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ORIGINAL ARTICLE

Radiation Dose During Coronary Angiogram: Relation to Body Mass Index

Ashish Shah [a*], Paul Das [b], Eduardas Subkovas [b], Ashesh N. Buch [c], Michael Rees [d], Christopher Bellamy [b]

[a]Department of Cardiology, University Health Network, Toronto, Canada
[b]Department of Cardiology, Glan Clwyd Hospital, Betsi Cadwaladr University Health Board, UK
[c]Department of Cardiology, East Carolina University, Greenville, NC, USA
[d]Department of Cardiology, Ysybty Gwynedd, Betsi Cadwaladr University Health Board, UK

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Objective Ionising radiation based diagnostic and therapeutic cardiology and radiology procedures are very common in present day medical practice and are one of the largest medical sources of radiation to humans. The risk to health from radiation has been extensively documented. Obesity is becoming epidemic not only in the western world, but also in developing countries. In the present study we investigated if a patient's Body Mass Index (BMI) has an effect on the radiation dose received by the patient and operator during diagnostic coronary angiography (CAG).

Methods We analysed data of 3678 consecutive patients who underwent CAG from September 2007 to April 2010 in our cardiac catheter laboratory. Trans-radial access was used in 622 patients, whereas 3056 patients underwent CAG through trans-femoral route. We calculated the radiation dose in dose area product (DAP) units and correlated it with body mass index, screening time, procedure time, contrast volume, vascular access route and individual operator.

Results Among the explored parameters, body mass index had the most significant association with the radiation dose during the procedure. Despite having similar procedure times and contrast doses, patients with increased BMI received much higher radiation dose during CAG. We also found the left anterior oblique (LAO) caudal and LAO cranial views produced the biggest increase in radiation dose in patients with a high BMI. There was no inter-operator variability.

Conclusion Obese patients require more than double the radiation dose in comparison to those with normal BMI. The operator should be aware of the increased dose of radiation required when performing CAG in patients with increased BMI, and especially in LAO cranial and caudal views.

Keywords Coronary angiography • Radiation dose • Body mass index • Radiation protection • Precautions

Introduction

Cardiovascular disease is one of the leading causes of death not only in the western world, but also in developing countries. Ionising radiation based diagnostic and therapeutic procedures are increasingly used in day-to-day clinical practice, especially in cardiology during coronary angiography, interventional procedures and electrophysiological studies [1,2], as well as in the radiology department. Over the last decade, despite a similar number of hospital admissions of

Abbreviations: ACS, acute coronary syndrome; BMI, body mass index; CAG, coronary angiogram; CDC, Centre for Disease Control and Prevention; FDA, Food and Drug Administration; Gy, Gray; LAO, left anterior oblique; PA, postero-anterior; RAO, right anterior oblique

*Corresponding author at: Interventional Cardiology Department, University Health Network, Toronto, M5G 0B2, ON, Canada. Tel.: +1 416 835 2822, Email: aashish.h.shah@gmail.com

patients with acute coronary syndromes (ACS), there has been an increased number of interventional cardiology procedures performed. Patients are exposed to nearly 30% of yearly recommended dose of radiation in a single admission [3]. Medical sources constitute the second biggest cause of radiation exposure to an individual apart from background radiation.

The prevalence of overweight (body mass index > 25 kg/m^2) and obesity (BMI > 30 kg/m^2) patients is increasing. Data from the Centre for Disease Control and Prevention (CDC) suggest that the nearly one in three people is obese in the USA [4]. The American Heart Association (AHA) has published similar data on obesity epidemiology [5], and a similar trend is observed around the world. An increased BMI is associated with an increased risk of coronary artery disease, left ventricular diastolic dysfunction [6], diabetes, hypertension and dyslipidaemia.

The risk to health of ionising radiation was established after following up people who had been exposed to the radiation from the atomic bomb detonations in Japan. Those who survived the initial blast had a significantly increased risk of death, mainly from cancer but also from cardiovascular aetiology [7,18]. Mortality was linked with radiation dose of more than 0.5 Gray (Gy). An article by Mulrooney et al., showed that in survivors of childhood or young adulthood cancer, who were treated with radiation, cardiovascular events were the leading non-malignant cause of mortality in comparison to their siblings, when they were followed up for 30 years. Subjects were divided in tertiles depending upon radiation dose received, and those who received more than 1.5 Gy dose had significantly increased mortality in comparison to subjects who received a less dose [8]. People in an atomic blast or during radiation based cancer treatment, receive a very high dose in comparison to diagnostic and interventional cardiac procedures, but many recently published papers have raised concerns in relation to possible long-term side effects of the radiation received during these procedures [9,10].

Coronary angiography (CAG) is a commonly performed diagnostic procedure and also forms an integral part of coronary interventional procedures [5]. The aim of the present study was to assess the factors affecting radiation dose during CAG.

Materials and Methods

Subjects

We retrospectively analysed the data of 3678 consecutive patients who underwent CAG only, between September 2007 to April 2010 in the cardiac catheter laboratory at Glan Clwyd Hospital, Betsi Cadwaladr University Health Board, Wales, UK. Out of all patients, 622 patients underwent CAG through trans-radial, whereas trans-femoral access was used in 3056 patients.

Measurement of Radiation Dose

All procedures were performed using Siemens ARTIS DFC image intensifier system (Siemens, Erlangen, Germany). The system was set to pulsed fluoroscopy at 10-pulses/second and cine acquisition at 15 frames/second. The image intensifier has diameter of 25 cm, which was used for all patients with appropriate use of collimation. The supervising radiographer determined collimation independent of the operator. Multiple views were obtained during each procedure, which included the following standard views, left anterior oblique (LAO) caudal (spider) (40^0 left, 40^0 caudal), postero-anterior (PA) caudal (30^0 caudal), right anterior oblique (RAO) caudal (30^0 right, 30^0 caudal), RAO cranial (30^0 right, 30^0 cranial), PA cranial (30^0 cranial), LAO cranial (40^0 left, 40^0 cranial). In some patients the tube angulations were subject to variation to obtain optimal views.

Radiation dose was quantified as dose area product (DAP), which is the product of radiation dose emitted and area exposed, calculated by a DAP meter, which is an integral part of image intensifier system. The dose was calculated in μGy.m^2. The image intensifier was serviced regularly and the DAP metre was calibrated yearly. The system records the total radiation dose emitted during the whole procedure and the data obtained is the total radiation exposure during combined fluoroscopy and cine image acquisition. The fluoroscopy time, procedure time and contrast volume used in each case was recorded.

In a sub-study to assess the effect of angulation on the radiation dose, we prospectively recruited 30 patients and analysed the dose of radiation emitted during each projection (Fig. 5).

Statistical Analysis

All data were expressed as mean ± standard error of the mean. Within group and between-group changes were compared by paired or unpaired Student's *t* test, or one-way ANOVA as appropriate. In all cases, $P < 0.05$ (two-tailed) was considered to be significant. Data analysis was performed using GraphPad Prism® version 5.

Results

Patient Characteristics

There were 2190 male and 1488 females in the cohort. Patient height and weight were recorded on the day of admission and their BMI calculated. Patients were subdivided into six groups. Group A was those with a BMI < 20 kg/m^2, Group B for those with BMI 20-25 kg/m^2, Group C for BMI of 25-30 kg/m^2, Group D for patients with BMI of 30-35 kg/m^2, Group E for a BMI 35-40 kg/m^2 and Group F for a BMI > 40 kg/m^2. The number of subjects in each group was 50, 683, 1545, 945, 327 and 128 respectively. The mean BMI of all subjects was 29.22 ± 0.08 kg/m^2.

Radiation Dose, Contrast Volume, Screening Time and Vascular Access

The mean radiation dose during the procedure was 4339 ± 286 μGy.m^2. Scatter graph of patients' BMI vs. radiation dose