



## Patients

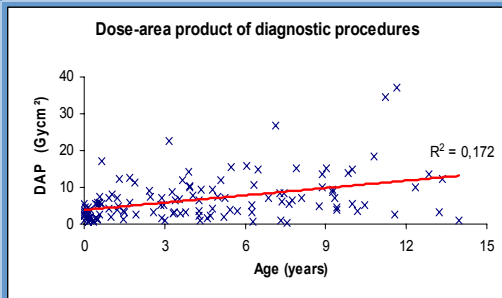
Group	Age	No. patients (diagnostic + therapeutic)
A	0 to 30 days	12 + 21
B	1 to 12 months	49 + 76
C	> 1 to 3 years	29 + 48
D	> 3 to 5 years	14 + 38
E	> 5 to 10 years	31 + 65
F	> 10 to 15 years	12 + 25

Total 273 patients = 126 diagnostic + 147 therapeutic interventions

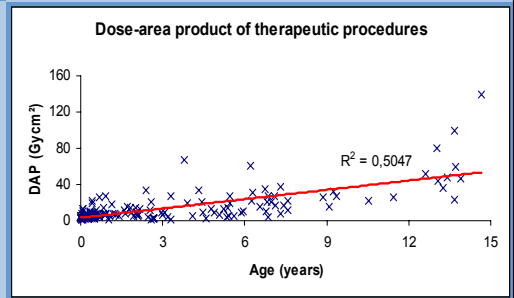
## Therapeutic procedures

Name procedure	Acronym	A	B	C	D	E	F
balloon dilatation of pulmonary valve	BD-PV	11	17	4		4	1
balloon dilatation of peripheral pulmonary stenosis	BD-PS		6	6	3	4	5
balloon dilatation for coarctation of the aorta	BD-R		3	1			1
stent implantation	S	1	11	4	4	10	2
occlusion of patent ductus arteriosus	PDA		6	6	1	2	
closure of atrial septal defect	ASD		2	4	4	5	1
closure of ventricular septal defect	VSD			4		2	
combination of at least 2 procedures from above	Complex	4		2	4	2	

## Results: DAP



## Results: DAP



## Results – fluoroscopy time (diagnostic)

Fluoroscopy time (minutes)	0 – 30 days	1 – 12 months	>1 – 3 years	>3 – 5 years	>5 – 10 years	>10 – 75 years
<b>A</b> Median	9	5	8	7,5	7	4
IQR (75th-25th)	12,5 - 3,75	7 - 3	12 - 4,5	12,75 - 4	9,5 - 4	12 - 3
<b>B</b> Median	2	1	3	1	0,1	0,5
IQR (75th-25th)	6 - 1,25	2 - 1	4 - 1	2,75 - 0,2	1,75 - 0	1,75 - 0
<b>A + B</b> Median	11	6	10	8	8	5
IQR (75th-25th)	18 - 6	11 - 4	14 - 8	14 - 5,25	10,5 - 5,75	16,5 - 3
<b>No. cines (median)</b>	8	6	6	10	8	6

A – frontal tube (PA)  
B – lateral tube (LAT)

## Results – DAP (diagnostic)

DAP (Gycm <sup>2</sup> )	0 – 30 days	1 – 12 months	>1 – 3 years	>3 – 5 years	>5 – 10 years	>10 – 75 years
<b>A</b> Median	1,7	1,3	3,2	3,6	4,3	5,5
IQR (75th-25th)	2,6 - 1,2	2,1 - 0,8	4,7 - 1,7	5,1 - 2,1	6,7 - 2,6	10,8 - 2,5
<b>B</b> Median	1,1	1,1	2,2	1,6	4,1	6,6
IQR (75th-25th)	1,6 - 0,8	3 - 0,5	3,7 - 1,2	4,4 - 0,2	6,6 - 2,5	1,75 - 0
<b>A + B</b> Median	2,7	2,5	5,1	5,8	7,1	9,9
IQR (75th-25th)	4,1 - 2,3	5,4 - 1,2	8 - 3,1	9,4 - 2,9	12,3 - 4,4	16,6 - 3,5

A – frontal tube (PA)  
B – lateral tube (LAT)

## Results – fluoroscopy time (therapeutic)

Fluoroscopy time (minutes)	0 – 30 days	1 – 12 months	>1 – 3 years	>3 – 5 years	>5 – 10 years	>10 – 75 years
<b>A</b> Median	9	8	19	12,5	18	15
IQR (75th-25th)	16 - 5	18 - 6	19,5 - 5,5	27,5 - 10	23 - 10	23,5 - 11
<b>B</b> Median	9,5	3	3	4	4	5
IQR (75th-25th)	10 – 4,25	6 - 2	5,5 – 1,5	5 – 2	6 – 1,75	8,75 - 4
<b>A + B</b> Median	16,5	12	16	18	21	20
IQR (75th-25th)	24,25-13,5	25 – 9	24,5 – 9,5	33,5 - 11	26 - 14	39,75 - 16

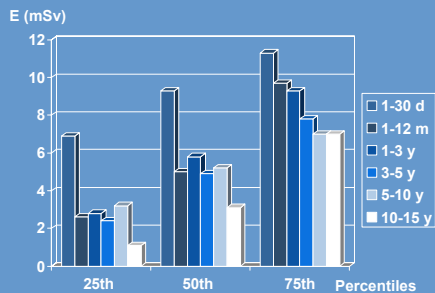
A – frontal tube (PA)  
B – lateral tube (LAT)

## Results – DAP (therapeutic)

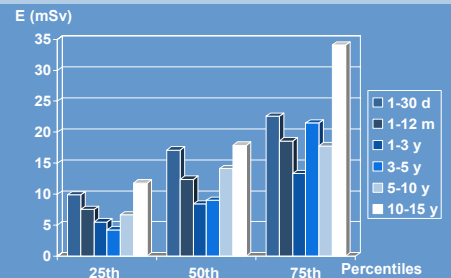
DAP (Gycm <sup>2</sup> )	0 – 30 days	1 – 12 months	>1 – 3 years	>3 – 5 years	>5 – 10 years	>10 – 75 years
<b>A</b> Median	2,1	3,5	4,3	5,9	11,1	26,5
IQR (75th-25th)	4,1 – 1,3	5,2 – 2,3	6,9 – 2,5	16 – 3,9	14,6 – 6,7	40,3 – 15,4
<b>B</b> Median	1,3	2,2	3,3	5,1	6,4	20,2
IQR (75th-25th)	3,5 – 0,9	3,7 – 1,3	4,5 – 1,7	11,2 – 2,7	11,5 – 1,7	34,7 – 14
<b>A + B</b> Median	4,8	5,9	7,5	9,5	17,1	46,8
IQR (75th-25th)	6,5 – 2,5	9,2 – 3,7	12,5 - 5	22,2 – 5	27 – 9,7	74,4 – 28,7

A – frontal tube (PA)  
B – lateral tube (LAT)

## Results – effective dose (diagnostic)



## Results – effective dose (therapeutic)



75th E (mSv) per type of therapeutic procedure

ASD 5.8	PDA 8.9	BD-PV 16.9	BD-R 17.6
S 18.3	VSD 20,4	BD-PS 22	Complex 39,4

## Results: literature review

Author	Population	DAP (Gycm <sup>2</sup> )	E (mSv)	Notes
Boothroyd (1997)	30 D + 20 T (2 – 18 y)	5.6 – 43 (D) 1.3 – 202.4 (T)	no	Entrance dose with TLD Included Epiphy
Rassow (2000)	2114 (0 – 21 y)	6.2 - 36	90% < 18 mSv for neonates	8 age groups DCF from Hart 5 percentiles
Schultz (2003)	Small sample	4.45 (D 0y) 18.8 (ASD, 6y)	7.4 6.6	MCNP & PCXMC
Bacher (2004)	28 D + 32 T (0 – 10 y)	0.96-14.6 (D) 0.4 – 20.4 (T)	0.6 – 23.2 (D) 1 – 37 (T)	Global DCF depending on filtration
Onnasch (2006)	2859 (1.5 – 115 kg) 217 adults with CHD	DAP/Kg 0.81 D 1.16 T	Estimated using DCFs of Schmidt	3 X-ray systems
Nickoloff (2007)	FPD – assessment of equipment variables with 15-30cm acrylic plastic 7 – 75 mSv (D) & 17 – 170 mSv (T)			

## Results – Dose conversion factors

DCF = E / DAP (mSv/Gycm<sup>2</sup>)

DCF (mean ± SD)	0 – 30 days	1 – 12 months	>1 – 3 years	>3 – 5 years	>5 – 10 years	>10 – 75 years
<b>Tube A (PA)</b>	3,61 ± 0,79	2,19 ± 0,58	1,21 ± 0,26	0,91 ± 0,19	0,71 ± 0,16	0,41 ± 0,16
<b>Tube B (LAT)</b>	3,31 ± 0,81	2,17 ± 0,62	1,11 ± 0,25	0,87 ± 0,17	0,65 ± 0,16	0,39 ± 0,13
<b>A + B all procedure</b>	<u>3,47</u> ± 0,61	<u>2,18</u> ± 0,61	<u>1,16</u> ± 0,25	<u>0,91</u> ± 0,17	<u>0,7</u> ± 0,16	<u>0,39</u> ± 0,14

DCF Schmidt (Phys.Med.Biol. 45 (2000))

	0 y	1 y	5 y	10 y	15 y
PA	2,050	0,815	0,415	0,241	0,129
LAT	2,337	1,156	0,641	0,381	0,215

65 kV, 8°, 3 mm Al → 3.5 mmAl + 0,1 mmCu ↑ 27% PA, 24% LAT

## Conclusions

- Doses in paediatric patients in the cath lab can be high. These patients are subject to various diagnostic and therapeutic procedures during growth period. It is important to verify typical dose levels
- We propose to use a DRL based on DAP and/or E
- Local DRLs in terms of DAP is the 1st step in implementation of the ALARA principle and gives clear guidance to the interventional cardiologist

## Conclusions

- Division in age bands is relevant
- Distinction between diagnostic and therapeutic procedure is relevant
- With larger databases, it may be relevant to propose DRLs for the different types of therapeutic procedure
- For easy communication to the medical staff, a single DRL for diagnostic and therapeutic procedures per age band is recommended

## Conclusions

- For estimation of E - to use equipment specific DCF (make sure your spectra and geometry match with the published conditions or personalize the calculations using, as an example, PCXMC)
- For dose survey studies, all available technical data of the Dicom header or the patient dose reports could be used, but today it remains a time consuming activity (transfer of data and linking technical and clinical data should & could be further optimized)
- Modern cardiac imaging equipment has the potential of dose saving if it is optimally utilized (choosing the right selectable settings !!)