INTERNATIONAL CONFERENCE ON RADIATION APPLICATIONS | In Physics, Chemistry, Biology, Medical Sciences, Engineering and Environmental Sciences

RAP2023 May 29 - June 2, 2023 | Hellenic Centre of Marine Research | Anavyssos | Attica | Greece

Relationship between Patient Radiation Dose and Procedural Factors in Anterior Cervical Discectomy and Fusion utilising VirtualDose-IR Software

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Purpose

This study aimed to evaluate **the effect of procedure's type (single-level, multi-level)** and **cervical levels (C3/C4, C4/C5, C5/C6, C6/C7)** on the **organs' dose (OD)**, **peak-skin dose (PSD)** and **effective dose (ED)** received by patients undergoing **anterior cervical discectomy and fusion (ACDF)** procedures 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 50 ACDF procedures 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]**.

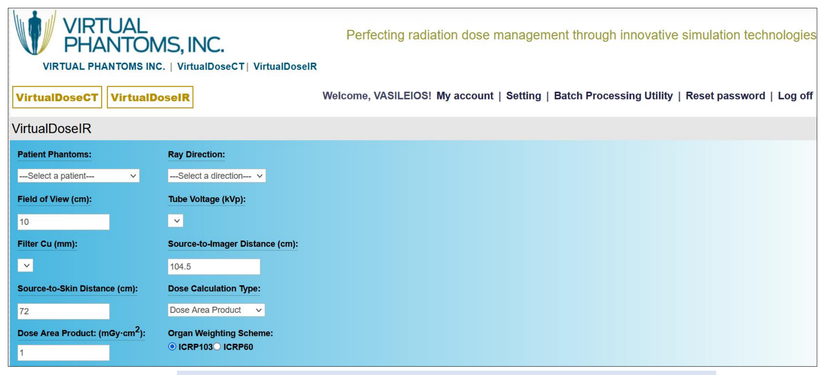

Figure 1. VirtualDose-IR interface.

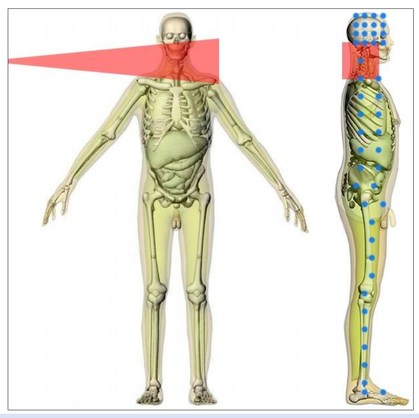

Figure 2. Anthropomorphic phantom.

Results

Table 1. Patient doses [mean (range)] categorised per procedure' type and cervical level.

Procedures	FT (s)	KAP ($Gycm^2$)	Cumulative K_{air} (mGy)	Incident K_{air} (mGy)	PSD (mGy)	ED (mSv)
Single-level	6.5 (1.0-29.0)	0.14 (0.002-1.13)	0.62 (0.009-5.08)	0.95 (0.02-7.83)	2.30 (0.05-16.69)	0.016 (0-0.150)
Multi-level	7.1 (1.0-18.0)	0.18 (0.009-1.46)	0.81 (0.04-6.58)	1.24 (0.06-10.10)	5.29 (0.28-31.16)	0.037 (0-0.200)
C3/C4	4.5 (2.0-14.0)	0.05 (0.01-0.13)	0.24 (0.05-0.59)	0.38 (0.08-0.91)	0.91 (0.24-2.90)	0.005 (0-0.020)
C4/C5	5.1 (1.0-12.0)	0.05 (0.002-0.11)	0.22 (0.009-0.51)	0.33 (0.02-0.78)	0.92 (0.17-2.17)	0.005 (0-0.010)
C5/C6	6.9 (1.0-21.0)	0.22 (0.009-1.11)	0.96 (0.04-5.00)	1.48 (0.06-7.70)	3.52 (0.05-23.70)	0.028 (0-0.150)
C6/C7	12.5 (5.0-29.0)	0.33 (0.04-1.13)	1.47 (0.18-5.08)	2.26 (0.29-7.83)	5.21 (1.20-14.70)	0.038 (0.010-0.100)

- An increase of **9%** was found in **FT**, **29%** in **KAP**, **31%** in **cumulative K_{air}**, **31%** in **incident K_{air}**, **130%** in **PSD** and **131%** in **ED** of **multi-level compared to single-level** procedures.
- The **PSD** values are significantly different among the cervical levels (Kruskal-Wallis test, p=0.036).
- The **ED** values significantly differed regarding the procedure type (Mann-Whitney test, p=0.037) and cervical levels (Kruskal-Wallis test, p=0.007).
- The procedures in **C5/C6** resulted in significantly higher **KAP, incident K_{air},** and **ED** than **C4/C5** levels, while those performed in **C6/C7** resulted in significantly higher **ED** and **PSD** than in **C4/C5** levels (Mann-Whitney test, p<0.05).
- In all groups, **the thyroid, oesophagus and salivary glands** received the highest doses.
- The **salivary glands** absorbed significantly higher doses in **males (0.170 mGy)** than **females (0.014 mGy)**, while the **extrathoracic region's** dose significantly increased for **multi-level than single-level** procedures.
- The procedures in **C6/C7** resulted in significantly higher oesophagus and thyroid doses than **C3/C4** and **C4/C5** levels, as well as procedures in **C5/C6** compared to **C4/C5** levels.

Table 2. ODs [mean (range)] categorised per procedure' type and cervical level.

	ODs (mGy)					
Organ	Single-level	Multi-level	C3/C4	C4/C5	C5/C6	C6/C7
Thyroid	0.220 (0-1.910)	0.460 (0-2.510)	0.088 (0-0.030)	0.081 (0.020-0.180)	0.360 (0-1.910)	0.450 (0.110-1.180)
Oesophagus	0.100 (0-0.920)	0.220 (0.010-1.210)	0.042 (0.010-0.110)	0.037 (0.010-0.090)	0.170 (0-0.920)	0.210 (0.050-0.570)
Salivary glands	0.080 (0-0.940)	0.200 (0-1.240)	0.022 (0-0.040)	0.032 (0-0.090)	0.130 (0-0.940)	0.190 (0.030-0.580)
Extrathoracic region	0.016 (0-0.140)	0.036 (0-0.190)	0.007 (0-0.020)	0.005 (0-0.010)	0.027 (0-0.140)	0.033 (0.010-0.080)

Conclusion: The dosimetric data could be used in optimising radiation protection during ACDF procedures by keeping the ODs and ED as low as reasonably practicable.