RADIATION EXPOSURE DURING ENDOVASCULAR ABDOMINAL AORTIC ANEURYSM REPAIR (EVAR)

G. ZATELLI[a], S. MAZZOCCHI[a] , S. MICHELAGNOLI[b], E. CHISCI[b], A. GHIRELLI[a], A. DIDONA[a], G. DEDOLA[c], S. PANCI[c], P. BOTTO DADDI[C], F. ROSSI[d]

[a] Fisica Sanitaria Azienda ASF, via San Salvi 12, Firenze Italy.
[b] Chirurga Vascolare, Azienda ASF Firenze, Italy.
[c] Diagnostica per Immagini, Azienda ASF Firenze, Italy.
[d] Fisica Sanitaria A.O.U. Careggi Firenze, Italy.

Email address of main author: giovanna.zatelli@asf.toscana.it

Abstract

Among the vascular procedures, the endovascular repair of abdominal aortic aneurysm (EVAR) is one of those procedures which may involve a high exposure to radiation both for patients and workers. The aim of this study was to evaluate the radiation protection aspects of the EVAR procedures realized both in the operating room (OT), and in angiosuite (AS). The dosimetric impact of the use of dynamic CT (Dyna CT, Siemens AG, Berlin, Germany) was also evaluated. In order to assess the occupational exposure, doses to the lens of the eyes of workers were measured and compared with the new limits proposed by the International Commission on Radiological Protection.

1. INTRODUCTION

Endovascular procedures require long exposure time to X ray. The quality improvement process has to undertake the radiation protection aspects in order to avoid possible damage resulting from use of ionizing radiation [1-3].

In the present study we evaluate the radiation protection aspects of the endovascular repair of abdominal aortic aneurysm (EVAR). These procedures were perfomed in the operating room (OT), and in angiosuite (AS). The dosimetric impact of Dynamic CT (Dyna CT, Siemens AG, Berlin, Germany) was assessed as well.

Finally, doses to the lens of workers were measured and compared with the new limits proposed by the International Commission on Radiological Protection [4].

2. MATERIALS AND METHODS

In a single high-volume vascular surgery center, EVAR procedures were analyzed.

Procedures were performed either in the operating room (OT) with a portable C-arm (Arcadis Avantic, Siemens, Germany) with 12-inch image intensifier and in an angiosuite (AS) equipped with a ceiling-mounted angiography system (Artis Zee dTA, Siemens, Germany) with a flat panel detector (FD 30cm×38cm) capable of digital fluoroscopy, subtraction/non-subtraction, and rotational angiography.

DynaCT software was used to generate CT-like images from on-table rotational angiography acquisitions directly in AS theatre. Both equipments have a PKA meter mounted on collimator housing: Artis Zee has a PTW KAP ionization chamber connected with Diamentor K1S electrometer; Arcadis Avantic is equipped with an IBA KermaX Plus KAP system.

Following requirements for the Safety of X Ray Equipment for Interventional Procedures (IEC 60601-2-43) [5], Air kerma at the reference point (mGy) and Air kerma rate at the reference point (mGy/min) are displayed at the operator’s working position together with cumulative KAP.

Angiographic Dyna CT parameters, with respiration suspended, were 200° total angle of rotation, 60 frames/second, with 396 projections. The time interval from C-arm rotation to automatic generation of images on the monitor was 60 seconds with an excursion time of 7 seconds. Mean Air kerma – Area Product (KAP), and total Air kerma at the reference point ($K_{a,r}$) values have been reported from modalities for all procedures and Dyna CT, by means of PACS archive.

Workers have been monitored by means of thermoluminescent dosimeters (LiF:Mg,Ti 3mm×3mm×0.9 mm), in order to assess eye lens exposure, during the whole EVAR procedure.

3. RESULTS

We analyzed one hundred procedures: 20 EVARs were performed in AS with a final Dyna CT. In the AS two different angiographic protocols were utilized: a standard vascular protocol and a low dose “carebody” protocol (n=10).

Mean (SD) fluoroscopic time in AS and OT was similar: 11±6 minutes for procedures performed in AS and 12±7 minutes in OT. Total mean KAP values (min, max) and total $K_{a,r}$ were 22119 (6495-66534) cGy·cm^2 and 4571 (972-14281) cGy·cm^2 ($p<0.007$), 964 (209-3866) mGy and 233 (46-741) mGy ($p<0.03$) in AS and in OT respectively, with standard protocol. Mean KAP value (min, max) using the low dose 'carebody' protocol in the AS was 9022 (2743-17111) cGy·cm^2, while mean $K_{a,r}$ is reduced to 400 (93-919) mGy.

The recorded radiation exposure in the AS vs. OT was still significantly higher but reduced ~~of~~ by two times ($p<0.02$) without significant loss of image quality. Mean KAP values (min, max) and $K_{a,r}$ (min, max) of the Dyna CT were 6762 (5745-7281) cGy·cm^2 and 228 (194-246) mGy respectively. The Dyna CT acquisition in AS with DynaAUT 8s protocol involves exposures with an overall mean 113 kV and 417 mA for patients of different body mass index.

As far as vascular surgeon exposure is concerned, the estimated $H_p(3)$ to unprotected eye lens is about 0.006 µSv/cGy·cm^2, with a mean value of 53 µSv for each procedure. Considering the typical workload of the vascular surgery centre the annual estimated exposure to eye lens of vascular surgeon, deriving only from EVAR procedures, is about 3 mSv, a value that can be strongly mitigated by the proper use of lead eye glasses and suspended transparent shielding

TABLE I. COMPARISON OF MIN-MAX KAP VALUES

EVAR Min- Max KAP (cGy·cm^2)	Geijer et al., 2005 [1]	Weiss et al., 2008 [2]	Kalef - Ezra, 2009 [3]	Our study Angiosuite theatre, standard DSA protocol	Our study Angiosuite theatre, carebody protocol	Our study, operating theatre mobile C-arm device
	1660-19500	5207-24536	900-13900	6495-66534	2743-17111	972-14281

Table II. DOSIMETRIC VALUES ;EASURED IN DYNA CT

Protocol DYNAAUT 8s DR	Air kerma – Area Product DynaCT (cGy·cm^2)	Total air kerma at reference point DynaCT (mGy)
Mean	6762	228
Min	5745	194
Max	7281	246
75 th percentile	6922	233

4. RESULTS

In our study we have monitored the radiation exposure during EVAR performed with different equipments. A wide range of patient exposures is associated to these procedures. Some patients may be exposed to very high doses especially in AS. As a result of the monitoring action, the low dose 'carebody' protocol has become the standard protocol in AS in the facility. Optimization process and comparison with other vascular centers is mandatory also for Dyna CT procedures.

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