Decreasing the radiation dose in paediatric cardiac catheterisation- Removal of scatter radiation : a randomised controlled clinical trial.

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Decreasing the radiation dose in paediatric cardiac catheterisation- Removal of scatter radiation : a randomised controlled clinical trial.

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Learning objectives

At the conclusion of this session, participants will be able to :

- Describe current research into radiographic protocols used in the UK and Ireland for paediatric interventional cardiology (PIC).
- Examine the results of a randomised controlled trial investigating different protocols in the clinical department
- Assess the use of the gamma-H2AX assay to quantify DNA double-strand breaks caused by radiation exposure

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Who do we have in the room?

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Why is radiation dose currently a concern?

- The number of PIC procedures performed in the UK increased by 139% between 2000 – 2014 [1] Decreased during the pandemic but it is anticipated will continue to increase [2].
- Increased reliance on IC [3].
- Children up to 8 - 10 times more sensitive to ionising radiation[4-6].
- 4 to 8 times higher risk of radiation-induced cancer as compared to adults [6].
- Children have:

A longer life expectancy to express radiation-induced cancer

Higher rate of mitosis

Higher water content in tissues

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Radiation skin injuries: interventional cardiology

Figure 1: Radiation-induced skin injury to the right arm of a 7 year old girl[5].

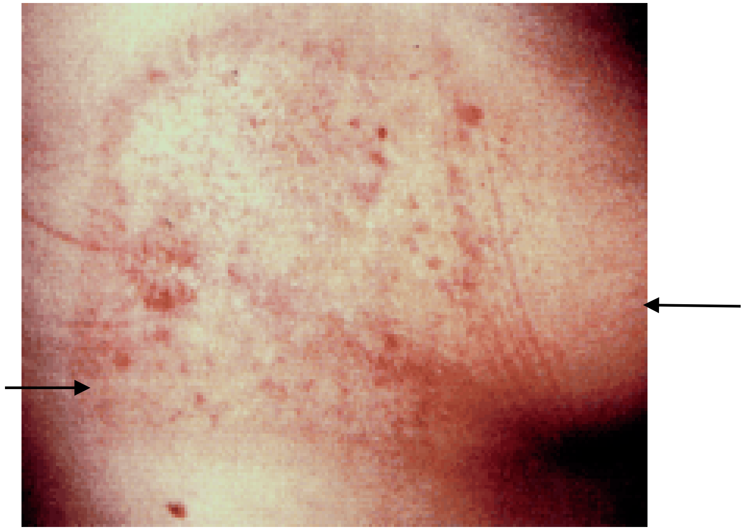

Figure 2: Radiation induced scaring to the right side of the chest and right breast on a 17 year old female. The photograph was taken 2 years post procedure[5].

Background to the research

Diagnostic reference levels (DRLs)

Defined as radiation dose levels for typical X-ray examinations for standard-size patients using standard equipment usually set at the 75th percentile of the histogram of aggregated dose data[7].

Aims to indicate abnormally high doses for common X-ray examinations.

Concept implemented Ionising Radiation (Medical Exposure) Regulations (IRMER) UK 2000[8].

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Initial research

IOP PUBLISHING JOURNAL OF RADIOLOGICAL PROTECTION

J. Radiol. Prot. 33 (2013) 313–319 doi:10.1088/0952-4746/33/2/313

Variation in radiographic protocols in paediatric interventional cardiology

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Abstract

The aim of this work is to determine current radiographic protocols in paediatric interventional cardiology (IC) in the UK and Ireland. To do this we investigated which imaging parameters/protocols are commonly used in IC in different hospitals, to identify if a standard technique is used and illustrate any variation in practice. A questionnaire was sent to all hospitals in the UK and Ireland which perform paediatric IC to obtain information on techniques used in each clinical department and on the range of clinical examinations performed. Ethical and research governance approval was sought from the Office for Research Ethics Committees Northern Ireland and the individual trusts. A response rate of 79% was achieved, and a wide variation in technique was found between hospitals. The main differences in technique involved variations in the use of an anti-scatter grid and the use of additional filtration to the radiation beam, frame rates for digital acquisition and pre-programmed projections/paediatric specific programming in the equipment. We conclude that there is no standard protocol for carrying out paediatric IC in the UK or Ireland. Each hospital carries out the

Phantom based work

IOP PUBLISHING JOURNAL OF RADIOLOGICAL PROTECTION

J. Radiol. Prot. **33** (2013) 433–443 doi:10.1088/0952-4746/33/2/433

An analysis of radiation dose reduction in paediatric interventional cardiology by altering frame rate and use of the anti-scatter grid

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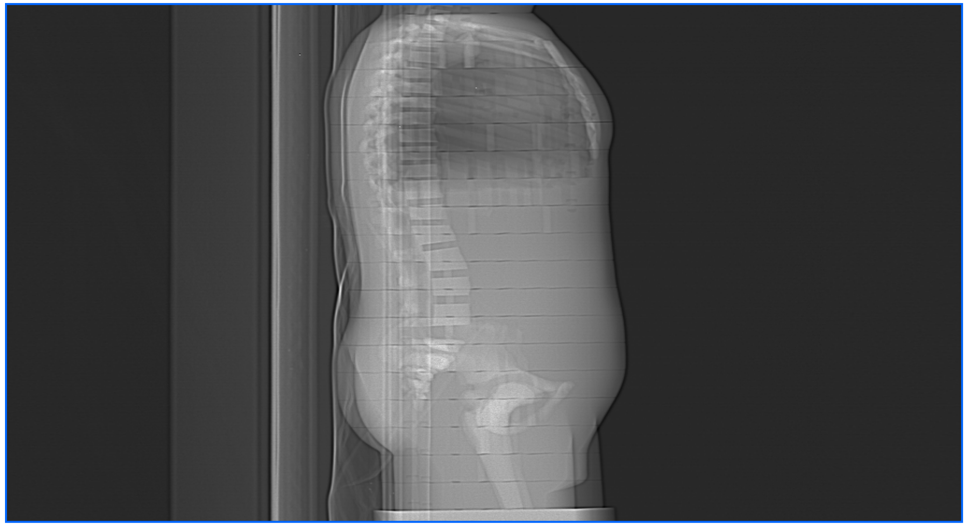
Abstract

The purpose of this work is to investigate removal of the anti-scatter grid and alteration of the frame rate in paediatric interventional cardiology (IC) and assess the impact on radiation dose and image quality. Phantom based experimental studies were performed in a dedicated cardiac catheterisation suite to investigate variations in radiation dose and image quality, with various changes in imaging parameters. Phantom based experimental studies employing

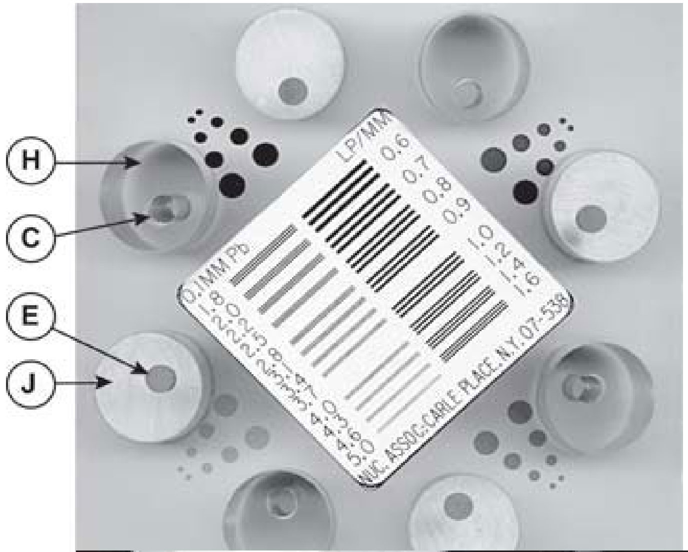
Clinical examination simulated

Anthropomorphic phantom



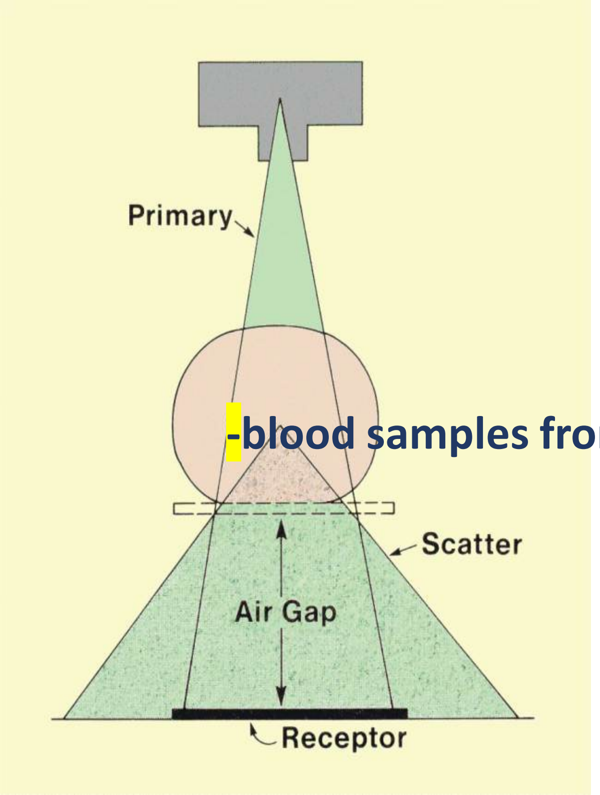
http://www.cirsinc.com/700_ct_xray.html

NEMA phantom

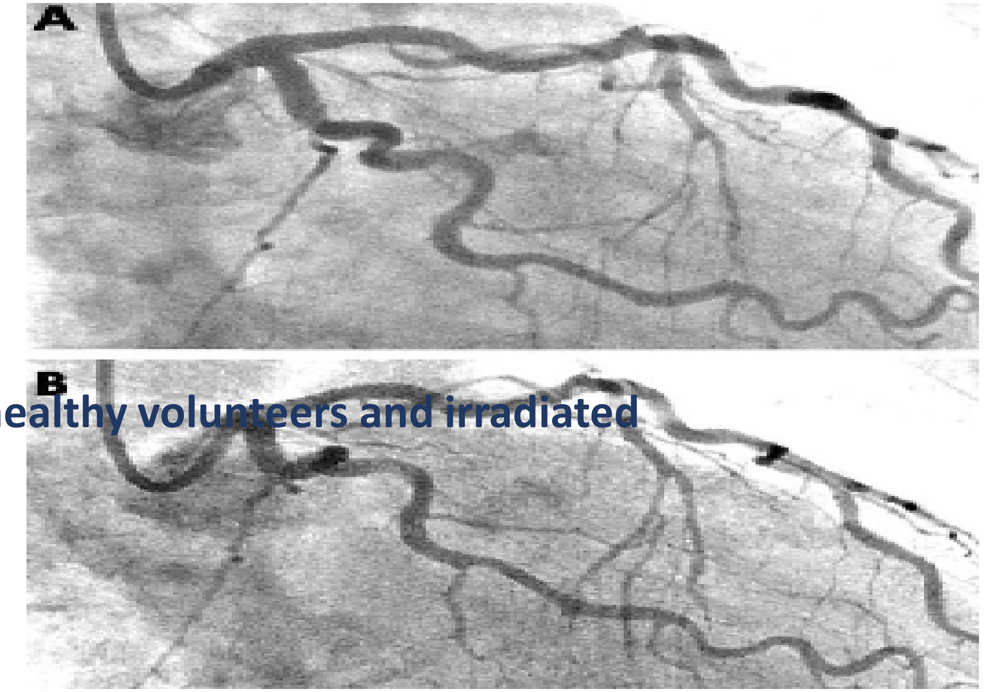


http://us.fluke.com/usen/support/Accessory.htmtxtProduct=phantom)

Air-gap method



-blood samples from healthy volunteers and irradiated



Left coronary arteriogram of an adult patient: A, Without AS grid and 15 cm AG and B, with AS grid[15]

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DNA damage **-gamma-H2AX assay**

- -blood samples from healthy volunteers and irradiated to equivalent PIC doses
- -mixed with different concentrations of contrast media to determine impact on DNA damage
- Results showed….

DNA paper

We wanted to translate the research into clinical practice

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Aim

To investigate ways to decrease the radiation dose in PIC

Objectives

1 - To investigate the random implementation of scatter removal techniques (informed by phantom studies).

2 - Quantify DNA double-strand breaks using gamma-H2AX assay (biological assessment of dose reductions).

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3 scatter removal techniques used

- Anti-scatter grid in place
- No Anti-scatter grid
- No Anti-scatter grid and 15 cm Air Gap between object and detector.

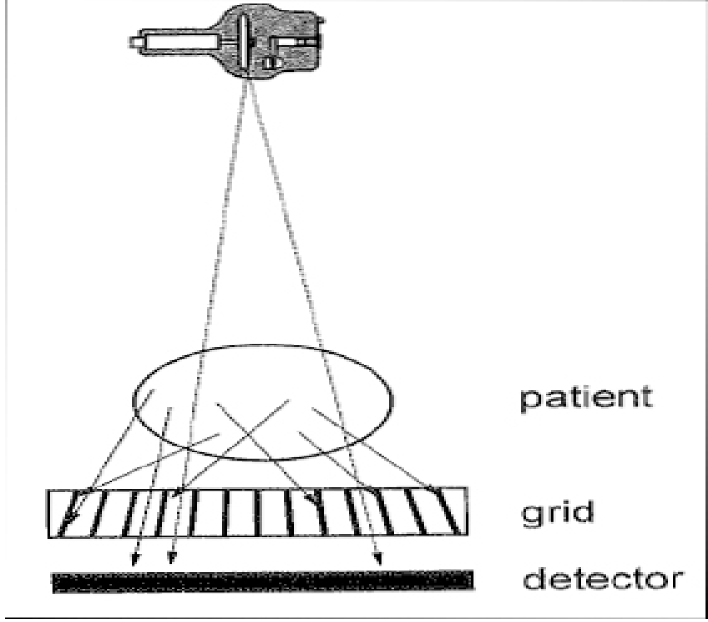

Figure 3. Anti-scatter grid technique

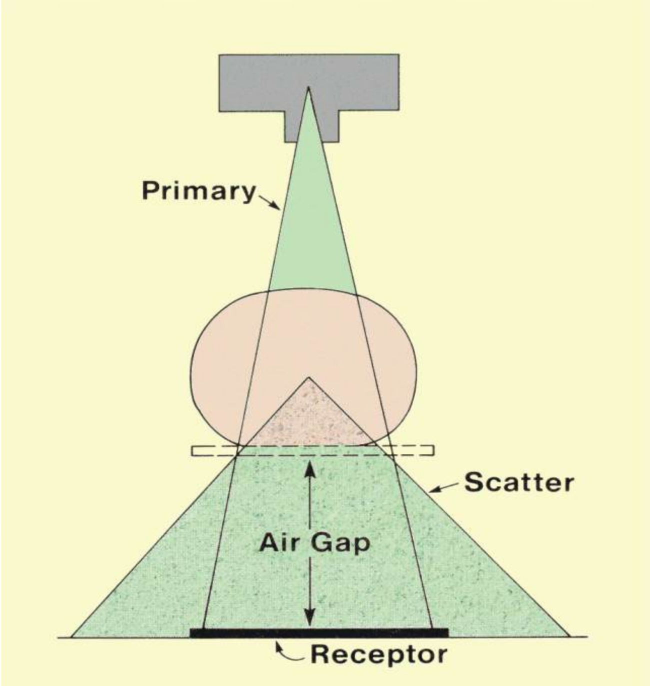

Figure 4. Air-gap technique

Methodology

Local ethical approval obtained for single centre randomised study implementing 3 imaging methods on 70 consecutive participants randomly assigned to an imaging method.

Inclusion criteria:

1) patients undergoing a PIC,
2) aged ≤ 16 years,
3) written informed consent.

Exclusion criteria:

1) written informed consent not possible
2) participant withdrawal,
3) emergency procedure.

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Methodology continued

Imaging conducted using a Philips Allura exper FD10/10 bi-plane system (Philips medical systems) caesium iodide flat panel detector.

Routine technique (AS grid) reverted to if deemed necessary.

Blinded image quality scoring performed by two paediatric interventional cardiologists on images selected from the highest and lowest radiation doses for each imaging method from 0-20 kg, 20-40 kg and >40 kg weight categories.

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Participant characteristics

	Patients	Males	Females	Age (years) mean	Weight (kgs) mean	Chest diameter (cm) mean
AS grid	24	12	12	5.8	23.0	12.9
No AS grid	23	13	10	5.2	20.1	12.3
15 cm AG	23	12	11	6.4	24.8	12.7

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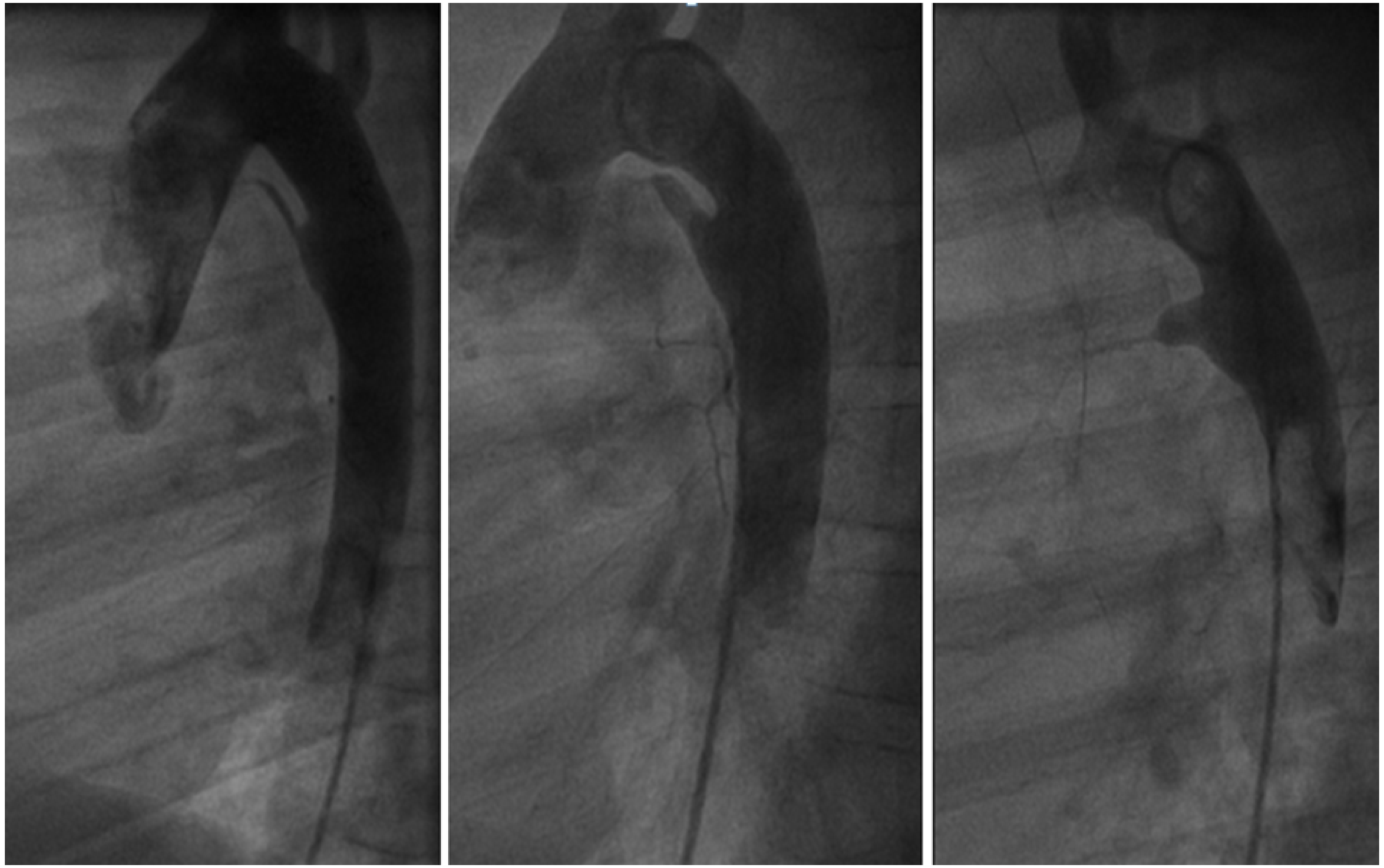
Sample image quality with the 3 techniques

What imaging method was used for each of the 3 lateral CINE images in 10-20 kg patients?



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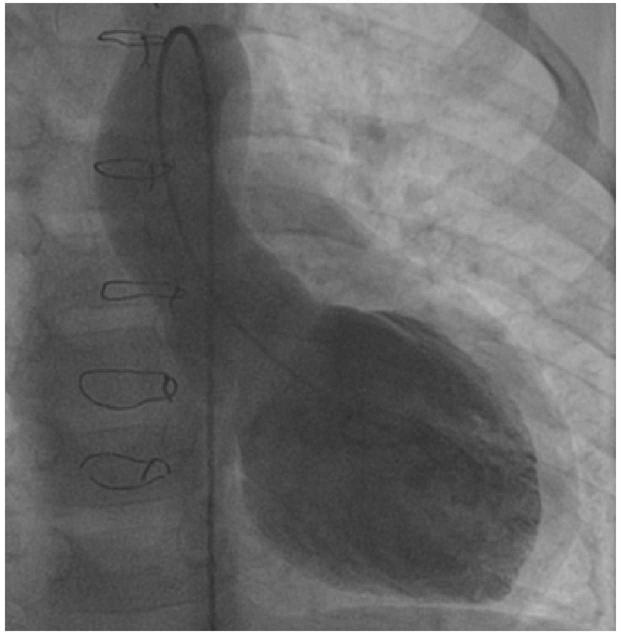
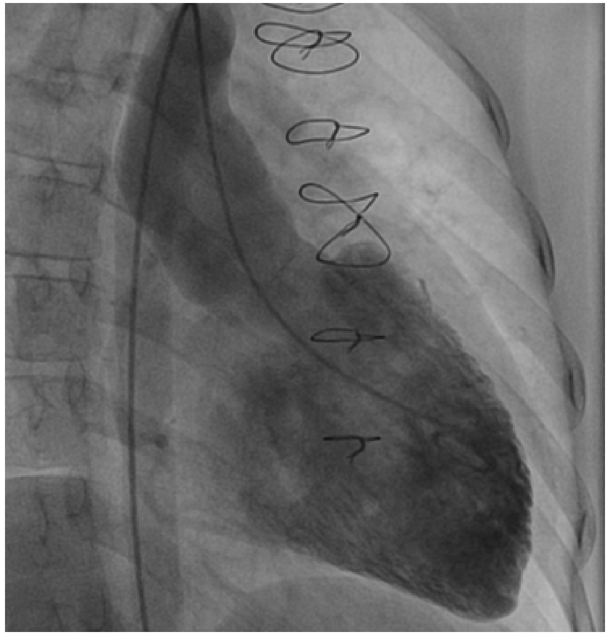
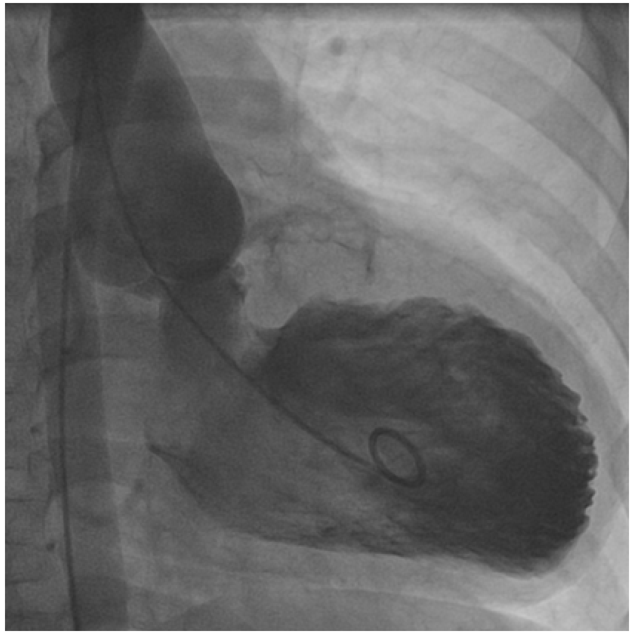
Left ventriculogram of ~ 20 kg patients

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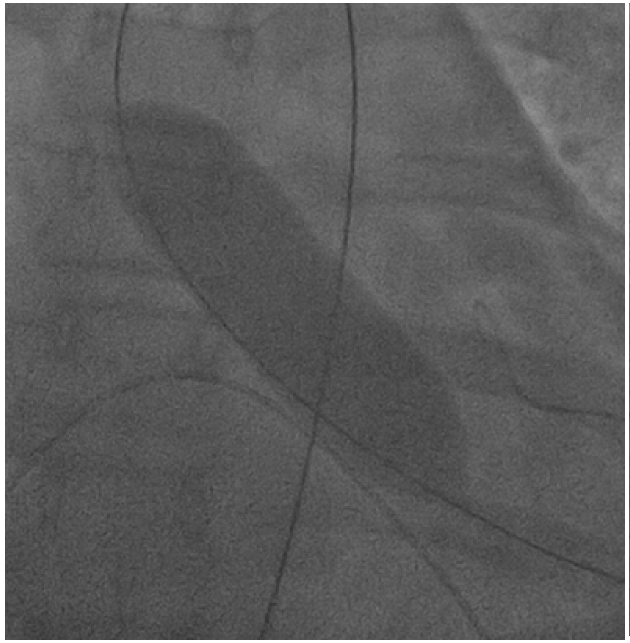
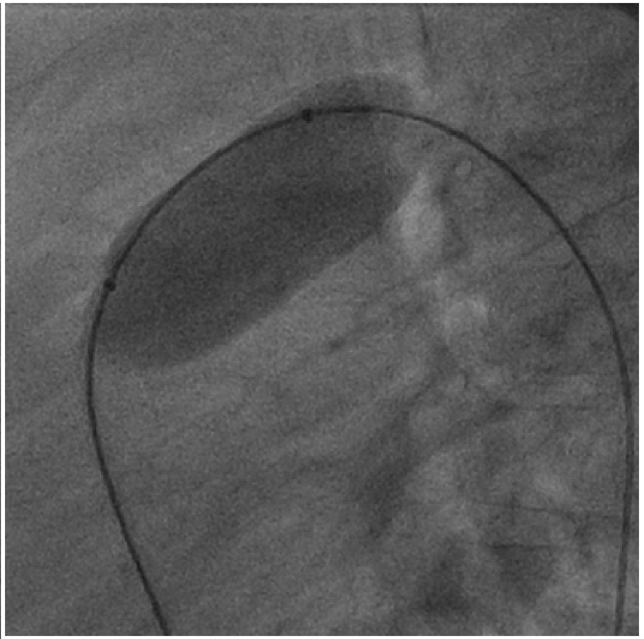
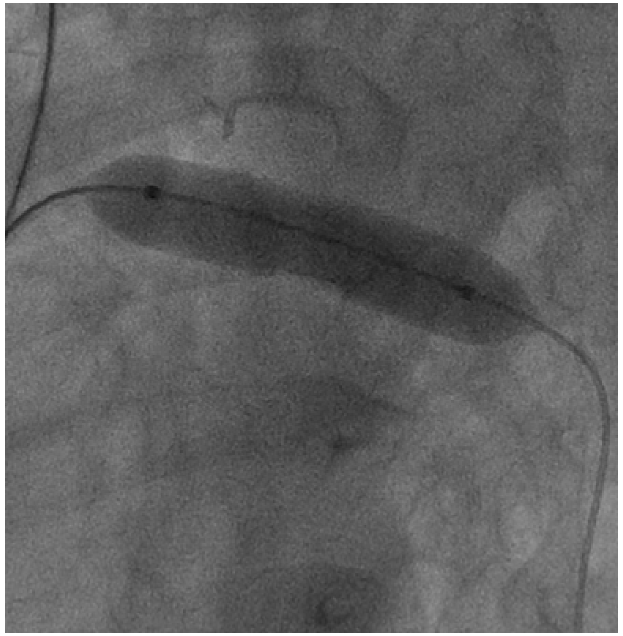
Balloon inflations



99 kg



17 kg



13.5 kg

Atrial septal defect – amplazter device insertion, 10 – 20 kg

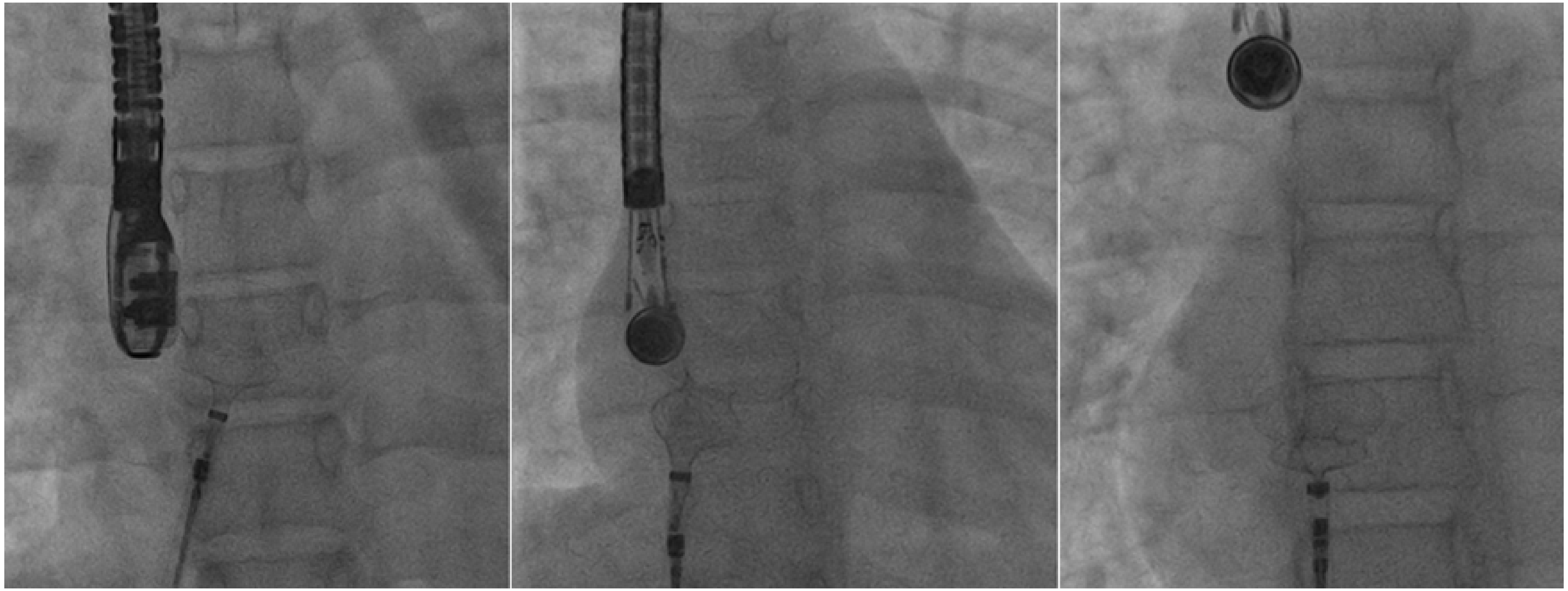


Image quality scores with the 3 techniques

Frequency of image quality scores for overall procedure

Score	Anti-scatter grid	No anti-scatter grid	15 cm air-gap
2	5	4	4
1	6	5	6
0	0	1	2
-1	0	0	0
-2	0	0	0

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Results of Clinical image quality

No request to reinsert the AS grid for any procedures.

Kappa measure of agreement demonstrated a strong agreement between image scorers ($p<0.05$).

Comparable blinded image scoring.

-However 1 scored zero for stent visualization during fluoroscopy in a large patient and oblique angulation using no AS grid and 2 scored zero for larger patients using an air gap (zero was diagnostically acceptable).

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Imaging parameters and examination types

	AS grid	No AS grid	15 cm AG
*Fluoroscopy time (s)	663±556	813±633	843±573
Total CINE acquisitions (n)	146	177	151
*Tube current (mA)	357±214	216±93	267±163
*Tube potential (kVp)	71±3.4	68±4.2	67±4
*CINE time (s)	4.3±1.4	4.3±1.3	4.1±2.1
Diagnostic (n)	5	8	9
Interventional (n)	19	15	14

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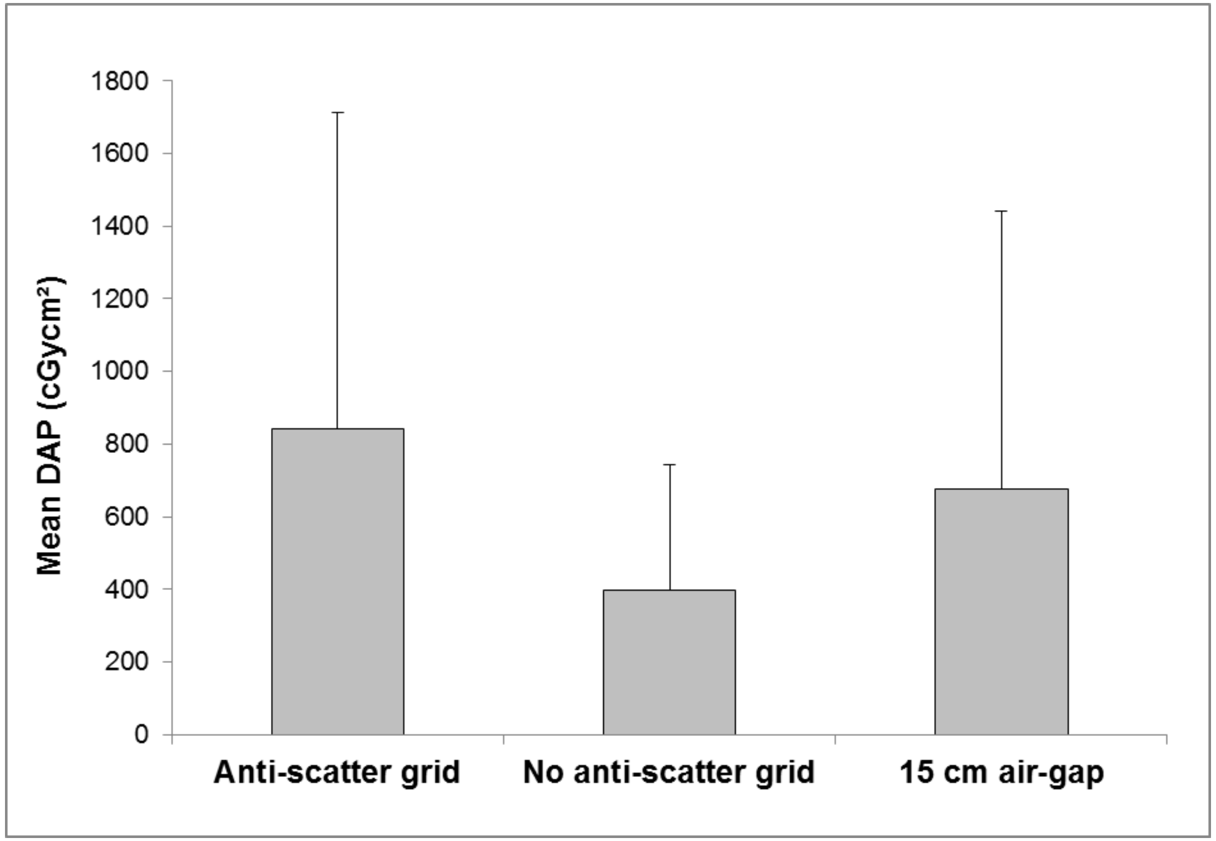
*Data presented as mean and standard deviation

Mean dose area product for each imaging method

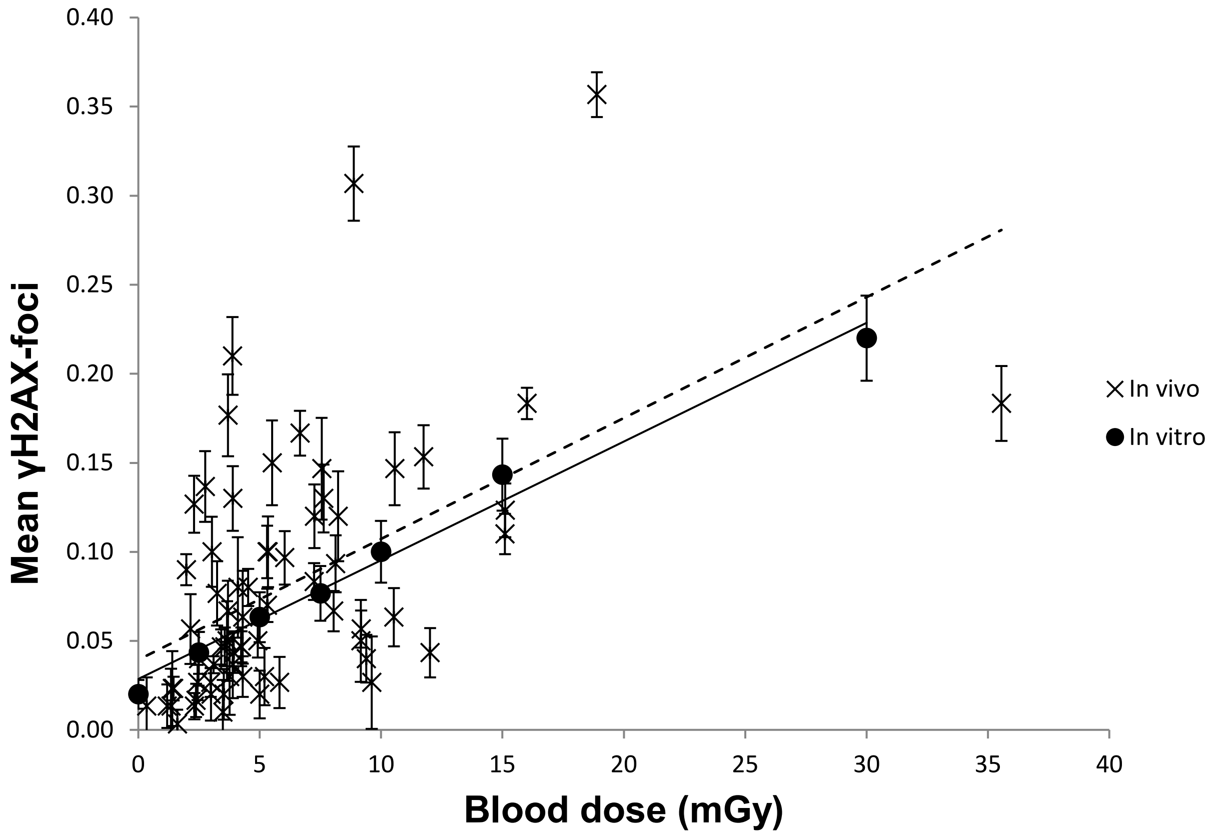


We knew we could decease the radiation dose, maintain image quality but what about the associated DNA damage?

-gamma-H2AX assay

-blood samples taken at the start and the end of each PIC procedure

Mean double-strand break induction with standard error for in vivo and in vitro ionising radiation exposures. Dashed line represents the *in vivo* response and the solid line represents the *in vitro* response.



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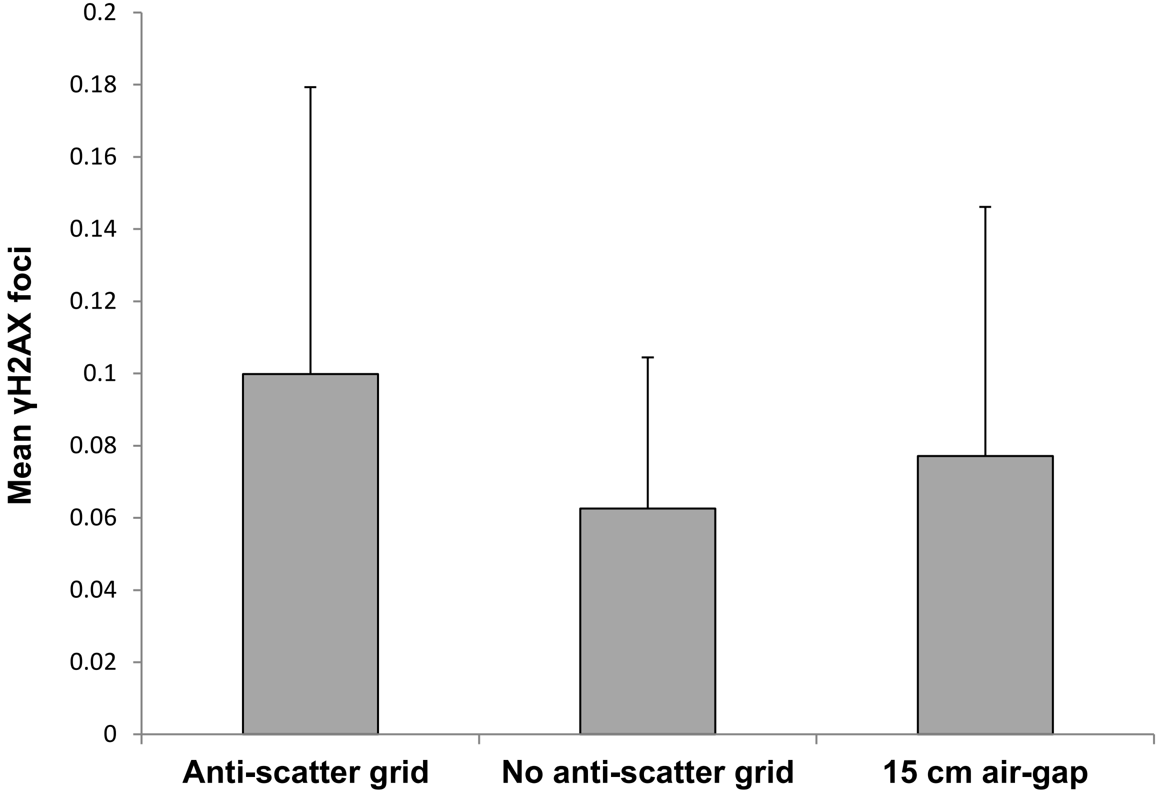
Mean double-strand breaks induced by each imaging method



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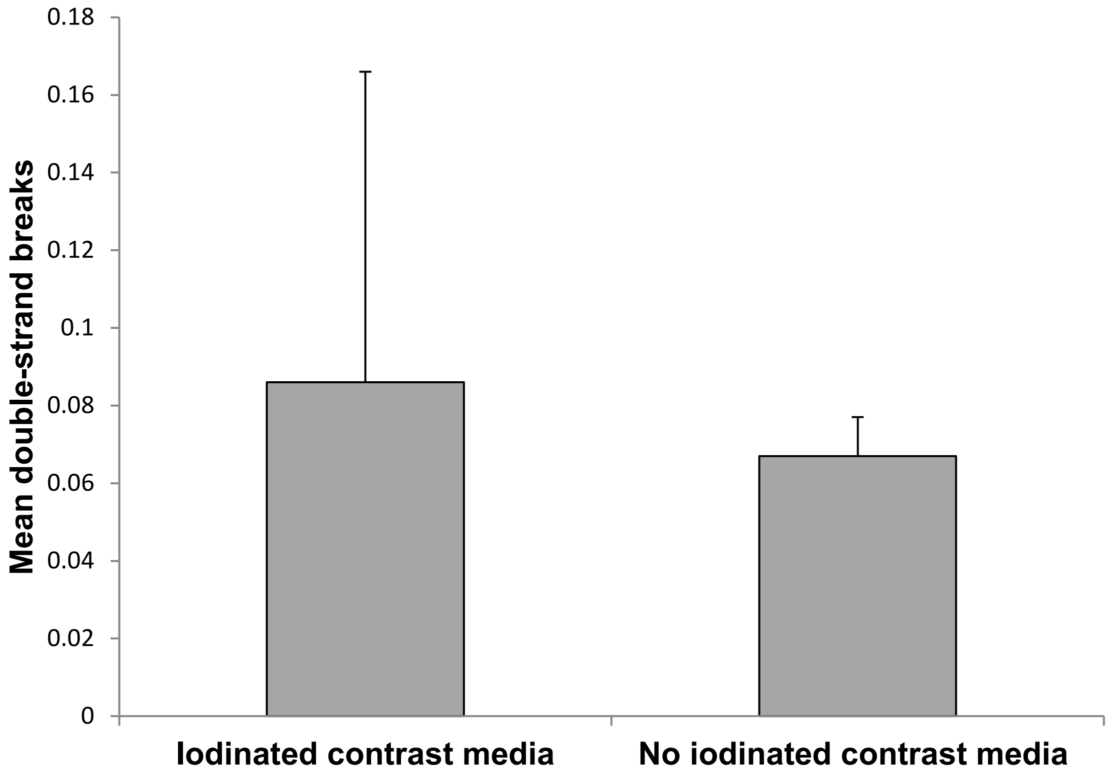
Comparison of double-strand breaks in contrast media and no contrast media groups (taking into account effect of radiation dose).



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Summary

- Apply basic knowledge of radiation dose optimization at all times. Remember lower patient dose = lower staff dose.

- Consider applying local DRLs.

- Consider removing AS grid (+/- air-gap) in children.
  - 20-53% less radiation,
  - 23-34% less DNA damage,
  - 20 – 35% less risk of radiation-induced cancer.

- Consider using no/diluted Iodinated contrast media, or reduce the dosage.

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Survey Monkey

Alter survey

Add q codes

Acknowledgements

Prof C Hughes, , Dr R Gould

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Questions and comments