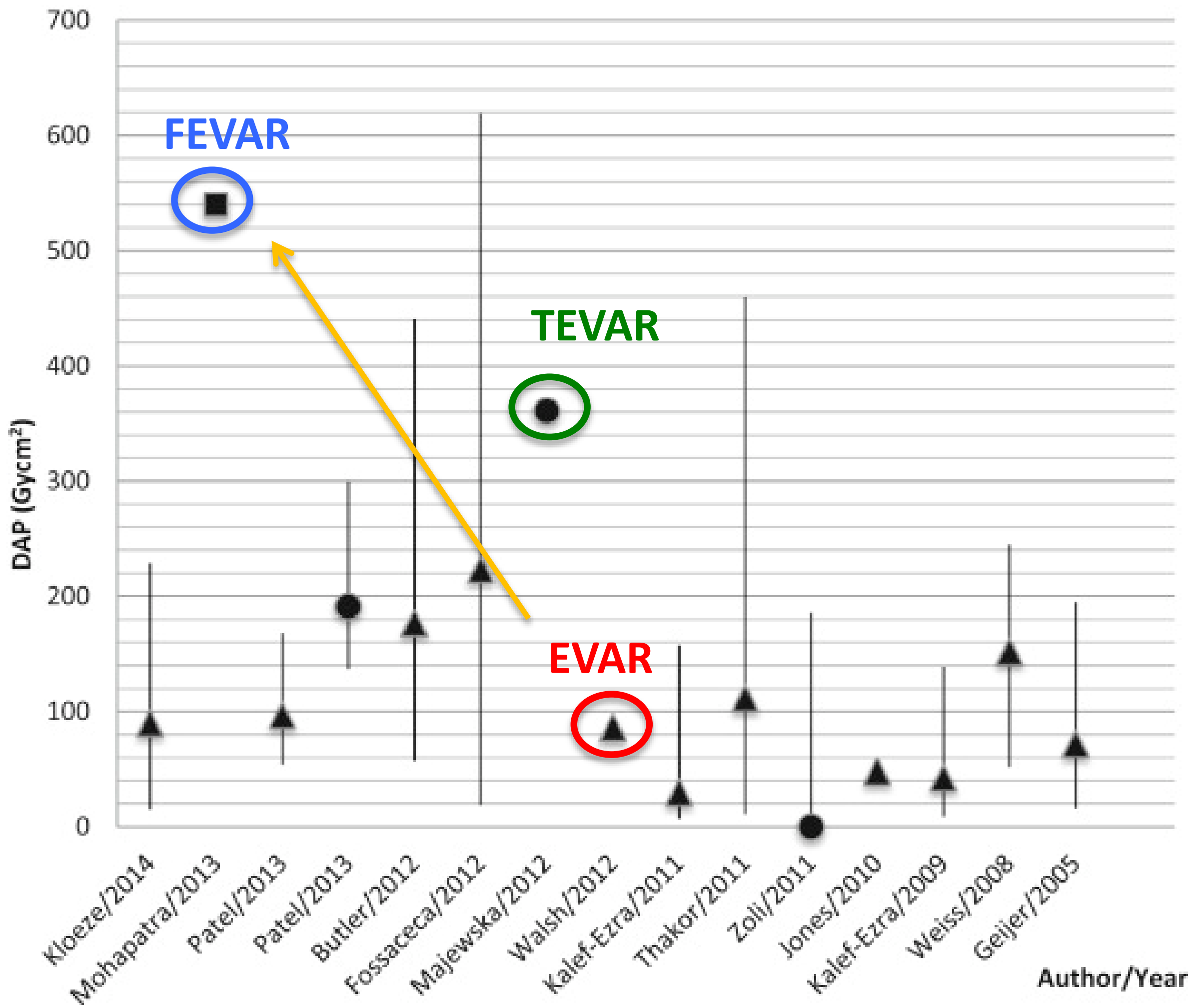
Radiation during EVAR and TEVAR

- As complex interventions and number of procedures increase, radiation exposure to medical stuff and patients becoming **a growing concern**

- Can create **significant radiation related illnesses**

- **Radiation safety is of major importance** for the staff and the patients

Intervention complexity and radiation exposure



Monastiriotis et al, J Vasc Surg 2015

News are becoming bad …

Heartwire from Medscape

Nine Brain-Cancer Cases Reported in Interventionalists

Reed Miller

February 23, 2012

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Radiation-Exposure Injuries

February 23, 2012 (Haifa, Israel) — Researchers in Israel and France have found a few cases that suggest interventional cardiologists and radiologists may be at risk for left-side brain tumors [1].

In the January 2012 issue of *Eurointervention*, **Dr Ariel Roguin** (Technion-Israel Institute of Technology, Haifa, Israel) and colleagues publish the summary of nine reports of brain tumors in people working in catheterization laboratories for 14 to 32 years, including four cases not previously reported in the literature.

In two cases in Haifa, Israel and two in Paris, the tumor was confirmed to be on the left side. In two cases in Toronto from 1998, the side of the tumor was not originally reported, but Roguin told ***heartwire*** that he recently confirmed they were on the left side. In three cases in Sweden, the side of the tumor is unknown. The types of tumor reported include glioblastomas, meningiomas, acoustic neurinomas, and oligodendromas.

As reported by ***heartwire*** , existing evidence suggests that chronic exposure to low-dose radiation such as that used in interventional cardiology can cause damage to somatic DNA that may be cumulative over time and increase the risk of cancer. Roguin et al point out that interventional cardiologists have the

Radiation induced cataract

Radiation Cataracts: New Data and New Recommendations

G. Donald Frey[1]

OBJECTIVE. This Minimodule discusses radiation cataracts and makes some basic suggestions for practicing radiologists.

CONCLUSION. For many years radiation-induced cataracts were considered unlikely by most radiologists. Recent data suggest that the likelihood is much higher than previously thought, and the International Commission on Radiological Protection has suggested lower exposure limits.

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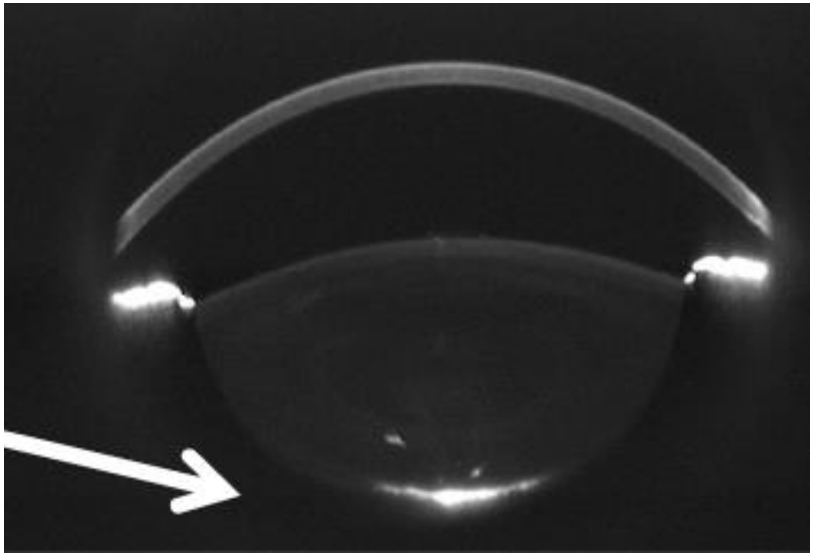
D. Frey, AJR 2014

Examination of Interventionists' Lens

59 attendees at Veith's conference

- Age 29 – 62
- **45 %** had radiation damage



L. Machan, as presented in Veith Symposium 2015

The invisible impact of radiation

Edward Diethrich, Founder Arizona Heart Inst

“Being a doctor, my whole motive was to help the patient and to get the patient well; I did not think about the hazardous conditions”

Strategies to reduce Radiation Exposure

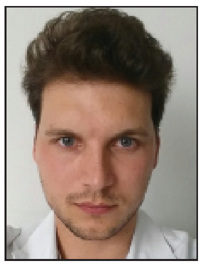
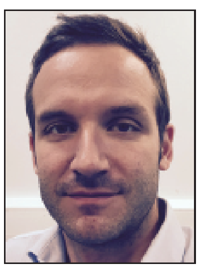
- **Knowledge basics** about radiation **has not been developed and incorporated** into training so far

- **Appropriate behavior** in the operating room **is very often ignored**, leading to **unnecessary radiation exposure**

How to Reduce Radiation Exposure During EVAR

Tips and tricks to minimize radiation exposure during EVAR procedures.

BY STÉPHAN HAULON, MD, PhD; ADRIEN HERTAULT, MD; JONATHAN SOBOCINSKI, MD, PhD; AND RICHARD AZZAOUI, MD


During the last 2 decades, technical improvements in biomaterials have enabled minimally invasive treatment of most vascular diseases. Endovascular aneurysm repair (EVAR) is now a large part of vascular surgeons' daily practice. Initially reserved for high-risk patients and expert centers, EVAR is now commonly performed as the first-line treatment defined as the highest dose delivered to any portion of the patient's skin, including backscattered radiation during a procedure, and is used to assess the risk of deterministic effects, such as skin injuries. A threshold of 2 to 3 Gy is commonly considered to be at risk.[1] The dose area product (DAP, in $Gy\ cm^2$) is the product of the AK by the exposed area. The DAP accumulated during the procedure is linked to the stochastic effect (ie, the increased risk of cancer) and can be converted in a first approximation to the effective dose (in Sv) using a conversion factor.[2] However, there is no consensus on the method used to compute this conversion factor. Since DAP was introduced on fluoroscopy equipment a long time ago, it has been widely used for comparing doses among

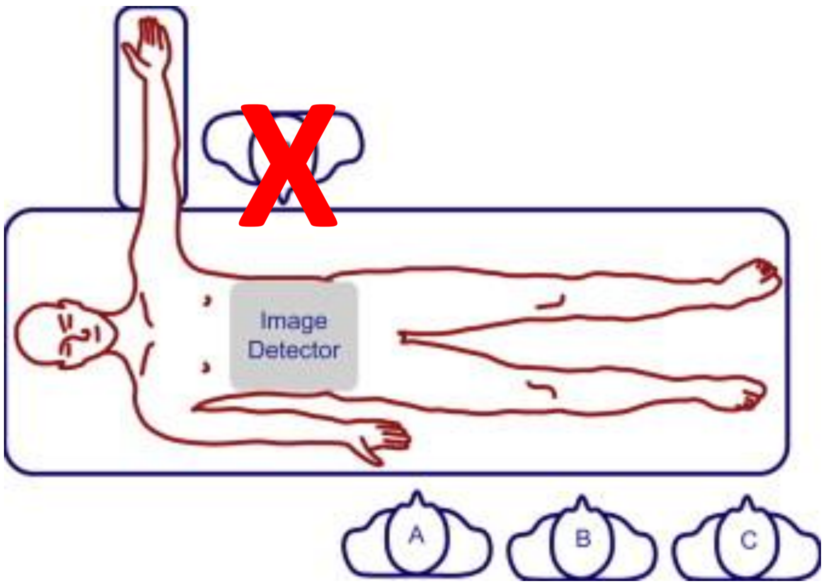
Goals

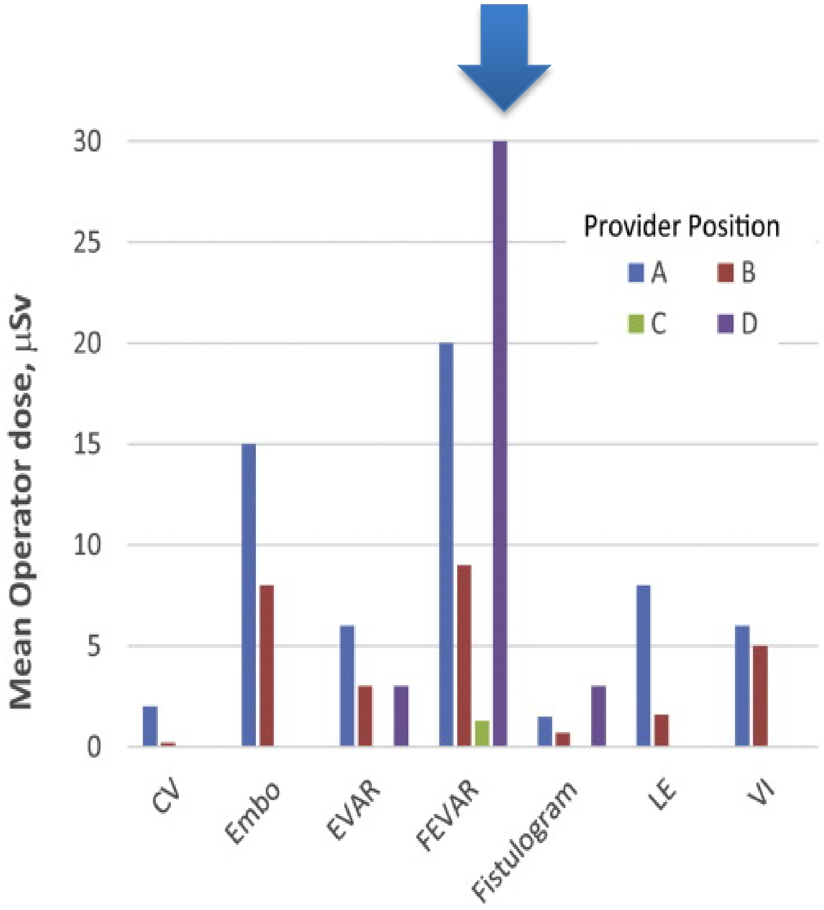
- ✓ **Minimize radiation** to the patient, physician and staff without increasing risk of procedure
- ✓ **Maintain image quality** while utilizing techniques to decrease overall radiation exposure
- ✓ ALARA (**As Low As Reasonable Achievable**) principle should guide every procedure

Radiation exposure

- ✓ Primary beam radiation exposure
- ✓ Leakage radiation from x-ray tube
- ✓ Scatter radiation

Set-up





Kirkwood et al, J Vasc Surg 2015

Key principles

- **Time** — Less imaging = less exposure
- **Intensity** — Lowest power beam possible
- **Shielding** — Lead aprons and shields absorbs 90% of radiation; Protection of eyes and thyroid is crucial and often overlooked
- **Distance** — As the distance double from the radiation source, exposure drops by 1/4th

Time

✓ **Limit fluoroscopy time**

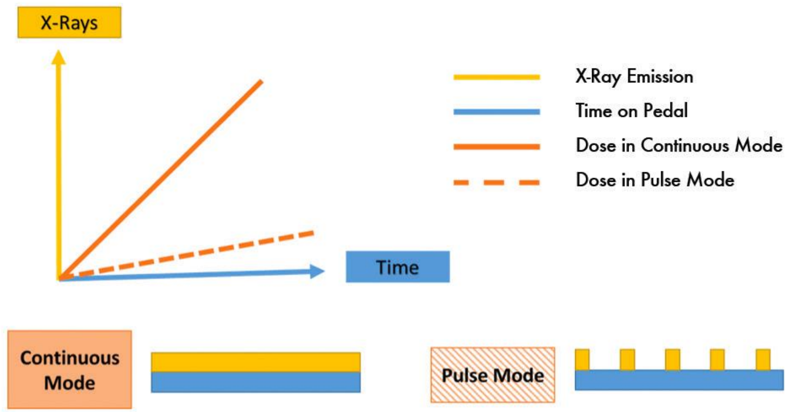
- only to observe objects in motion
- use last-image-hold or stored fluoroscopy loops

Intensity

✓ Use:

- lowest fluoroscopic dose yielding adequate image
- lowest digital acquisition rate providing necessary information
- pulse mode

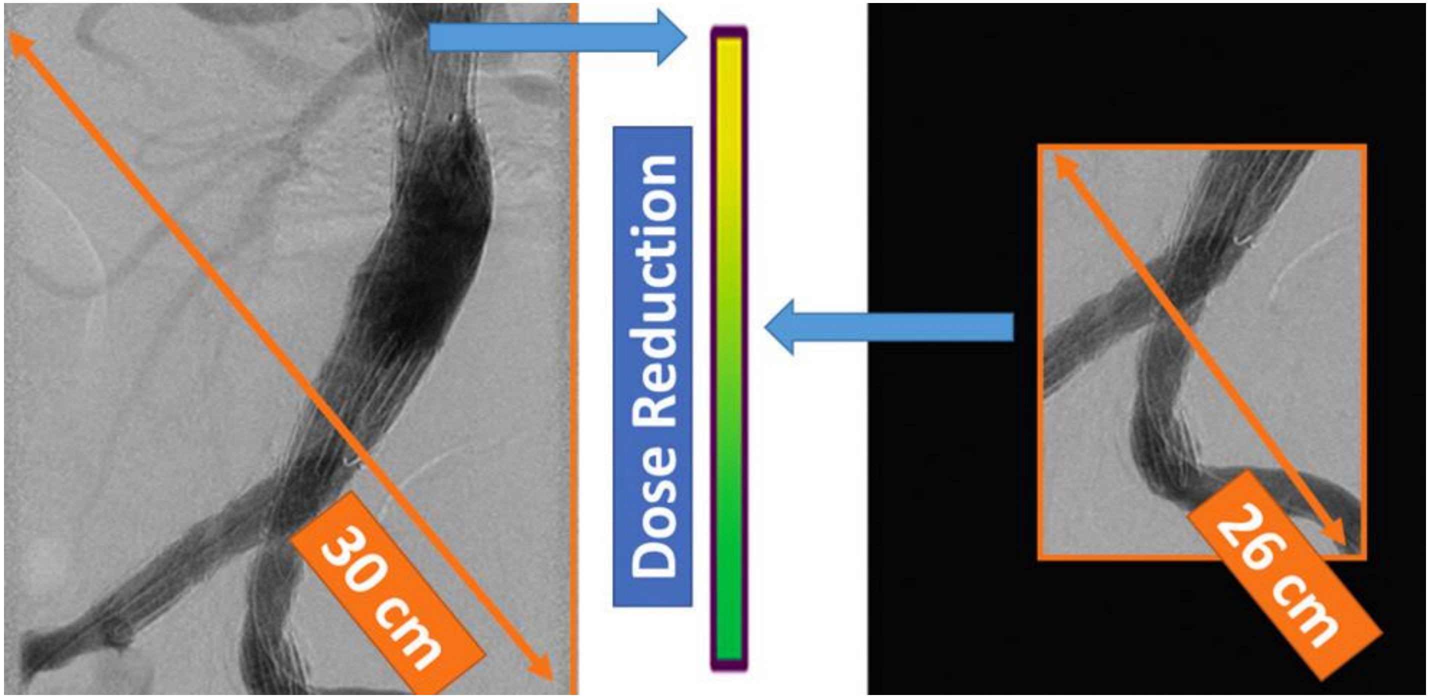
✓ *At a typical frame rate of 7.5 images/s, a 90% reduction of produced images is observed compared with continuous mode*



Hertault et al, Eur J Vasc Endovasc Surg 2014

Intensity

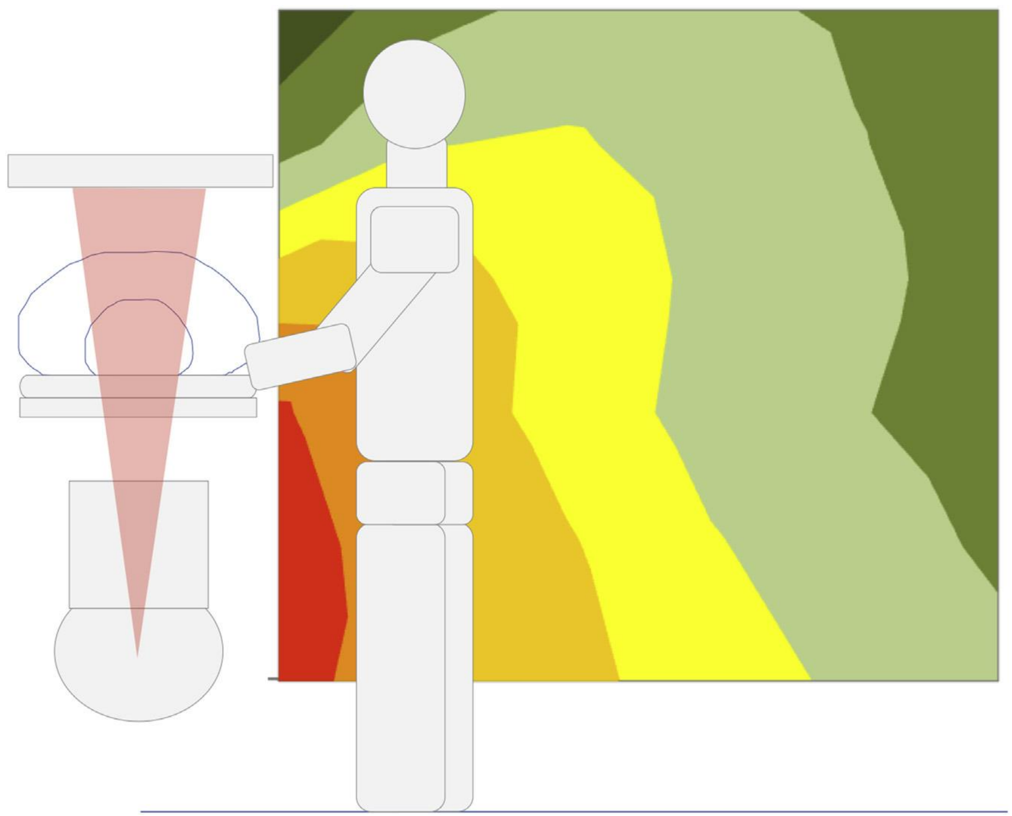
- Avoid magnification (digital zooming-large screens)
- Collimation (reduce field of view)



Haulon et al, Endovascular Today 2015

Distance

- Stay as far away as possible



Hertault et al, Eur J Vasc Endovasc Surg 2014

Shielding

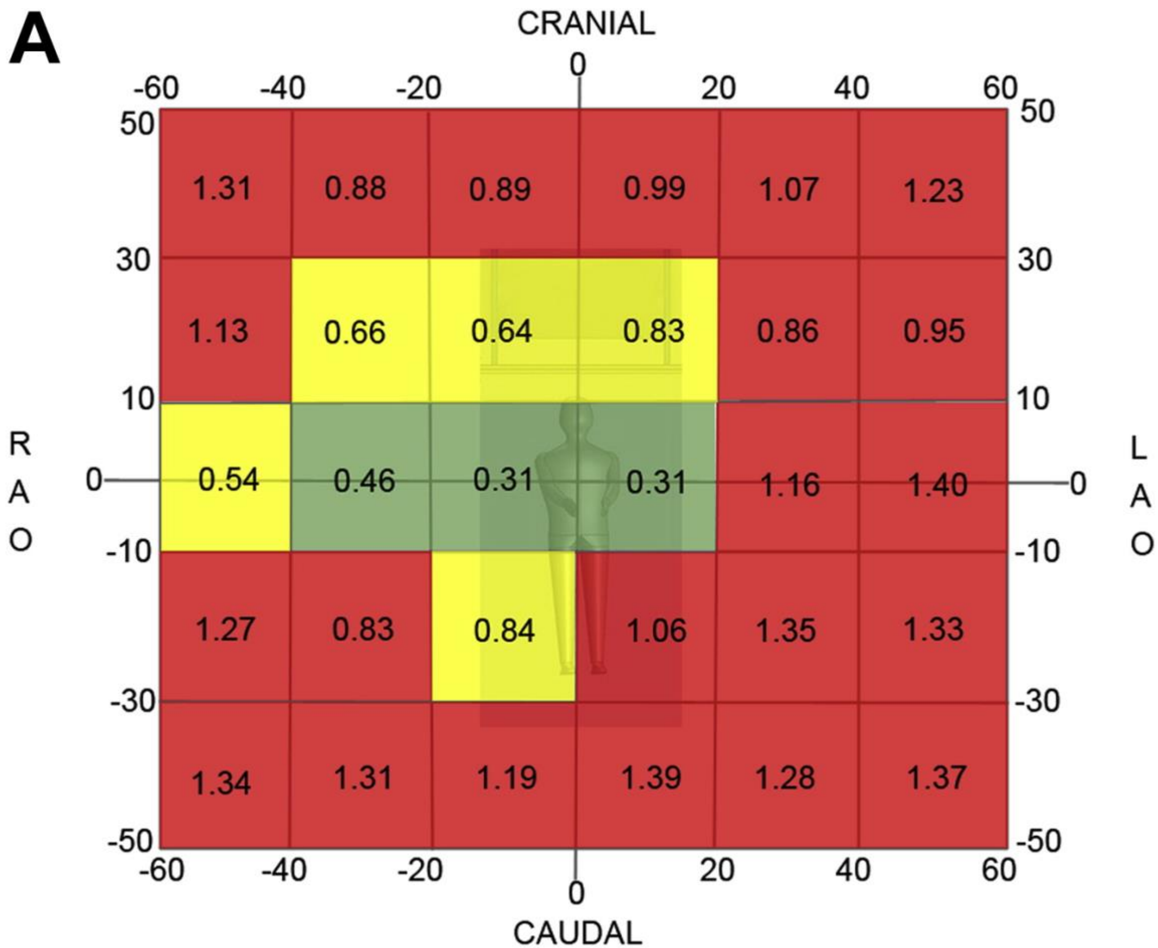
- ✓ Minimum 0.5mm lead apron
- ✓ Thyroid lead
- ✓ Lead glasses

Check the apron each year for cracks

Eliminate air gap

Haqqani et al, J Vasc Surg 2012

Limit angulations of the image intensifier



Agarwal et al, J Am Coll Cardiol Intv. 2014

Operator controlled imaging

Operator-controlled Imaging Significantly Reduces Radiation Exposure during EVAR

G. Peach*, S. Sinha, S.A. Black, R.A. Morgan, I.M. Loftus, M.M. Thompson, R.J. Hinchliffe

St George's Vascular Institute, 4th Floor, St James Wing, St George's Healthcare NHS Trust, Blackshaw Road, London SW17 0QT, UK

Median values before and after change to OCI.

	Median value before OCI (range)	Median value with OCI (range)	p value[b]
Dose area product ($mGy\ m^2$)	6.9 (1.91–95.0)	4.9 (1.25–13.3)	0.005
Screening time (min)	20.0 (4.8–49.3)	16.2 (3.1–51.1)	0.027
Contrast dose (ml)[a]	100 (60–300)	90 (50–180)	0.21
Operative duration (min)	130 (65–240)	120 (60–205)	0.44

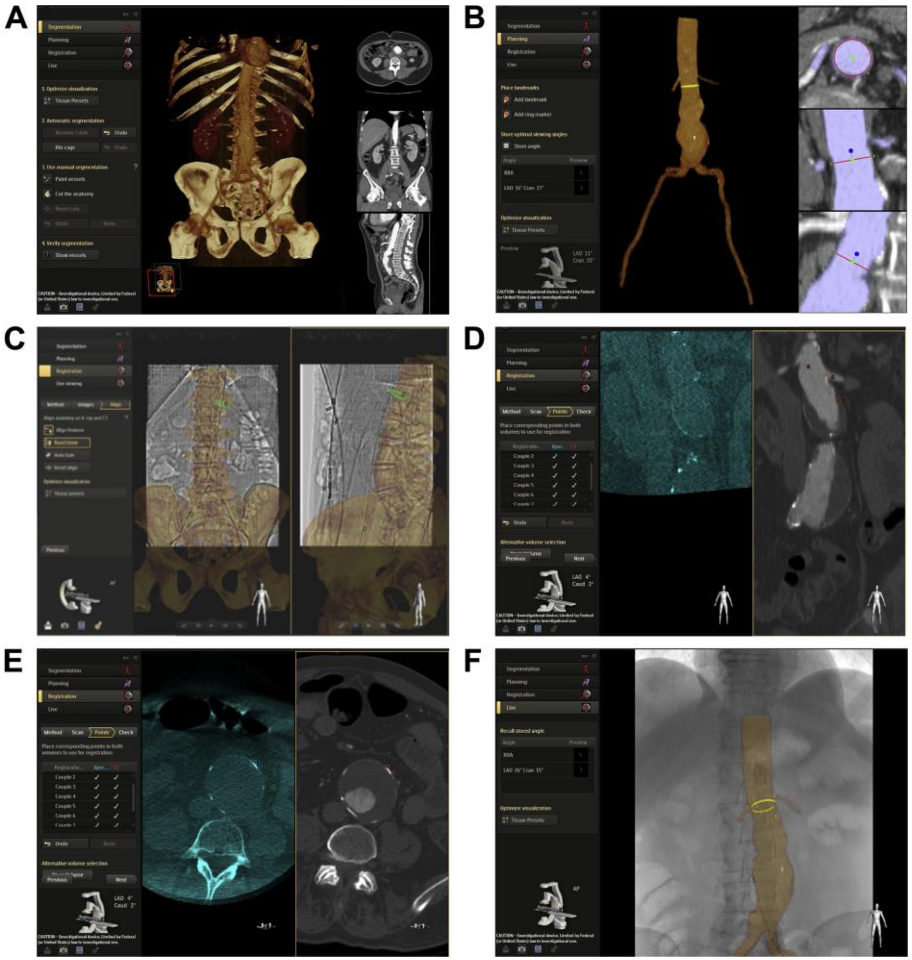
Peach et al, Eur J Vasc Endovasc Surg 2012

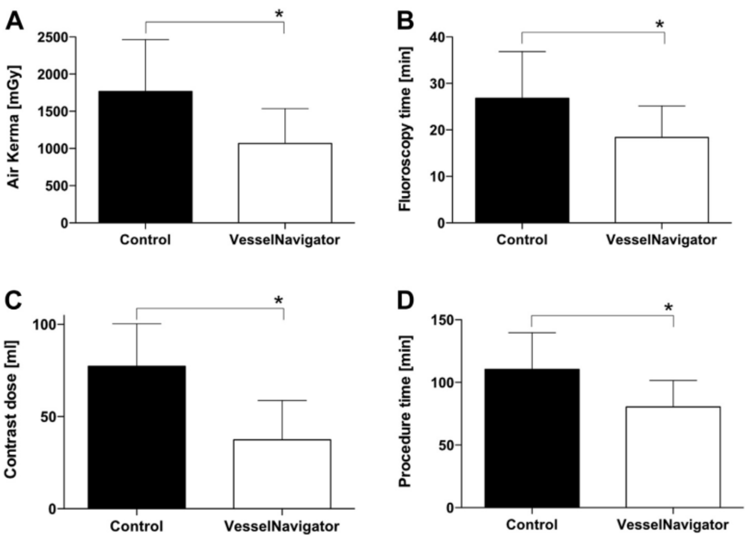
Pre-op planning in 3D workstation

- in order to **appropriately position** the gantry during the intervention and avoid unnecessary radiation

Haulon et al, Endovascular Today 2015

3D roadmapping-fusion during EVAR

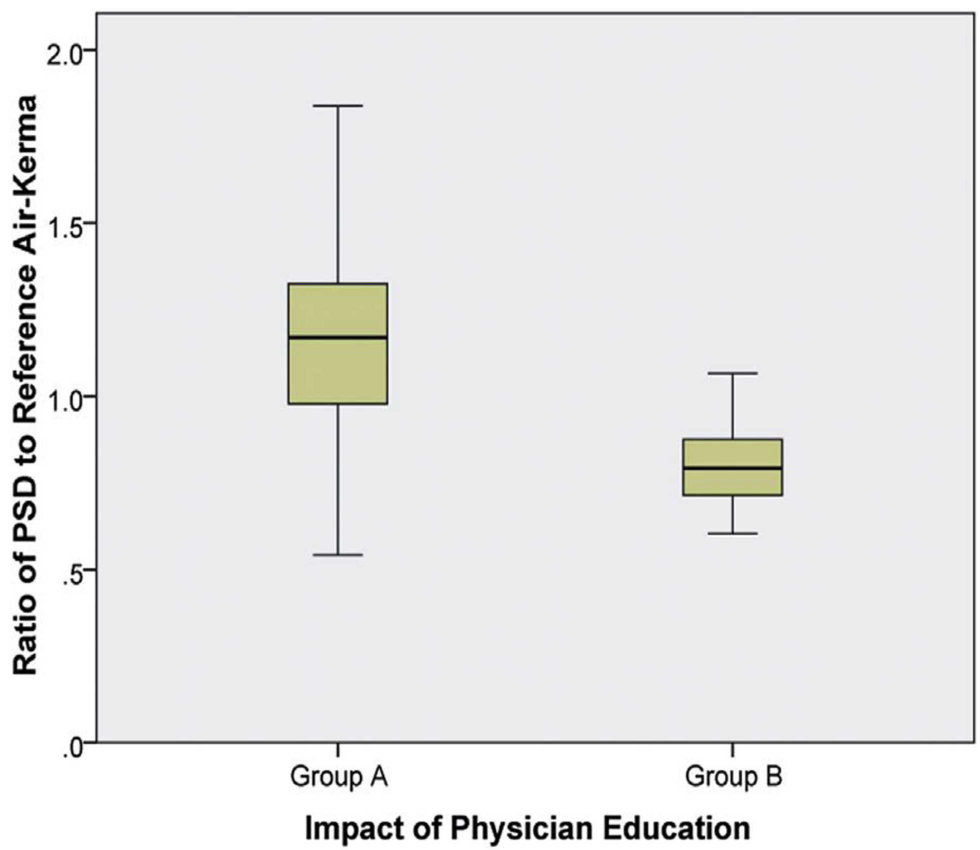




Stagenberg et al, J Vasc Surg 2015

Surgeon education decreases radiation dose in complex endovascular procedures and improves patient safety

Melissa L. Kirkwood, MD,[a] Gary M. Arbique, PhD,[b] Jeffrey B. Guild, PhD,[b] Carlos Timaran, MD,[a] Jayer Chung, MD,[a] Jon A. Anderson, PhD,[b] and R. James Valentine, MD,[a] *Dallas, Tex*



Kirkwood et al, J Vasc Surg 2013

Training and radiation exposure

Table IV. Fellows' practice of ALARA strategies based on their attendings' practice of ALARA strategies

	ALARA attendings, No. (%)	*Non-ALARA attendings, No. (%)*	P
Always	12 (42.9)	2 (14.3)	<.001
Almost always	11 (39.3)	2 (14.3)	
Usually	5 (17.9)	4 (28.6)	
Sometimes	0 (0)	6 (42.9)	

ALARA, As Low As Reasonably Acceptable.

> "WHAT THE TEACHER IS, IS MORE IMPORTANT THAN WHAT HE TEACHES."
>
> KARL A. MENNINGER

- Residents with ALARA attendings were significantly more likely to practice ALARA strategies themselves compared with residents with non-ALARA attendings

Bordoli et al, J Vasc Surg 2014

Conclusion

- ✓ Radiation exposure is our “**TRUE**” ghost-enemy
- ✓ Small differences in daily practice **CAN** lead to significant accumulated dose reduction over 30y period
- ✓ Exposure can be reduced through a **combination of techniques**
- ✓ There are **no safe doses** of radiation

We can make it work…

“take heed, radiation can really make a great deal of difference in your future; it has for me”

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