Estimating patient weight from body CT images – how accurate are the results?

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Motivation/Challenge

PACS and RDIM (Radiation Dose Index Monitoring) systems

- ➢ dosimetric parameters ($CTDI_{vol}$, KAP) for thousands of exams
- ➢ easy to obtain mean values, distributions...

- ➢ **typical values depend on patient size**
- ➢ **patient weight (and height) not usually archived in PACS**

- ➢ Patient weight collected only during dose audits or collection of data for Diagnostic Reference Levels (DRLs)

- ➢ Retrospective studies?
- ➢ Comparison of mean values for different institutions and different populations?

Motivation/Challenge

Other metrics of patient size easily obtained from CT images:

- ➢ **AP and lateral dimensions**

- ➢ **Effective diameter**

- ➢ **Water equivalent diameter (D_w)**

Oncology hospital: many patients with multiple exams

- ➢ Is it possible to obtain an estimate of patient weight from archived CT images?

- ➢ How accurate is the result?

Summary of present work

➤ **2014** – large-scale optimization study & internal dose audit: biometric patient data and D_{w_ave} for 119 chest+abdomen+pelvis (CAP) CT exams

➤ **2018** – national data collection to establish Diagnostic Reference Levels (DRLs)

    ➤ **biometric&dosimetric data**

    ➤ **11 CAP CT exams**

    ➤ **31 chest RX**

    ➤ **9 chest RX with CAP CT images archived in PACS**

In this work:

❖ Calculated D_w for these new CAP CT exams

❖ Estimated patient weight (W_e)

❖ Compared W_e with the patient weight recorded during data collection (W_{da})

Chosen patient-size metric:
water equivalent diameter (Dw)

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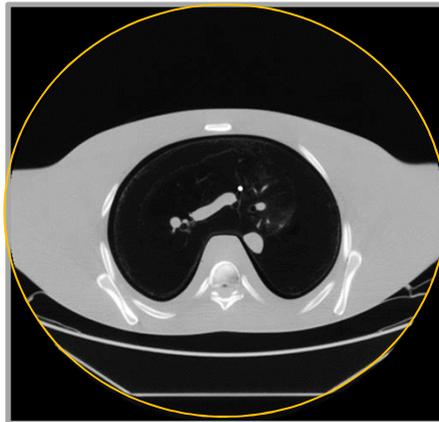
AAPM TG 220

$$A_w = \frac{1}{1000} <HU>_{ROI} A_{ROI} + A_{ROI}$$

$$D_w(z) = 2\sqrt{\frac{A_w(z) - A_w(table)}{\pi}}$$

Water equivalent diameter: $D_w(z)$
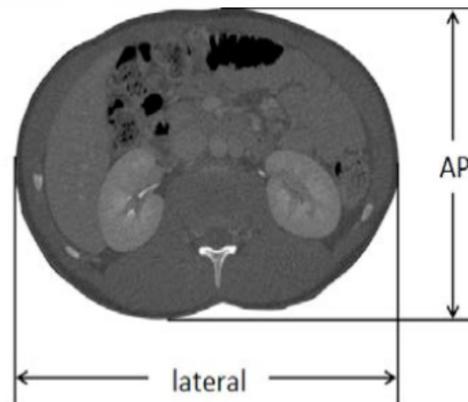
~300 images: D_{w_ave}

Dw : diameter of a water cylinder with the same attenuation as the patient

SSDE – Size Specific Dose Estimates:

AAPM TG 204

$$SSDE = CTDI_{vol}^{32} \times f_{D_{eff}}^{32}$$

$$D_{eff} = \sqrt{AP \times Lateral}$$

Effective Dia (cm)	Conversion Factor
8	2.76
9	2.66
10	2.57
11	2.47
12	2.38
13	2.30
14	2.22

Use of Water Equivalent Diameter for Calculating Patient Size and Size-Specific Dose Estimates (SSDE) in CT - Report of AAPM Task Group 220. College Park, MD: American Association of Physicists in Medicine; 2014.

Size-Specific Dose Estimates (SSDE) in Pediatric and Adult Body CT Examinations - Report of AAPM Task Group 204.; 2011
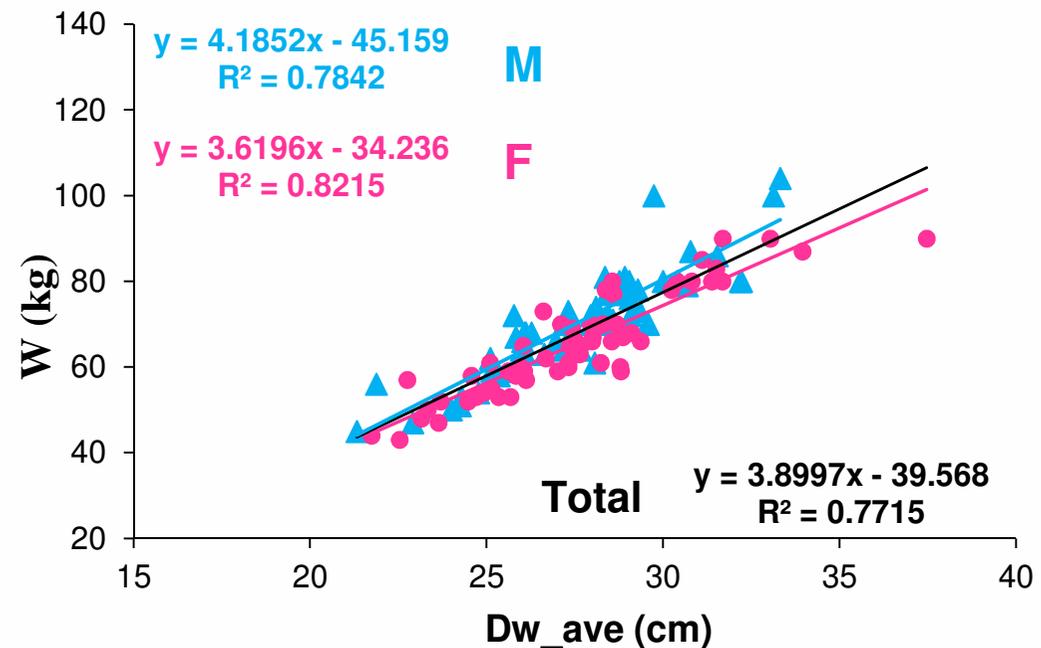
Previously existing data for CAP CT exams

scanner	# patients	Age (y)	W (kg)	Height (cm)
GE Lightspeed	41 (22 M; 19 F)	60 (32 - 80)	65 (44 - 90)	163 (145 - 180)
Toshiba Aquilion	78 (38 M; 40 F)	63 (36 - 83)	70 (43 - 104)	163 (144 - 185)
Total	119 (60 M; 59 F)			

two 16-slice scanners

2014 dose audit
randomly selected exams

Representative of patient
population in the hospital

CAP – chest+abdomen+pelvis

$y = 4.1852x - 45.159$
$R^2 = 0.7842$ **M**

$y = 3.6196x - 34.236$
$R^2 = 0.8215$ **F**

Total $y = 3.8997x - 39.568$
$R^2 = 0.7715$

W (kg) vs Dw_ave (cm)

S. Sarmento *et al* "Automatic calculation of patient size metrics in
computed tomography : What level of computational accuracy do we
need?," *J. Appl. Cinical Med. Phys.*, 2018

Lincoln 2018

National DRL data collection: April 2018

11 CAP CT – chest+abdomen+pelvis CT

M/F	Wda (kg)	H(m)	# acq	CTDIvol (mGy)	DLP (mGycm)
M	60	1.73	1	5.7	444.4
M	60	1.71	1	7.0	522.5
F	63	1.60	1	9.9	663.8
F	63	1.66	1	8.9	624.8
M	64	1.64	1	9.9	651.6
F	68	1.65	1	12.4	795.9
M	70	1.70	2	9.9	1493.8
M	71	1.62	1	12.3	832.4
F	78	1.60	1	18.1	1204.4
M	78	1.80	1	11.5	880.7
M	80	1.78	1	17.2	1282.6
Mean	**69**	**1.68**		**11.2**	**854.3**
StdDev	**7.4**	**0.07**		**3.8**	**336**

Patient weight: 60 – 80 kg

Patient height: 1.60 – 1.80 m

10 patients per exam type

NRD PORTUGAL
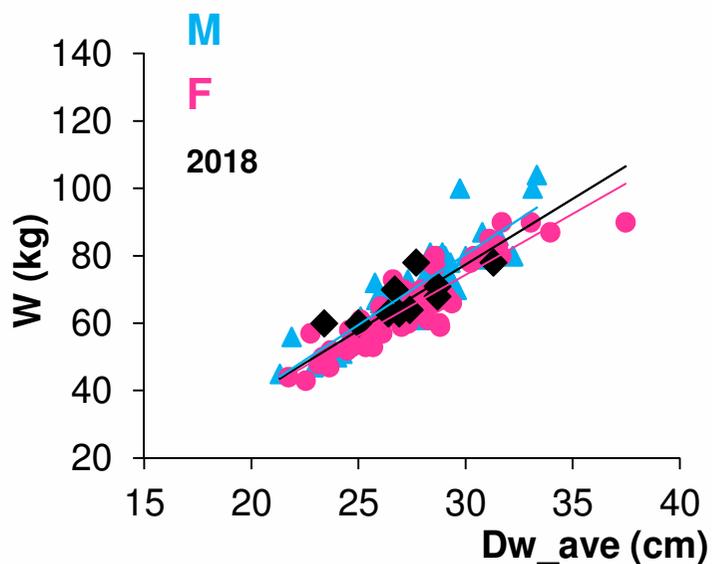NÍVEIS DE REFERÊNCIA DE DIAGNÓSTICO EM PORTUGAL
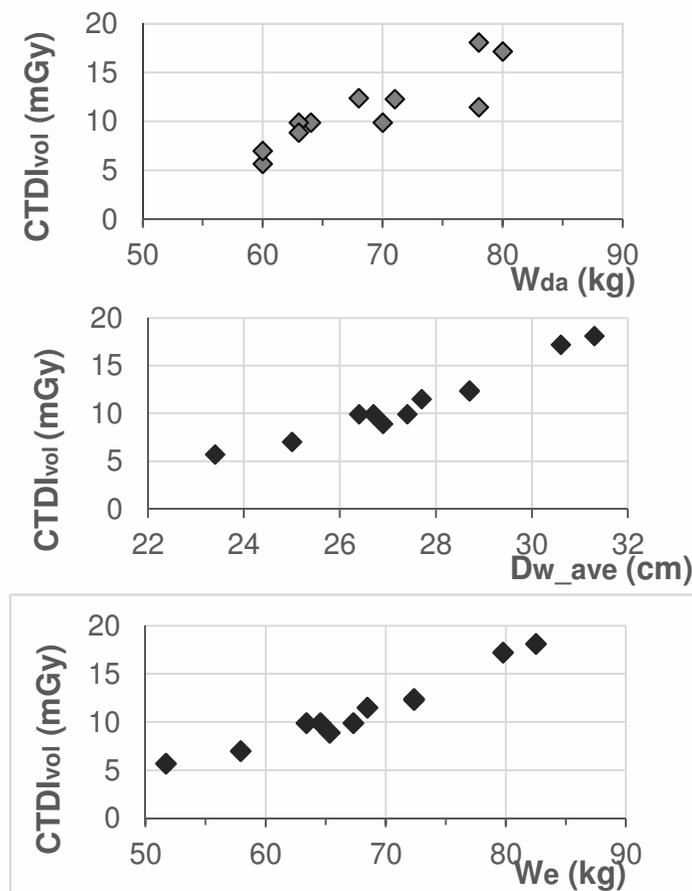
Questionário Nacional

2018

National DRL data collection: 2018

- D_{w_ave} calculated for all 2018 CAP CT exams

- W_e (Weight estimated from D_{w_ave})

- W_{da} (Weight recorded in 2018 dose audit)

W_{da} vs D_{w_ave} well aligned with previous data (as expected: same patient population)

$CTDI_{vol}$ correlates better with D_{w_ave} and W_e than W_{da}

Difference between W_e (estimated from D_{w_ave}) and W_{da} (recorded in the dose audit)

CAP CT – chest+abdomen+pelvis CT

M/F	W_{da} (kg)	H(m)	$CTDI_{vol}$ (mGy)	D_{w_ave} (cm)	W_e (kg)	Diff (%)	Diff (kg)
M	60	1.73	5.7	23.4	52.8	-12%	-7.2
M	60	1.71	7.0	25.0	59.5	-1%	-0.5
F	63	1.60	9.9	26.4	61.3	-3%	-1.7
F	63	1.66	8.9	26.9	63.1	0%	0.1
M	64	1.64	9.9	27.4	69.5	9%	5.5
F	68	1.65	12.4	28.7	69.6	2%	1.6
M	70	1.70	9.9	26.7	66.6	-5%	-3.4
M	71	1.62	12.3	28.7	75.0	6%	4.0
F	78	1.60	18.1	31.3	79.1	1%	1.1
M	78	1.80	11.5	27.7	70.8	-9%	-7.2
M	80	1.78	17.2	30.6	82.9	4%	2.9
Mean	**69**	**1.68**	**11.2**	**27.5**	**68.2**	**-0.7%**	**-0.4**
StdDev						**6.2%**	**4.2**

Lincoln 2018
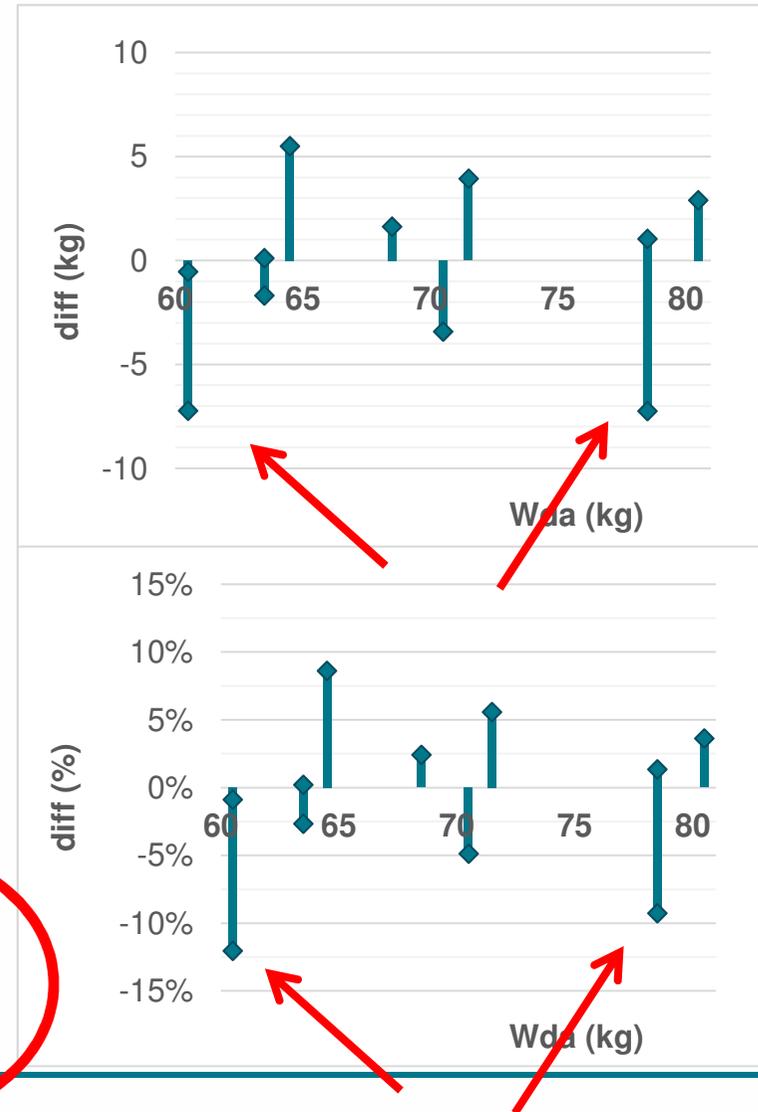
9 Chest RX with CAP CT exams archived in PACS

CAP CT on a different-day :

RX Date	M/F	Wda (kg)	H (m)	Dw_ave (cm)	CT date	Days between RX and CT	We (kg)	Diff (%)	Diff (kg)
18/04/2018	F	60	1.60	25.8	29/06/2018	72	59.1	-1%	-0.9
18/04/2018	F	61	1.60	25.6	05/06/2018	48	58.4	-4%	-2.6
18/04/2018	M	70	1.65	29.4	02/05/2018	14	72.2	3%	2.2
18/04/2018	F	72	1.70	26.7	09/03/2018	-40	62.4	-13%	-9.6
18/04/2018	M	78	1.65	30.6	23/01/2018	-85	76.5	-2%	-1.5
17/04/2018	F	66	1.60	30.8	05/07/2018	78	77.2	17%	11.2
18/04/2018	M	67	1.65	27.3	06/03/2018	-43	64.6	-4%	-2.4
11/04/2018	M	77	1.75	28.6	08/02/2018	-69	69.3	-10%	-7.7
19/04/2018	F	68	1.65	28	22/03/2018	-27	67.1	-1%	-0.9
	Mean	68.8	1.65	28.1		-5.8	67.4	-1.7%	-1.3
	StdDev					60.9		8.6%	5.9

Larger differences than in previous sample: weight gain/loss from oncological treatments?

Conclusions

❖ Same-day CT: mean difference -0.4 ± 4.2 kg (max 7 kg)

❖ Different-day CT: mean difference -1.3 ± 5.9 kg (max 11 kg)

❖ Not easy to find CT scans in same year as chest RX

Ideas for future work

➢ Use only **abdominal** CT images to obtain D_w(abdominal) and estimate W(kg) ⇨ more CT exams available: CAP, CA, AP, even chest CT for lung cancer includes abdominal area

➢ Follow A. Dedulle *et al (*oral presentation OA 194 - ECMP2018): obtain a relation between D_w(abdominal - CT) and the attenuation measured by the RX AEC, expressed as the ratio $EI / (KAP/A_{exp})$

OA194 ECMP2018 CALCULATION OF THE PATIENT SIZE FOR ABDOMINAL RADIOGRAPHY IN TERMS OF WATER EQUIVALENT DIAMETER An Dedulle, Niki Fitousi, Jurgen Jacobs, Hilde Bosmans

Thank you!