

The Effect of Body Mass Index on Patient Radiation Dose during Lumbar Discectomy and Fusion utilising VirtualDose-IR Software

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Purpose

This study aimed to evaluate the effect of body mass index (BMI) on the organs' dose (OD), peak-skin dose (PSD) and effective dose (ED) received by patients undergoing lumbar discectomy and fusion (LDF) operations utilising Monte Carlo software.

Materials and Methods

- Patient-related (age, sex, weight, height, and BMI) and procedure-related data (x-ray projection, field-of-view, tube voltage, additional copper filtration, source-to-detector distance, and source-to-skin distance) were obtained from 102 LDF operations conducted at the University Hospital of Patras.
- Fluoroscopy time (FT), kerma-area product (KAP) and cumulative air-kerma (K_{air}) (at interventional reference point) were also recorded from the dosimetric report of the fluoroscopy system (Philips BV Endura). Additionally, the incident K_{air} was calculated.
- The intra-operative data were inserted into the VirtualDose-IR software [Figure 1] implementing sex-specific and BMI-adjustable anthropomorphic phantoms to calculate OD, PSD and ED [Figure 2].

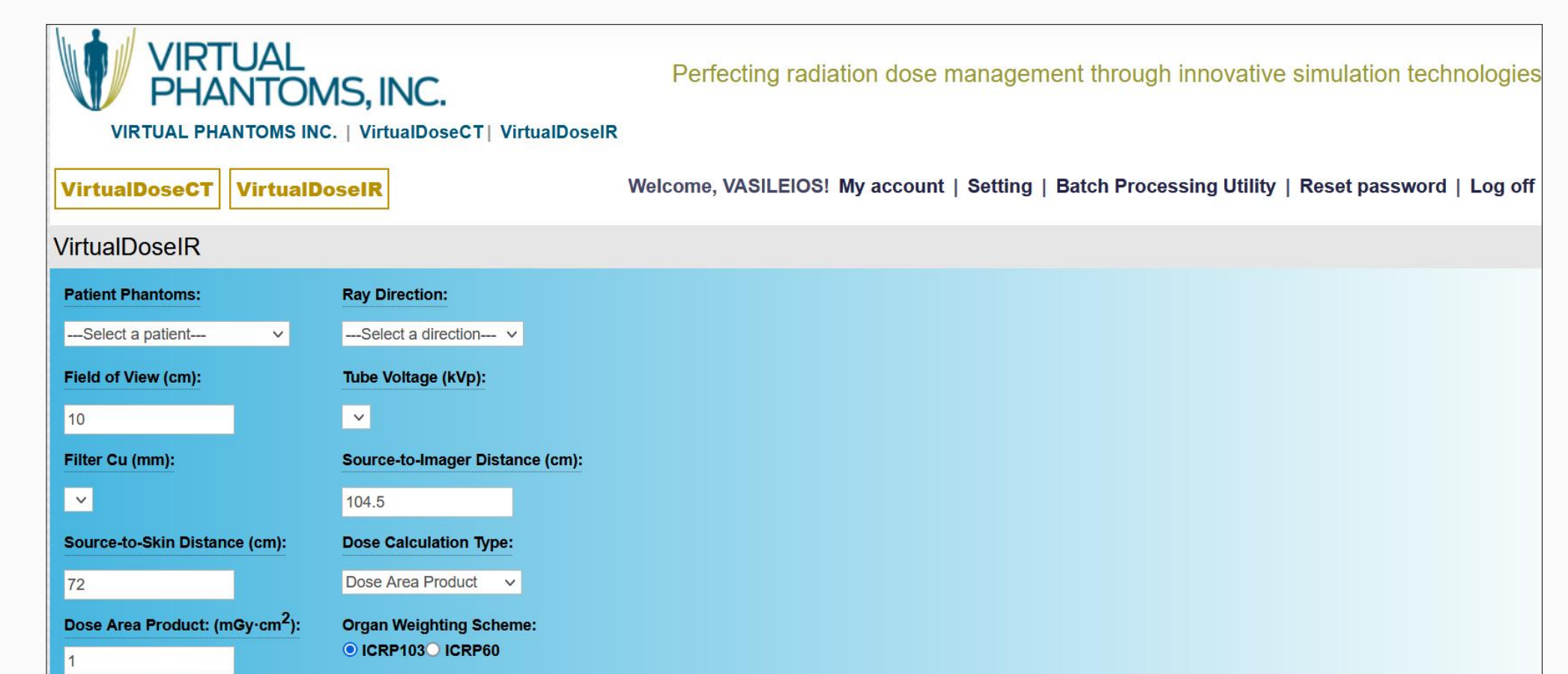


Figure 1. VirtualDose-IR interface.

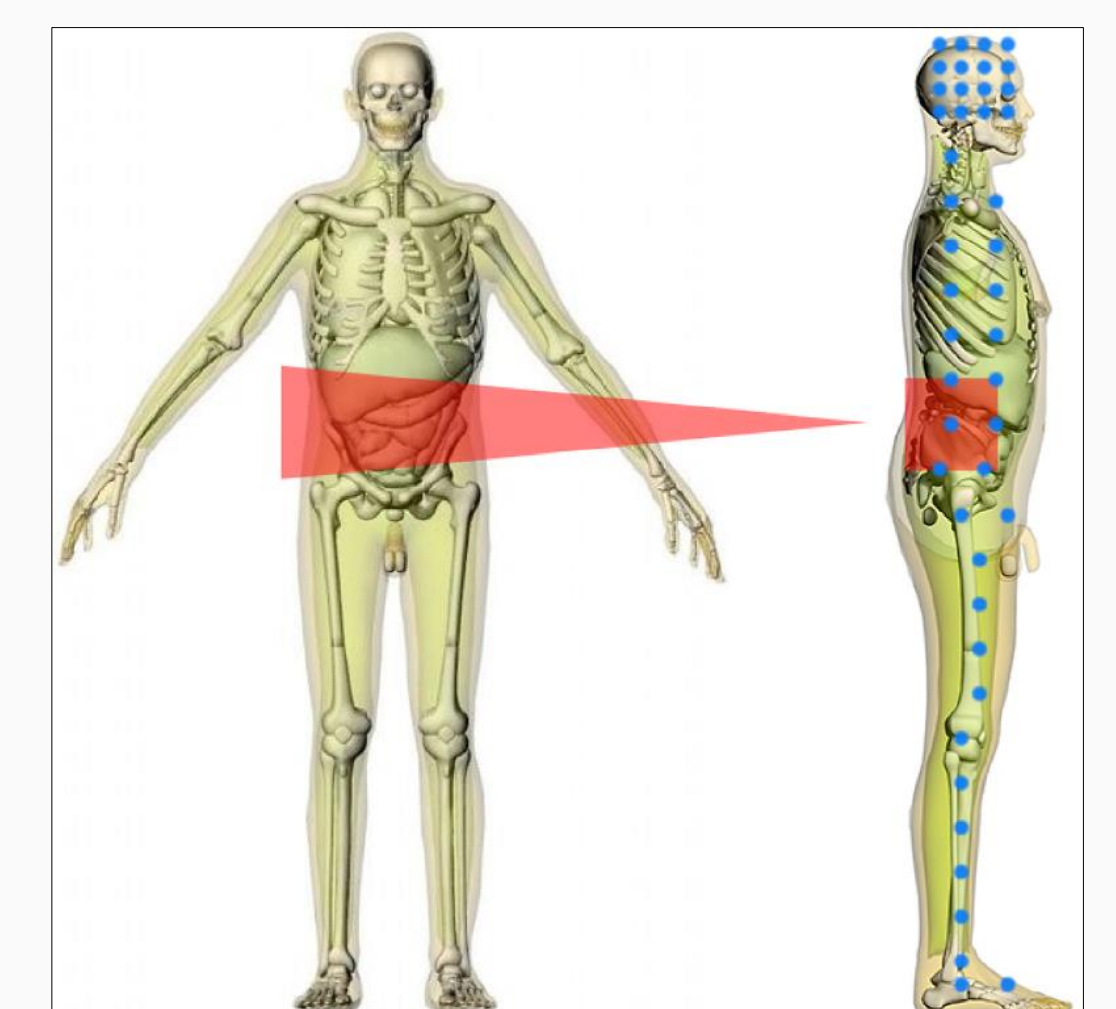


Figure 2. Anthropomorphic phantom.

Results

Table 1. Patient doses [mean (range)] categorised per BMI group.

BMI group	FT (s)	KAP (Gycm ²)	Cumulative K_{air} (mGy)	Incident K_{air} (mGy)	PSD (mGy)	ED (mSv)
Normal-weight	13.4 (1.0-72.0)	0.71 (0.0005-10.20)	3.22 (0.002-46.30)	9.25 (0.008-140.00)	62.00 (0.06-961.00)	0.27 (0.01-3.24)
Overweight	21.2 (1.0-296.0)	0.90 (0.0002-16.50)	4.08 (0.0008-75.10)	14.98 (0.003-296.00)	116.00 (0.03-2383.00)	0.30 (0.01-4.90)
Obese	52.6 (1.0-354.0)	2.80 (0.11-17.30)	13.90 (0.49-93.50)	60.86 (2.17-391.00)	475.00 (15.00-2828.00)	1.18 (0.04-7.42)

- A 58% and 293% increase was found in FT, 27% and 294% in KAP, 27% and 332% in cumulative K_{air} , 62% and 558% in incident K_{air} , 87% and 666% in PSD and 11% and 337% in ED of overweight and obese compared to normal-weight patients, respectively.
- The threshold for transient erythema is exceeded for one overweight patient (PSD 2383 mGy) and two obese patients (PSD 2828 mGy, 2669 mGy) without skin erythema observed in the subsequent follow-ups.
- The PSD values significantly differ among the three BMI groups (Kruskal-Wallis test, $p=0.026$), while incident K_{air} between normal-weight and obese patients (Mann-Whitney test, $p=0.015$).

- In all BMI groups, the spleen, kidneys and colon received the highest doses.
- The doses received by the kidneys, pancreas, and spleen increased significantly (Mann-Whitney test, $p<0.05$) only in obese compared to overweight patients, whilst the urinary bladder doses showed a significant increase in overweight compared to normal-weight patients (Mann-Whitney test, $p=0.044$).

Conclusion

The reported dosimetric data could contribute to optimising LDF procedures and establishing a radiation protection culture at the Neurosurgery operating theatre.

Table 2. ODs [mean (range)] categorised per BMI group.

Organ	ODs (mGy)			
	Total	Normal-weight	Overweight	Obese
Urinary bladder	0.21 (0-6.36)	0.10 (0-1.94)	0.19 (0-4.55)	0.61 (0-6.36)
Colon	1.31 (0-22.60)	1.00 (0-15.50)	0.90 (0-18.40)	3.83 (0.11-22.60)
Kidneys	1.77 (0-74.00)	0.90 (0-3.57)	1.00 (0-11.30)	7.34 (0.16-74.00)
Pancreas	0.90 (0-31.50)	0.61 (0-3.22)	0.48 (0-4.98)	3.41 (0.11-31.50)
Spleen	3.88 (0-183.00)	2.34 (0.01-13.00)	1.68 (0-24.30)	17.10 (0.25-183.00)

References: <https://doi.org/10.1016/j.apradiso.2023.110781>