

Gafchromic XR-RV2 radiochromic films dosimetry in interventional radiology

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1. Introduction

- Patient skin injuries in interventional procedures are fully documented in the scientific literature.
- Research into new methods for patient dose measurement should be encouraged.
- There is a need to define and group IR procedures in order to account for their complexities since a number of parameters like fluoroscopy duration and x-ray beam orientation affect the differences in peak skin dose measurement.
- Mapping skin doses, with the use of a dosimetry film, is useful to determine peak skin dose and to detect areas of overlapping radiation fields.



a

b

c

(a) Condition of patient's back, six to eight weeks following multiple coronary angiography and angioplasty procedures.

(b) Appearance of skin injury approximately 16 to 31 weeks following the procedures with small ulcerated area present.

(c) Appearance of skin injury approximately 18 to 21 months following procedures evidencing tissue necrosis.

Thomas B. Shope, Ph.D. "Radiation-induced skin injuries from fluoroscopy. ", Center for Devices and Radiological Health. FDA, Rockville, 2010

2. Purpose

The aim of the work was:

- to use the new Gafchromic XR-RV2 film and / to measure patient skin dose during interventional radiology procedures
- to evaluate dose distributions using the film for some frequent procedures, identified in three categories:
 1. Nefrostomies (PCN) and urinary stenting
 2. Biliary stenting and PTBD
 3. Aorta stent grafting

3. Materials and Methods

Materials: Gafchromic XR-RV2 film

Number of patients: 45 interventional procedures

Tips:

- ❖ The film was placed in the area of interest between the patient and the exam table
- ❖ Dosimetric data such as fluoroscopy duration and dose-area product for fluoroscopy and cine radiography were recorded

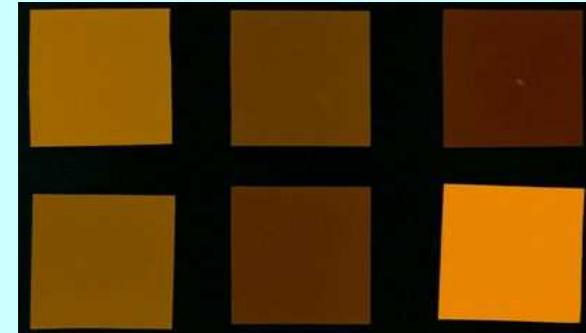


Exposed film after an interventional procedure

3.1 Characteristics and calibration of the Gafchromic XR-RV2 film

Gafchromic XR-RV2 film

- ✓ Measures doses up to 50 Gy from photons with energies ranged from 30 keV to 30 MeV
- ✓ Self-developing film media
- ✓ Handled in normal room light with no hazardous chemicals or waste to dispose of
- ✓ Can be cut to any size
- ✓ No dose fractionation and dose rate dependence were recorded
- ✓ Principal absorption peak at 675 nm
- ✓ The colour of the film is orange and becomes darkened according to radiation exposure. Darker film areas represent higher absorbed doses.



Gafchromic XR-RV2 films exposed to radiation. The last piece is unexposed.

Film Calibration

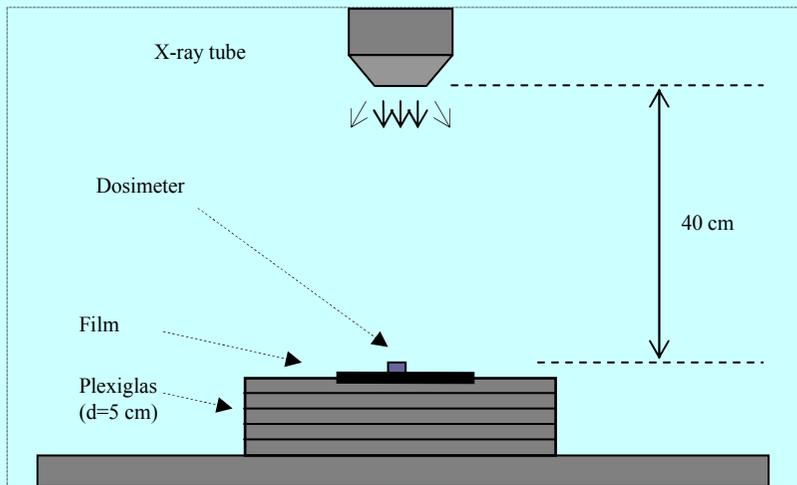
➤ Set up & Measurements

- ✚ Five 6 cm x 6 cm sections of the film were irradiated using a radiographic x-ray tube (Philips Integris 5000 C-arm).
- ✚ Each piece of film was placed at 5 cm plexiglas thickness centered in the radiation field (10 cm x 10 cm) at a distance SSD=40 cm in order to include backscattered radiation in dose measurement.
- ✚ Electronic dosimeter with a solid state detector (Solidose Model 400, R100, RTI Electronics) was used to measure the exposure rate in air. Backscattered factor was used to correct the dose reading (BSF=1,30).
- ✚ The peak potential of the x-ray unit was adjusted to 100 kVp (HVL=3,6 mm Al) and the film pieces were repeatedly irradiated to reach high doses (0-7000 mGy).

➤ Processing & Results

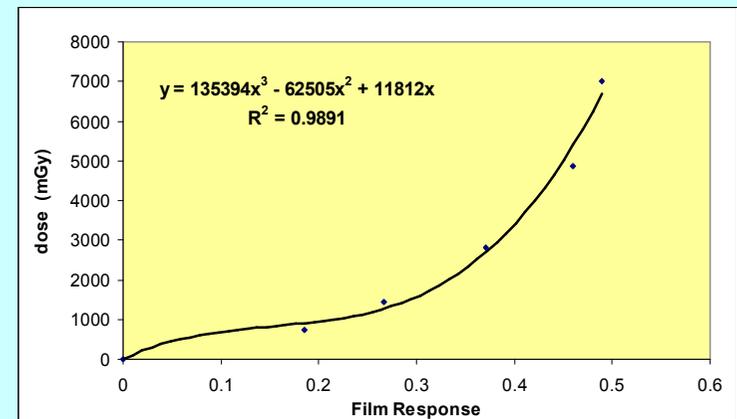
- ✚ Exposed films were scanned by a flat bed scanner (Microtek ScanMaker 9800XL, TMA 1600) on the reflective mode and red pixel values were extracted from the RGB image using Matlab routine.
- ✚ The film response (FR) was read in its red component.

$$FR = \log_{10} \left\{ \frac{(\text{pixel value})_{D_0}}{(\text{pixel value})_{D_i}} \right\}$$
- ✚ The calibration curve of dose values vs film response was generated.



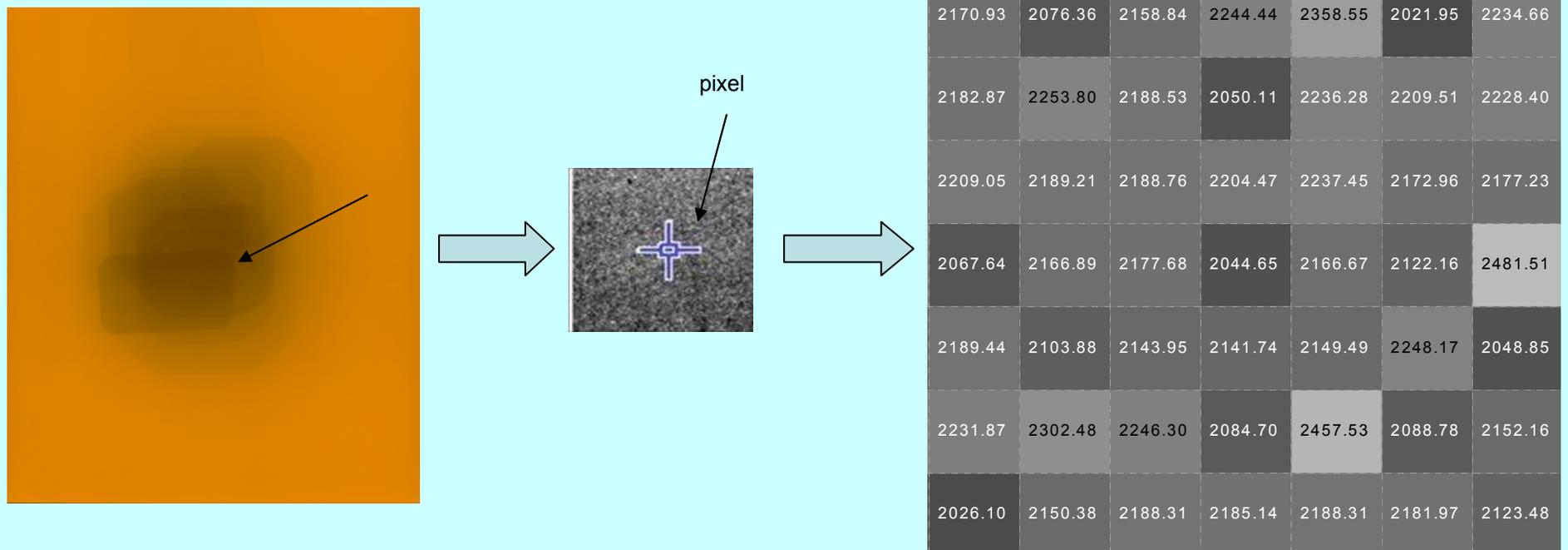
<i>D</i> (mGy)	<i>FR</i>
750,57	0,186
1438,60	0,267
2814,65	0,371
4878,73	0,459
7005,35	0,490

Calibration curve



3.2 Measuring skin dose during interventional procedures

- Three days after the procedure, the film was scanned by a flat bed scanner on the reflective mode and the RGB image was stored as 48 bit in .tiff format for further analysis.
- Matlab routine has been chosen for image processing analysis.
- After the extract of the red component from the original image, red pixel values were converted firstly to film response (FR) and secondly to dose according to the calibration curve.
- A numerical matrix of dose values was generated for subsequent processing and peak skin dose (PSD) was defined.

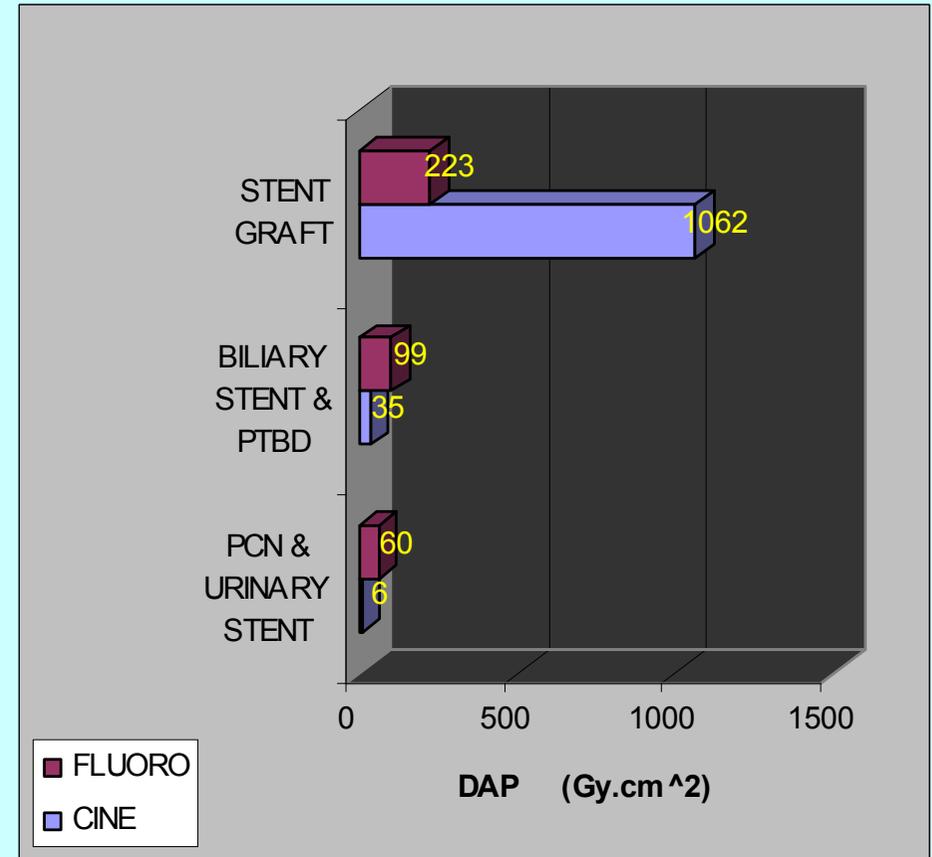
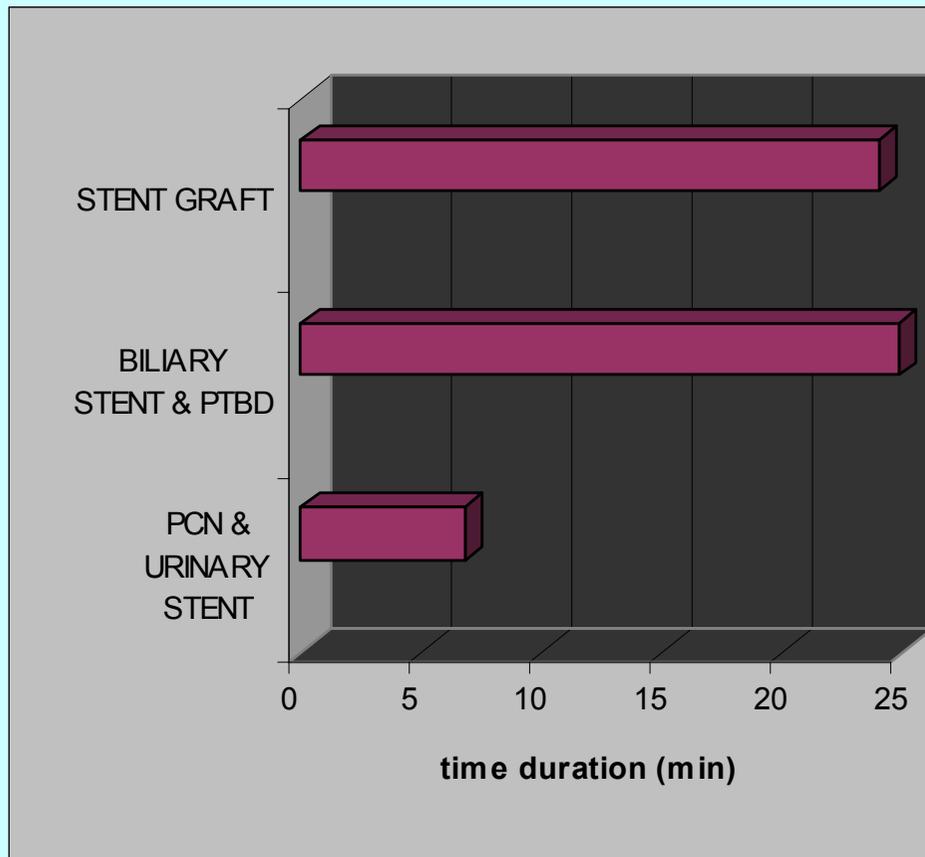


4. Results and Conclusion

- Mean and standard deviation for fluoroscopy duration, fluoroscopy and cine DAP and patients skin doses are summarized in table. For each procedure the number of patient reports is given in parenthesis.

	<i>Fluoroscopy duration (min)</i>		<i>Fluoroscopy DAP (Gy.cm²)</i>		<i>Cine radiography DAP (Gy.cm²)</i>		<i>Peak Skin Dose (mGy)</i>	
	<i>Mean</i>	<i>Stand. Dev.</i>	<i>Mean</i>	<i>Stand. Dev.</i>	<i>Mean</i>	<i>Stand. Dev.</i>	<i>Mean</i>	<i>Stand. Dev.</i>
<i>Nefrostomies (PCN) & Urinary stent (19)</i>	6,8	2,8	60	26	6	5	534	119
<i>PTBD & Biliary stent (12)</i>	24,8	16,6	99	40	35	25	1339	631
<i>Aorta stent grafting (14)</i>	24,0	16,6	223	109	1062	240	2434	569

➤ Aorta stent grafting procedure involve fluoroscopy and cine radiography mode in use. Digital acquisition contributes in great amount to dose delivered to patient.
Nefrostomy and urinary stenting is almost a routine procedure in an interventional radiology department with relatively low duration and dose to patient.



- Gafchromic XR-RV2 film is suitable for complex high dose interventional procedures guided by fluoroscopy.
- Dose in complex interventional procedures like aorta stent grafting is above the threshold of 2 Gy for erythema. Those procedures should be recorded and distinguished with reference to patient's benefit.
- Long time fluoroscopy combined with cine radiography make large x-ray dose distributions and overlapped radiation fields result entrance doses near the erythema dose threshold. Those areas of the patient's skin that received high dose should be identified and noted in the patient file record.