Patient and Staff Radiation Doses in Percutaneous Transluminal Coronary Angioplasty using 3 different Flat Panel Digital X-ray Systems

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***Abstract*—Two hundred and fifty four (254) patients in three hospitals (A, B, C) underwent Percutaneous Transluminal Coronary Angioplasty (PTCA). Patient dose was measured in terms of fluoroscopy time, number of frames, Dose Area Product. Patients' weight and height were also recorded. For assessing staff exposure/procedure, thermoluminescent dosemeters (TLD) were placed in three different body regions of the cardiologist. The results of Hospital A and C are lower than preliminary reference levels (RL) reported in literature for image intensifier systems (75 Gycm^2, 17 min, 1300 frames). In hospital B, patient doses are higher than RL. The standardization of PTCA procedure in digital flat panel systems will definitely limit the range of patient and staff doses encountered.**

I. INTRODUCTION

Digital imaging has progressed by large steps the last years, recently introducing dynamic flat panel (FP) digital detectors that replaced conventional image intensifiers. These dynamic FP detectors have recently been applied in Interventional Cardiology (IC), a medical specialty widely known to generate high radiation dose procedures to patients as well as to the medical staff involved [1]-[5]. Digital imaging provides the opportunity to store images in a Picture Archiving and Communications System (PACS), thus eliminating the need for film storage making this technology even more popular.

Few studies can be found in recent literature regarding the use of FP detectors in IC [6]-[9].

Most of these studies investigate the performance of the X-ray machines [7]-[9]. Recognizing the need for continuously monitoring the radiation dose in IC procedures, specially with the introduction of new dynamic detectors, the European Concerted Action Project SENTINEL «Safety and Efficacy for New Techniques and Imaging using New Equipment to Support European Legislation (FP6 – 012909)» included the investigation of patient and staff doses in new technology X-ray systems. With this framework measurements of patient and staff doses were performed in three (3) flat panel (FP) digital technology cardiac angiography X-ray equipment during Percutaneous Transluminal Coronary Angioplasties (PTCA) in 3 major hospitals in Greece. The objective of the study was to explore the clinical and technical factors that influence the radiation dose imparted to the patient and operator performing the IC procedure.

II. MATERIALS AND METHODS

Two hundred and fifty four (254) patients participated in the study, 46 of which were treated in Evangelismos Hospital (Hospital A, system installed in 2004), 40 in Athens General Hospital "G. Gennimatas" (Hospital B, system installed in 2006) and 168 in Onassis Cardiac Center (Hospital C, system installed in 2003). Main technical characteristics are found in Table 1.

Patient dose was measured in terms of Dose Area Product (DAP) (as well as DAP in fluoroscopy (DAPf) and in cine imaging (DAPc) in Hospitals B and C). All X-ray systems comprised a DAP meter for patient dose measurements. The DAP meters were calibrated following the National Protocol for Patient Dose Measurements in Diagnostic Radiology [10]. The reading uncertainty of the instruments, as quoted by the manufacturers, was ± 4% for tube potentials ranging from 50 kVp to 100 kVp. Apart from patient dose data, his weight, height, fluoroscopy time (T) and total number of frames (F), were also recorded.

For assessing staff exposure/procedure, thermo-luminescent dosemeters (TLD) were placed in three different body regions of the cardiologist performing the PTCA: on left hand (h), left shoulder (s) and left foot (f).

TABLE 1. Main technical characteristics of the flat-panel (FP) digital X-ray systems used in this study.

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Characteristics	*Hospital A*	*Hospital B*	*Hospital C*
Type	GE Inova 2000	Philips Allura F10	Philips Allura F9
Field of view (cm)	12-15-17-20	15-20-25	15-20-25
Additional filtration	0.1 Cu; 0.2 Cu; 0.3 Cu	0.1 Cu; 0.2 Cu	0.1 Cu; 0.2 Cu
Fluoroscopy modes	Low, Normal	Low, Normal, High	Low, Normal, High
Cine modes (frames/sec)	7.5-15-30	12.5-25	12.5-25

III. RESULTS

Median values of total patient dose in terms of DAP, fluoroscopy time (T) and total number of images (F) are presented in Figure 1.

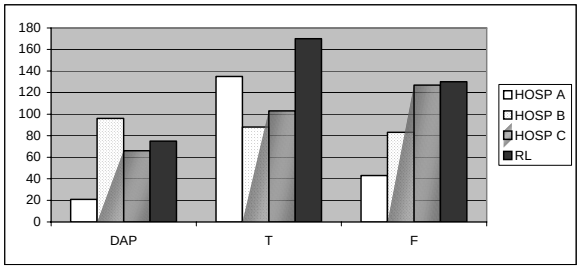

Fig. 1. Median values of DAP (Gycm^2), fluoroscopy time T (min*10) and total number of images (F/10) for all 3 hospitals are presented together with preliminary reference levels (RL).

The results reveal a large range of patient doses with max/min value equal to 4.6. Figures 2 and 3 show the correlation of DAP with T and F.

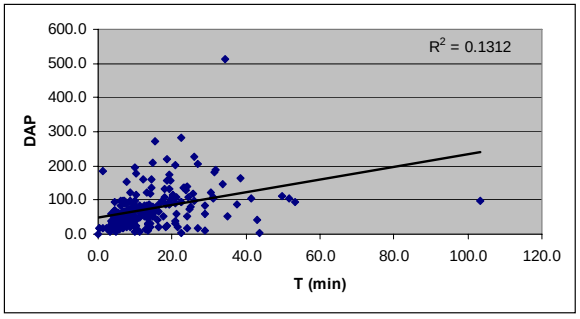

Fig. 2. Correlation of DAP (Gycm^2) with fluoroscopy time (T) (min).

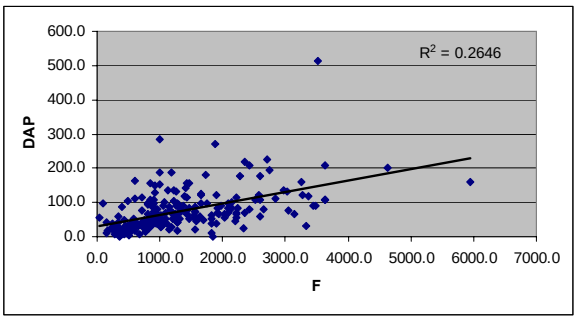

Fig. 3. Correlation of DAP (Gycm^2) with total number of images (F).

It appears that practically no linear correlation exists due to the large number of factors influencing patient dose.

Figure 4 shows the operator dose measurements in the 3 positions of the body (left shoulder, left hand and left foot). Hospital C operator results are consistently higher than Hospital A. The max/min ratio is 2 for the shoulder, 5 for the hand and 2 for the foot. The results reveal the large variation in the radiation dose to the staff depending highly on the way the operator performs the procedure. The variability in dose found in PTCA can be explained by the fact that it is a therapeutic procedure that depends on the pathology of the patient. Bernardi et al [11] found an increase of T and F in complex PTCA procedures. Padovani et al [12] found an increase of about 50% in radiation dose for medium complex procedures and an increase of 100% for complex procedures.

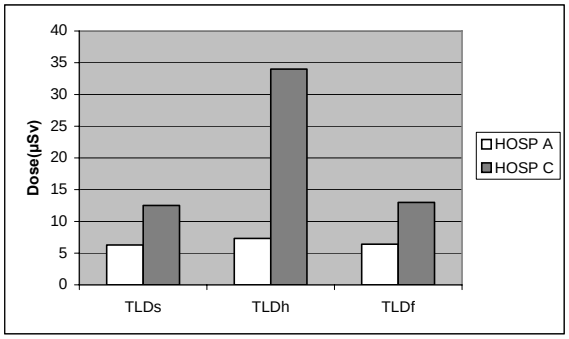

Fig. 4. Median value of TLD dose measurement on shoulder (TLDs), hand (TLDh) and foot (TLDf) in Hospitals A and C.

IV. Conclusion

PTCA is routinely performed in a number of hospitals and is considered a safe therapeutic IC procedure in the hands of experienced operators. However, as the technology evolves in terms of X-ray equipment, catheters and stents, the procedure is becoming more and more complex. This has a great impact not only on the patient but also on the operator radiation dose. The standardization of PTCA procedure in digital flat panel systems will definitely limit the range of patient and staff doses encountered.

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