Benefit of Fusion in Everyday Practice, Results from a Multicentric Evaluation

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REVIEW

Editor's Choice — Minimizing Radiation Exposure During Endovascular Procedures: Basic Knowledge, Literature Review, and Reporting Standards

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Literature overview
Where do we stand?

Impact of Hybrid Rooms with Image Fusion on Radiation Exposure during Endovascular Aortic Repair

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WHAT THIS PAPER ADDS
Experience has shown that the routine use of fusion during endovascular aneurysm repair has significantly reduced the exposure of patients and operators to X-rays and contrast volume injection during complex repairs, without jeopardising the overall procedure workflow.

Objective: To evaluate exposure to radiation during endovascular aneurysm repair (EVAR) performed with intraoperative guidance by preoperative computed tomographic angiogram fusion.
Methods: All consecutive patients who underwent standard bifurcated (BIF) or thoracic (THO), and complex fenestrated (FEN) or branched (BR) EVAR were prospectively enrolled. Indirect dose–area product (DAP), fluoroscopy time (FT), and contrast medium volume were recorded. These data were compared with a previously published prospective EVAR cohort of 301 patients and to other literature. Direct DAP and peak skin dose were measured with radiochromic films. Results are expressed as median (interquartile range).
Results: From December 2012 to July 2013, 102 patients underwent standard (56.8%) or complex (43.2%) EVAR. The indirect DAP (Gy.cm^2) was as follows: BIF 12.2 (8.7–19.9); THO 26.0 (11.9–34.9); FEN 43.7 (24.7–57.5); and BR 47.4 (37.2–108.2). The FT (min) was as follows: BIF 10.6 (9.1–14.7); THO 8.9 (6.0–10.5); FEN 30.7 (20.2–40.5); and BR 39.5 (34.8–51.6). The contrast medium volume (mL) was as follows: BIF 59.0 (50.0–75.0); THO 80.0 (50.0–100.0); FEN 105.0 (70.0–136.0); and BR 120.0 (100.0–170.0). When compared with a previous cohort, there was a significant reduction in DAP during BIF, FEN, and BR procedures, and a significant reduction of iodinated contrast volume during FEN and BR procedures. There was also a significant reduction in DAP during BIF procedures when compared with the literature ($p < .01$). DAP measurement on radiochromic films was strongly correlated with indirect DAP values ($r^2 = .93$).
Conclusion: The exposure of patients and operators to radiation is significantly reduced by routine use of image fusion during standard and complex EVAR.

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Keywords: Aorta, Endovascular procedures, Fusion imaging, Hybrid room, Radiation, Radiation protection

INTRODUCTION

The evolution of device technology has allowed physicians to perform more and more complex minimally invasive aortic endovascular repairs. Imaging systems have also evolved to facilitate these challenging procedures. For example, fixed-room flat panel detectors have demonstrated strong imaging superiority over standard fluoroscopic two-dimensional (2D) fluoroscopy imaging systems (mobile C-arms), which are limited by overheating and image degradation, particularly when performing complex endovascular aneurysm repair (EVAR).[1] Hybrid rooms, combining an optimal open surgical environment and advanced imaging capabilities are currently replacing mobile C-arms in the operating room.

The latest hybrid rooms have advanced imaging applications, such as contrast-enhanced cone beam computed tomography (CBCT; three-dimensional [3D] images acquired through a C-arm rotation around the patient), and preoperative computed tomography angiography (CTA) image fusion with live fluoroscopy to provide a "3D roadmap". The latter facilitates endovascular navigation and increases the accuracy of endograft implantation.[2,3] Despite the current widespread use of these new imaging applications, little has been published on their impact on exposure to ionising radiation.[4–6]

Published evidence suggests that repeated injections of contrast medium contribute to the development of lifelong nephropathy.[7] The effects of radiation are cumulative and put patients at deterministic risk of radiation injuries after exposure.[8] Also, clinical staff regularly exposed to radiation during everyday fluoroscopy-directed procedures are

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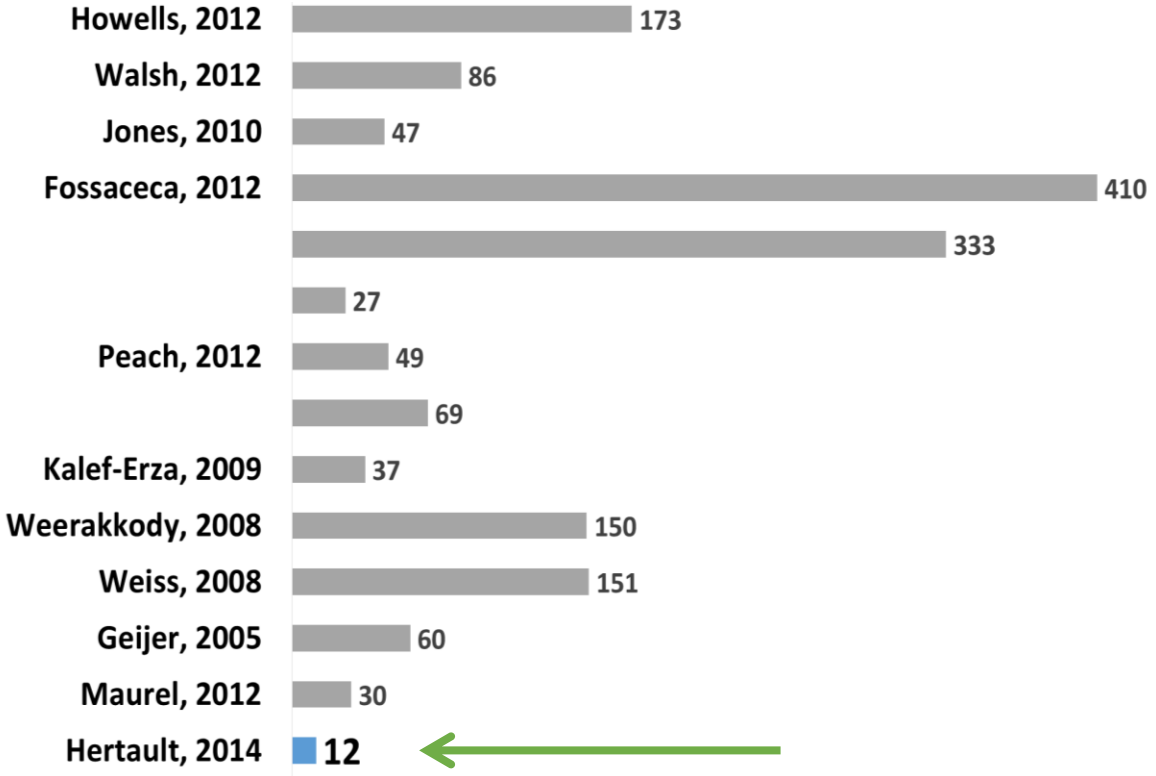
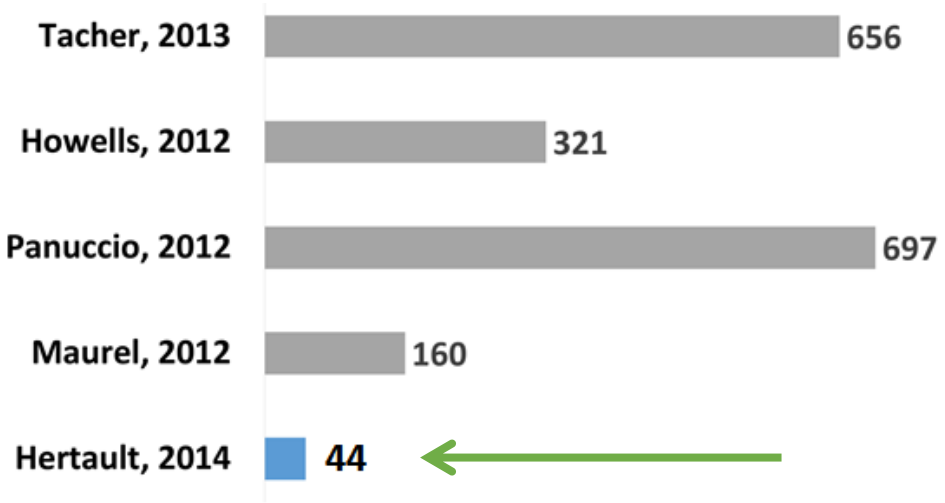
Literature overview
Where do we stand?

Median DAP (Gy.cm²) values reported in the Literature for Bifurcated EVAR procedures



Literature overview
Where do we stand?

Median DAP (Gy.cm²) values reported in the Literature for complex EVAR procedures

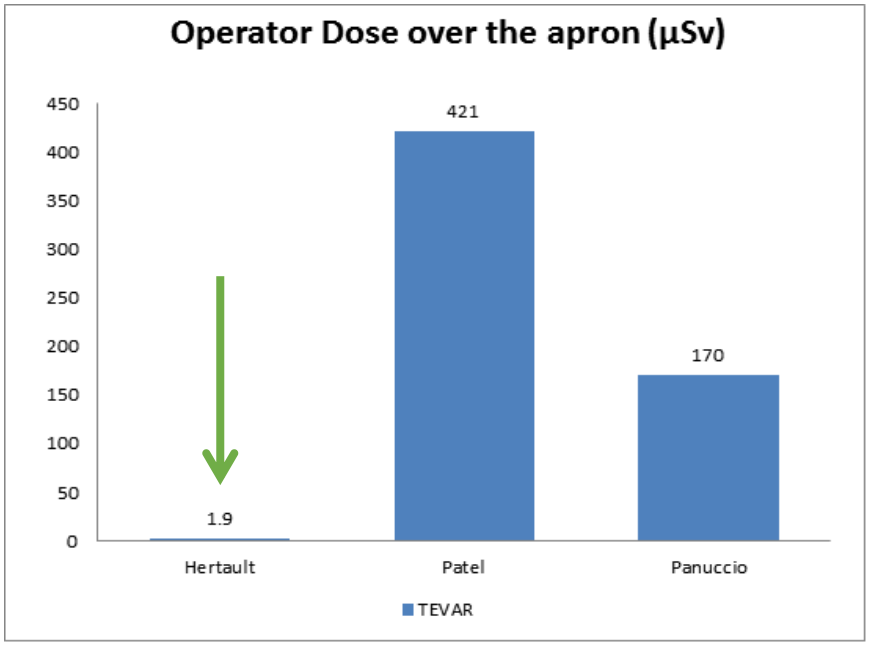


x3 to 15 times higher than in Lille Aortic Center

Literature overview
Where do we stand?

Operator exposure over the lead apron per procedure type[c]

Procedure type	Median operator exposure (µSv)
Branched + four-fenestrated endografts	23.1 (6.3–248.0)
Two- or three-fenestrated endografts	9.1 (1.8–67.7)
Bifurcated + iliac branch endografts	11.6 (3.6–94.4)
Bifurcated endografts	3.7 (0.2–215.7)
Thoracic endografts	1.9 (0.0–19.7)



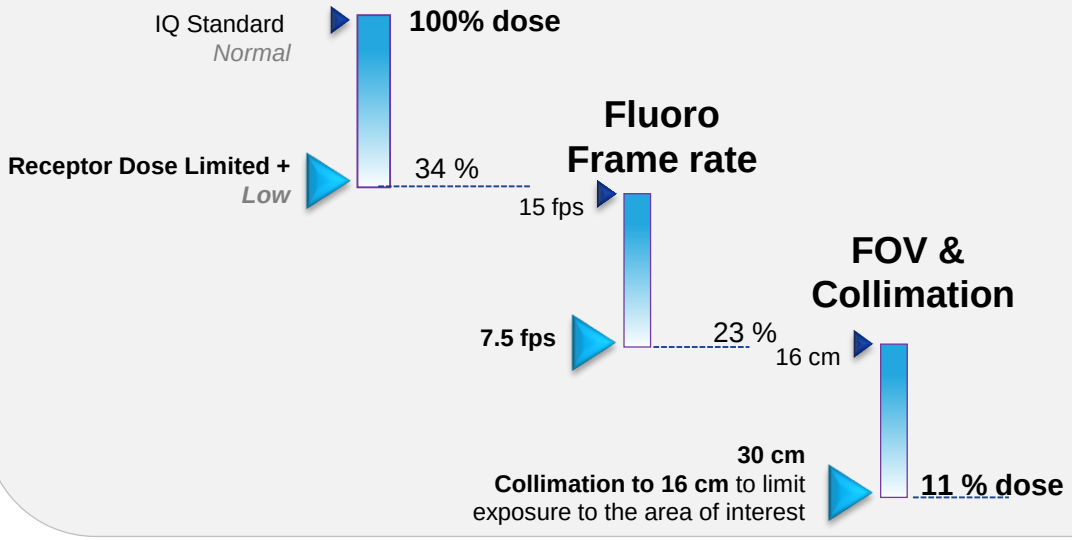
The limit for occupational exposure suggested by the ICRP is maximal 50 mSv/year[d].

a. Patel A.P. et al, Occupational Radiation Exposure During Aortic Procedures, Eur J Vasc Endovasc Surg. 2013 Oct;46(4):424-30
b. G. Panuccio at al. Comparison of indirect radiation dose estimates with directly measured radiation dose for patients and operators during complex endovascular procedures. J Vasc Surg 2011;53:885-94.
c. Hertault A et al. Impact of Hybrid Rooms with Image Fusion on Radiation Exposure during
Endovascular Aortic Repair, Eur J Vasc Endovasc Surg. 2014 Oct;48(4):382-90.
d. International Commission on Radiological Protection, 1990. Recommendations
of the International Commission on Radiological Protection. ICRP Publication 60. Ann ICRP 1991.

Dose saving

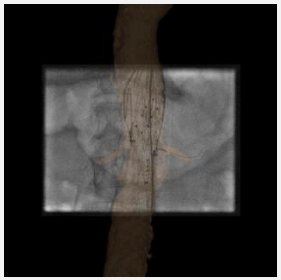
Imaging parameters

Auto kV, mA settings (Acq. protocol)
& Normal/Low dose setting (table side control)



Imaging modes

- **Use of CTA Fusion**
  - No need of intra-op. 3D
  - Center anatomy and optimize C-arm angulation without x-ray as 3D fusion mask follows the table and gantry movements
- **Minimization of DSA runs** in favor of subtracted fluoroscopy runs specifically for iliac arteries imaging



Could these results be achievable elsewhere?

MULTICENTRIC

REVAR Study

Radiation Evaluation during EVAR

Could these results be achievable elsewhere?

MULTICENTRIC
REVAR Study
Radiation Evaluation during EVAR

Methods

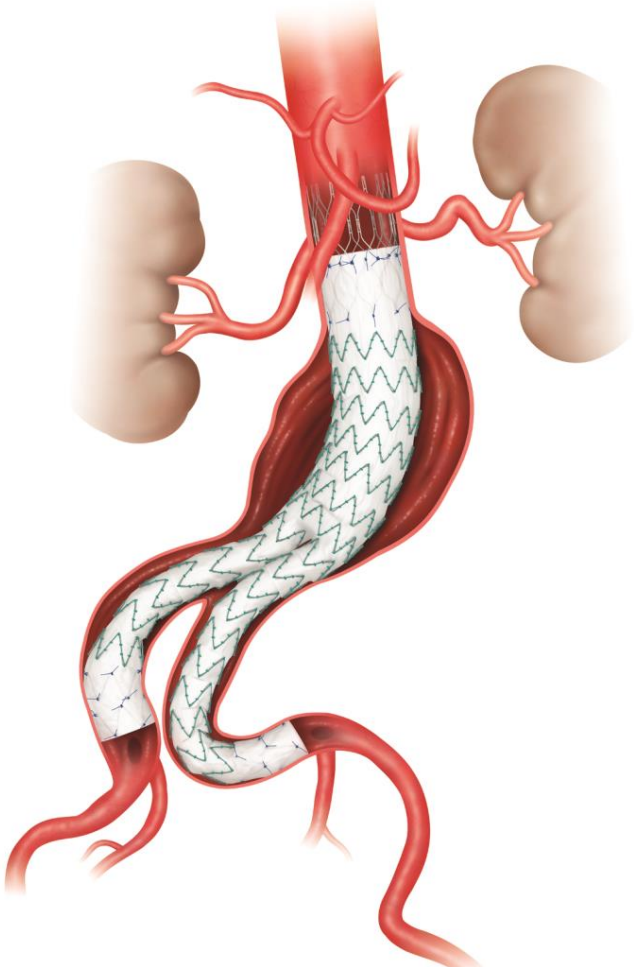
- Bifurcated EVAR
- All centers using same Hybrid Room (Discovery IGS 7 serie from GE Healthcare)
- Each center has received a dose and fusion imaging training before enrolling patients
- Monitoring dose and practice via Dosewatch, cloud-based tracking system

Methods: EVAR

MULTICENTRIC

REVAR Study

Radiation Evaluation during EVAR



Methods: Same Hybrid Room
Discovery IGS 730/740 - GE Healthcare

MULTICENTRIC
REVAR Study
Radiation Evaluation during EVAR

Methods

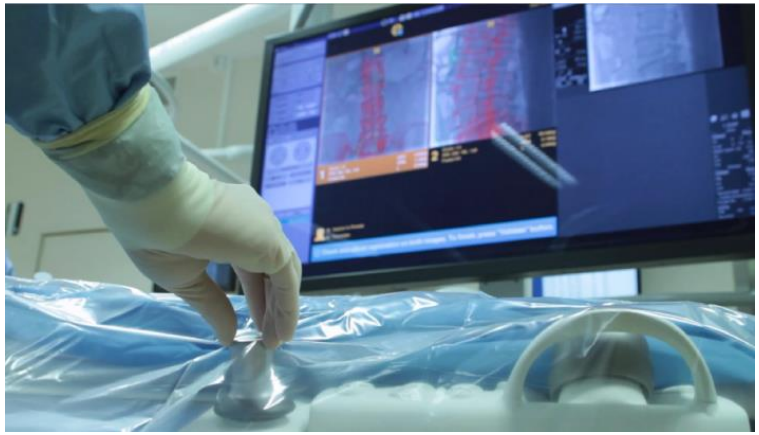
MULTICENTRIC
REVAR Study
Radiation Evaluation during EVAR

- Dose and fusion imaging training before enrolling patients
- Monitoring dose and practice via Dosewatch, cloud-based tracking system

Routinely use Image Fusion

and get the best of your pre-operative dataset

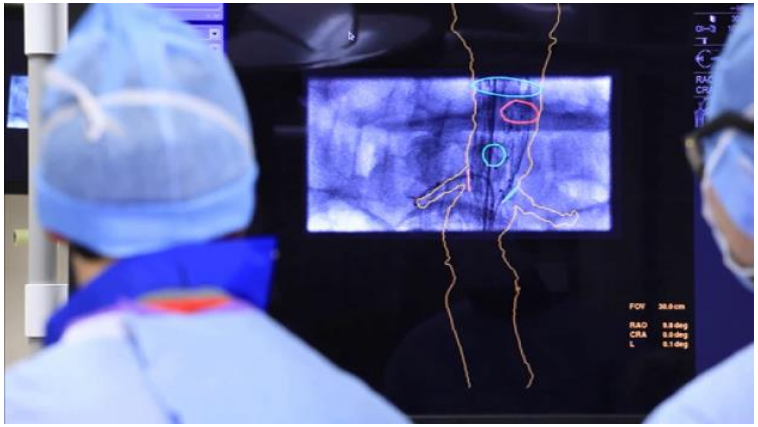
Register with Biview (2D/3D regsitration)



Find working position without X-ray

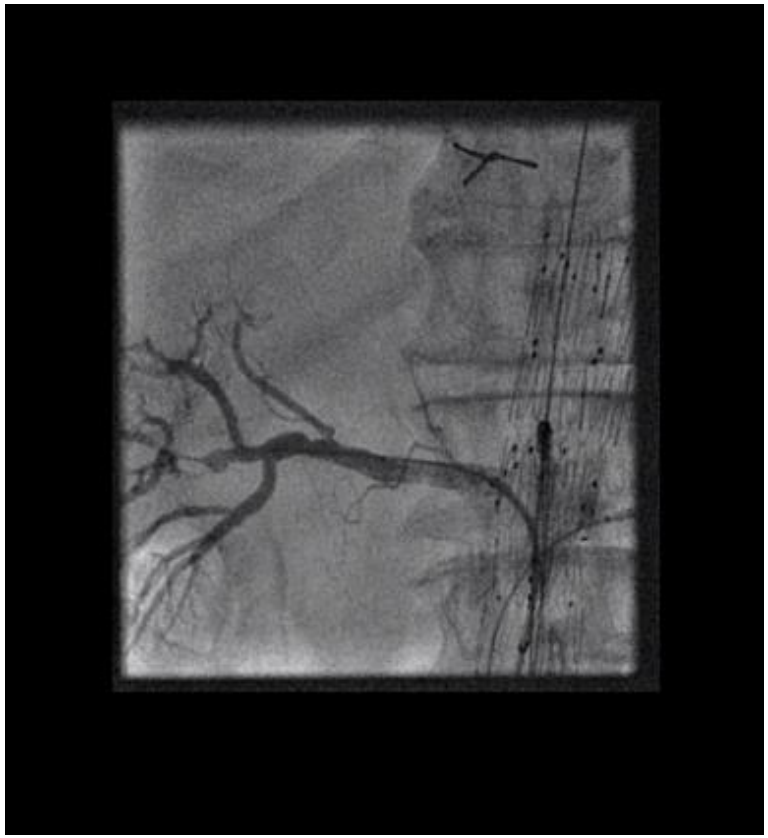
Fine tune 3D mask at table side

Use Digital Zoom



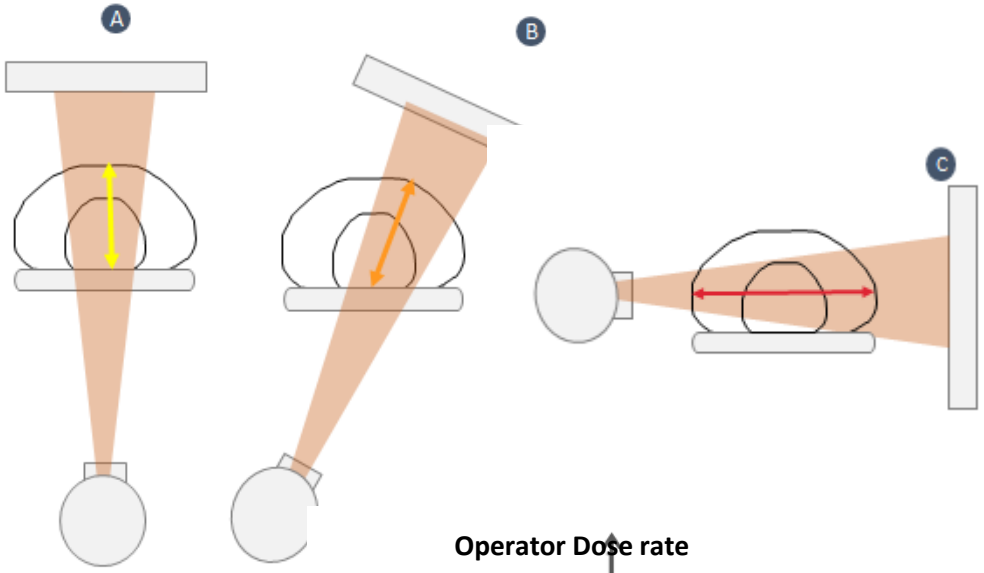
Limit DSA runs

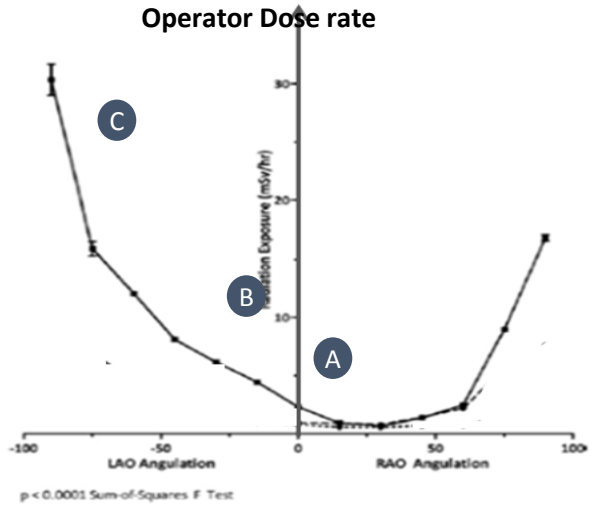
In term of dose,
1 DSA image ~ 500 fluoro images

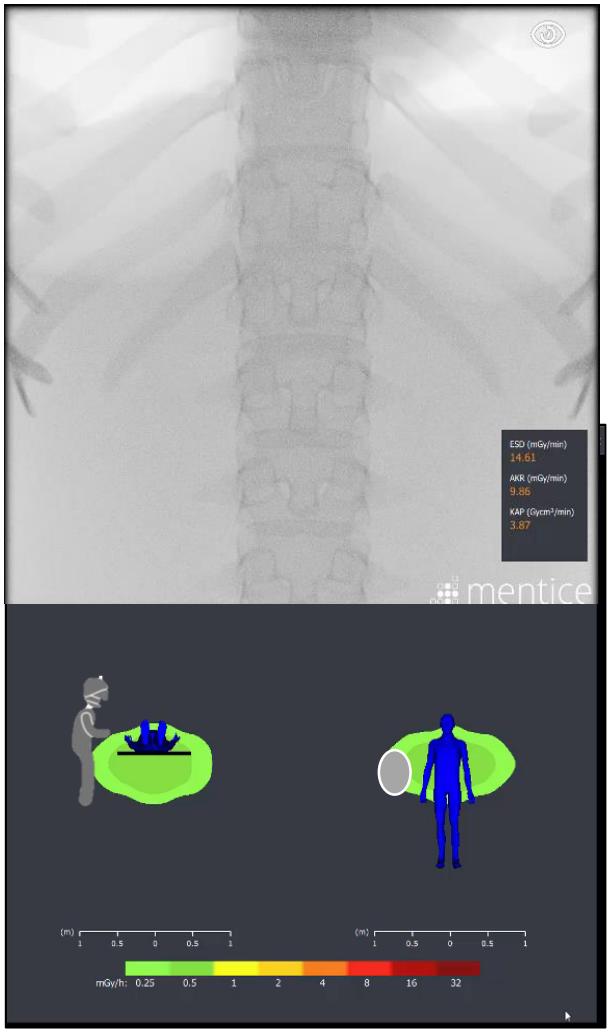


Prefer fluoroloop instead of DSA, except for completion angio or difficult situations

Limit C-arm angulation



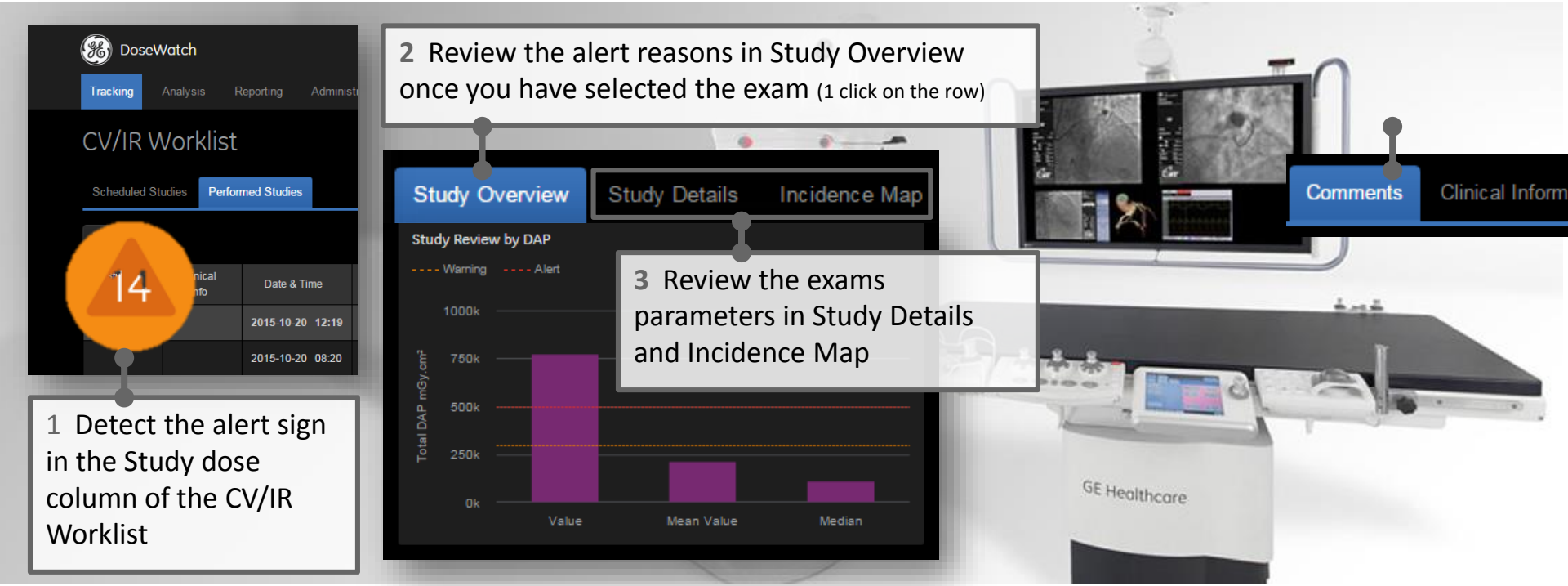




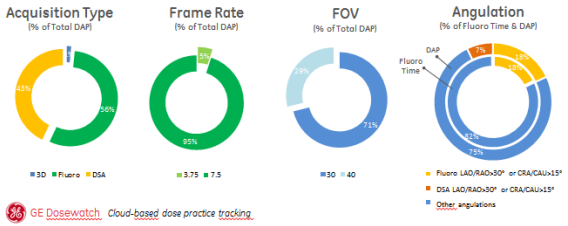
When LAO/RAO angle are >30°, patient & operator dose rate increases exponentially.
Same with CRA/CAU >15°

Dosewatch - Analyze, Understand, Optimize

- Risk Management



- Performance Management with Practice tracking

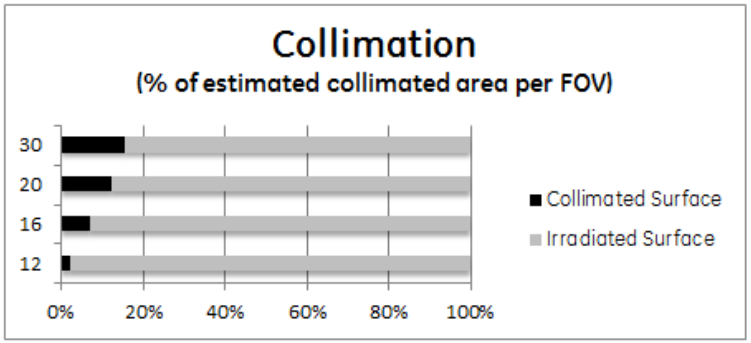


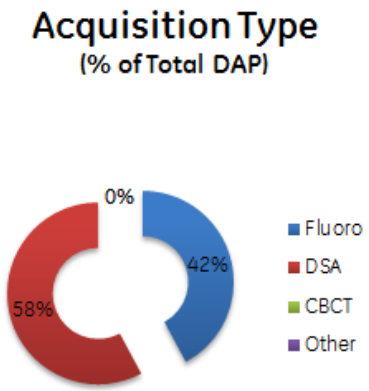
GE Dosewatch

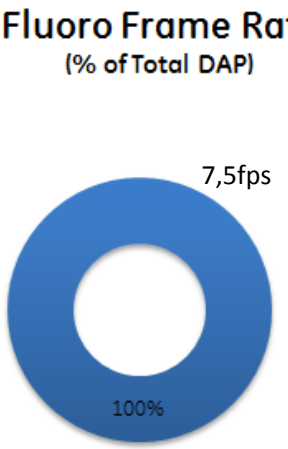
TRAINING

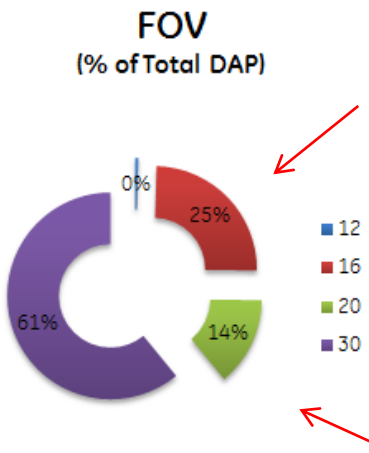
Site X prior the study

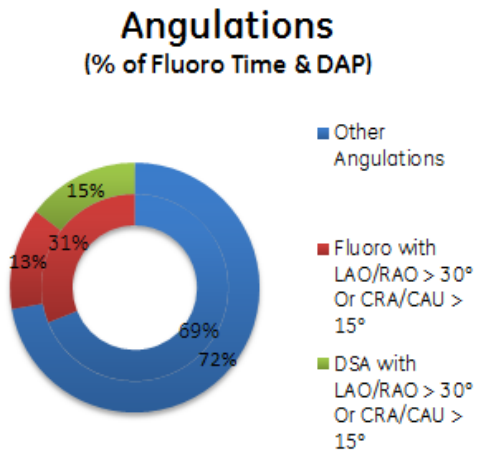
Mean AK (Gy)	**0.23**
Mean DAP (Gy.cm²)	**37.37**
Mean Fluorotime (min)	14.93
Number of DSA Frames per Exam	142.90
Mean EPT (cm)	22.08
Mean SID (m)	1.17
Number of Exams	**10**





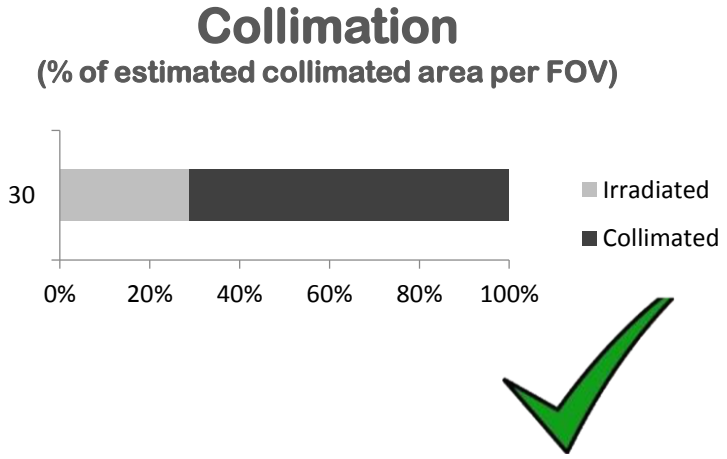


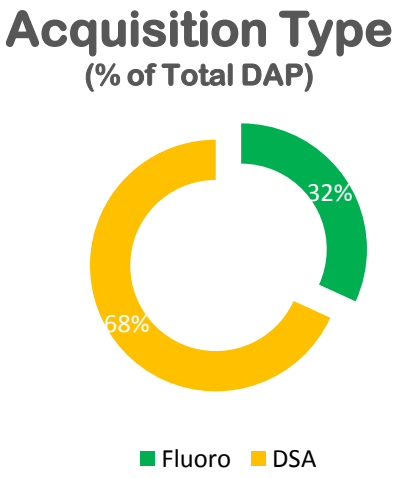


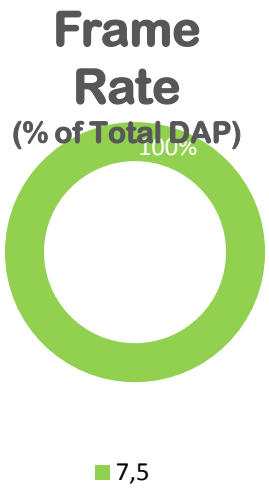


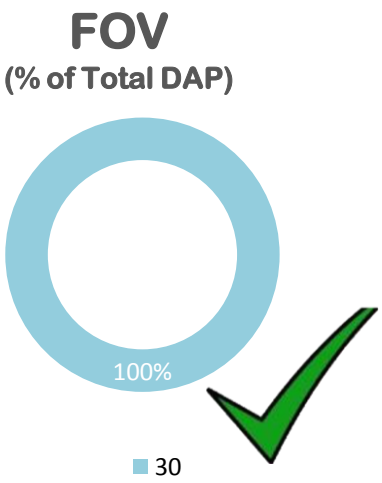
After Practise analysing and dedicated training…

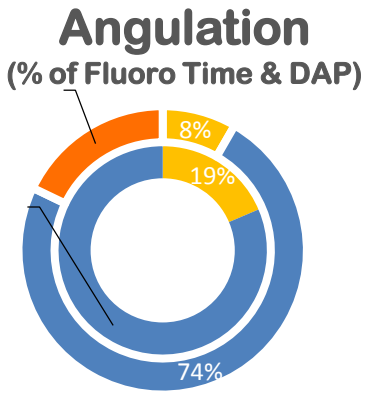
Number Of Cases	**8**
MeanDAP	**16.5 Gy.cm²**
	0.10
MeanAK	**5 Gy**
Mean Fluoro Time	**14.05 min**
Mean SID	**1.15 m**







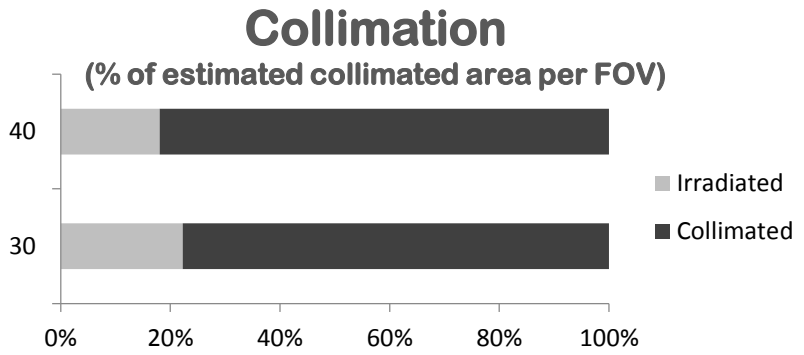


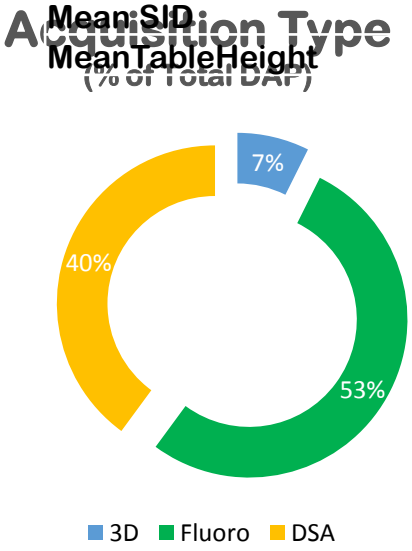


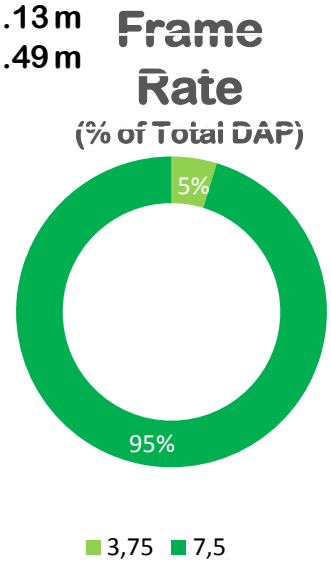
… DAP divided by 2 thanks to FOV & Collimation better management

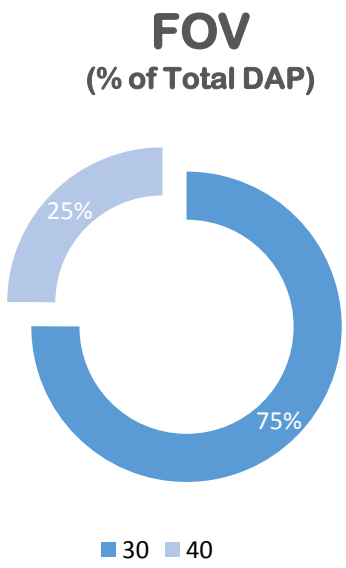
Preliminary Results with Dosewatch

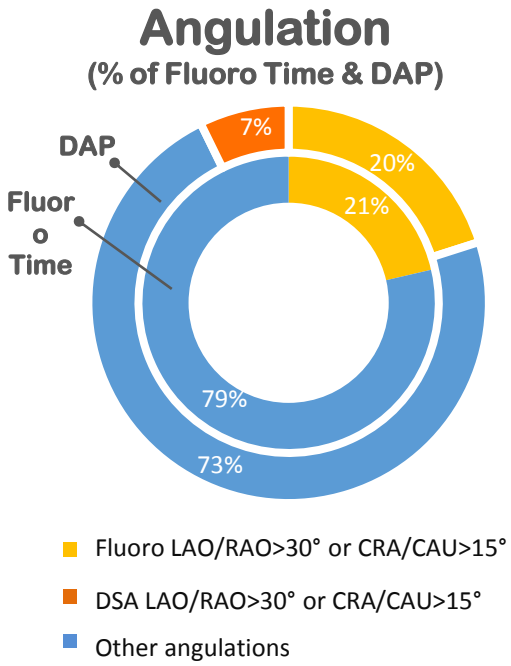
Number Of Cases	37
MeanDAP	17.2 Gy.cm²
MeanAK	0.15 Gy
Mean Fluoro Time	13.02 min
Mean SID	1.13 m
MeanTableHeight	1.49 m











GE Dosewatch *Cloud-based dose practice tracking*

Conclusion

- Low dose technology design must be associated with good practices
- Each step has a huge impact on dose results
- Routine use of fusion imaging with full control at table side enables to achieve low dose results in every center