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EFFECT OF DELAYED FILM PROCESSING AND MILLIAMPERAGE CHANGES ON IMAGE QUALITY

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ABSTRACT
A study of the effect of delayed clinical processing and milliamperage changes on image quality was carried out at the Radiology Department, University of Calabar, Nigeria, using filmstrips exposed to x-radiation at milliamperage (mA) values of 50, 100, 200, 300, 400 and 500. Exposed film strips were processed over varied post exposure, pre-processing keeping times ranging from 0 hours (control) to the 18th day. Results show progressive decrease in optical densities measured on the film, with prolonged pre-processing keeping time, and this is more marked at low (50) mA procedures, and is less in high (500) mA procedures, at which mA also, the onset was highly delayed (commencing about the 12th hour). The implication of this in a developing economy is discussed.

ABSTRAIT
Une étude de l'effet des changements cliniques retardés de traitement et de milliamperage sur la qualité d'image a été effectuée au service de radiologie, Université de Calabar, Le Nigéria, employer des filmstrips a exposé au x-rayonnement aux valeurs du milliamperage (mA) de 50, 100. 200. 300. 400 et 500. Les bandes exposées de film étaient post-exposition changé par excédent traité, garder de prétraitement chronomètre s'étendre de 0 heures (commande) au 18ème jour. Les résultats montrent la diminution progressive des densités optiques mesurées sur le film, avec le prétraitement prolongé gardant le temps, et ceci davantage est marqué aux procédures du bas (50) mA, et est moins (des 500) procédures élevées de mA, à quel mA également, le début a été fortement retardé (débutant au sujet de la 12ème heure). L'implication de ceci dans une économie se développante est discutée.

INTRODUCTION:

The radiographic image must contain the required diagnostic information in a form that is easy to extract visually (under suitable conditions). How easily this information is extracted depends on the subjective assessment of the differences in the optical densities. The degree of film blackening on the film is defined by the equation

$$D = \text{Log}_{10} I_o / I \quad (1)$$

where D is the optical density measured on the radiograph or exposed film, Io is the value of the incident intensity of light falling on the film, and I is the value of the transmitted intensity.

The ease with which this information is extracted depends in part, on the magnitude of the measured optical density differences present in the image (contrast) and, the values of the optical densities forming these differences. Optical densities result from exposure and chemical processing of the exposed film, hence, development affects the values of optical densities obtained and therefore the density differences by its influence on the fog (inherent optical density of a film before exposure plus

densities produced by development of unexposed silver halide) produced.[1] These effects of development on film characteristics are usually studied with the characteristic curve Fig. 1A and 1B as shown below.

Fig A.

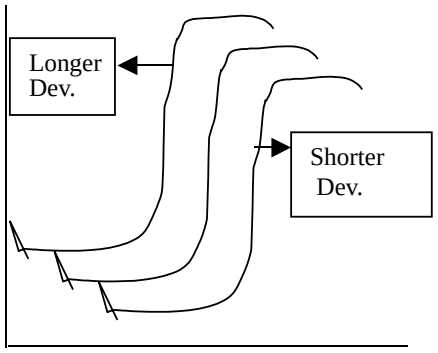


Fig B.

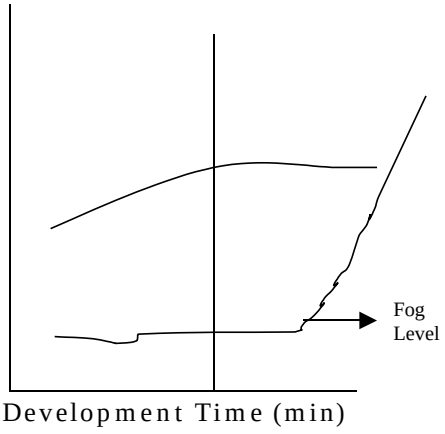


Fig. 1A: Influence of development on Characteristic Curve
1B: Influence on speed and fog levels of the film.

The film emulsion is made of silver bromide in ionic form[2]. When subjected to development, a chemical reduction process registers visible film blackening which indicates the pattern of transmission of the radiation beam through the subject. The quality and accuracy of resulting radiography depends on many factors[3] one of which is the time between exposure and development[1]. In the interval between exposure and processing, recombination of silver and bromide has been reported, although this is largely prevented by halogen acceptors in the emulsion[1]. Carrol (1985)[4] affirms the occurrence of recombination and attributes it to the delay before processing (development). The result of this recombination is manifest as decrease in optical density recorded on the film. The image is said to undergo fading as a result of silver and bromide recombination, so that density decreases with the timed delay of commencement of film processing, i.e., the time between exposure and development[1,4].

In developing countries, inadequacy of amenities like electricity supply often result to the adoption of non-standard or unorthodox procedures to obtain required results. One of these is the increased 'keeping time' of exposed X-ray films before processing due to power outages that make even manual processing (the predominant method of film processing in these parts) a “nightmare”, as electrical ventilation of the darkroom is cut off, and film identification devices cannot be used. During such periods it is impossible to monitor the progress of film development with safe lights. Operators have had to resort to scratching patients' identification on radiographs while processing in completely dark and poorly ventilated darkrooms resulting in poor film quality. Unnecessary radiation exposures to the patients[5].so affected have been the result.

It is in an attempt to find a way around this problem that this study was designed. Considering the reports[1,4], would it be of any benefit to the patient and the radiographer if films were delayed post exposure before processing

in these areas? Would this phenomenon occur and to what extent, with mA variation? Milliamperage (mA) has tremendous effect on the intensity of radiation reaching the film to form the image. Milliampere-seconds (mAs) is generally said to affect only the density, however, in radiography of some dense structures, a change in milliampere-seconds affects both density and contrast.

EQUIPMENT

All exposures were made with a three phase, high frequency, GEC X-ray generator (Roentgen 501) with a maximum output of 150KV, 500mA and 5 seconds, and a minimum output of 40KV, 25mA and 0.01 seconds. Duplitized, fast 18x24 cm X-ray films manufactured by Konica, with fast tungstate GEC medical intensifying screens cassettes emitting blue light were used. Other essential equipment used were the manual processing unit,(which is more commonly used in these parts), processing chemicals (Agfa-Gevaert Dev. G 153 and Agfa-Gevaert Fixer G 353), a dryer unit (Quick dry Film unit Model No. 119DS) having sixty cycles and AC 6Amps. A Sakura densitometer, Model No. PDA-85 was used to determine the optical density of the films. All equipment used were pre-tested for efficiency before use.

PROCEDURE

The X-ray films were made into appropriate sizes (strips), grouped in six (A-F), and were exposed to X-radiation as shown in table 1.

Mean optical densities, measured with the densitometer are tabulated in Table 3 below. The means were obtained by taking three readings (top, middle and bottom) of each filmstrip, since each exposure covered the entire area of the strip used.

Exposed films were stored in their cassettes and kept in an air-conditioned and humidity free darkroom to avoid other causes of film deterioration[1]. Each group of exposed filmstrips, were then processed manually at a temperature of 26 degrees Celsius under thermostatic control. Replenishment of processing solutions was done periodically using the area by volume method[1.] The film strips were developed one at a time for three minutes, timed with a stop watch, rinsed for thirty seconds, fixed for forty minutes and then dried for fifteen minutes using the automated drying system.
The procedure for processing is as in table 2.

DISCUSSION:

Film processing involves several stages but development being the first has the most profound effects on the quality of the image produced. The beam of x-rays whose intensity is a function of mAs at a given kilovoltage, forms a developable latent image on a film emulsion, which is made visible by the process of chemical reduction of silver and ions to metallic silver and bromine atoms[6].
From our results, we note the following;

(i) The optical density produced on a radiograph decreases with the prolonged delay of the exposed film before processing, and
(ii) the onset of this decrease, and the rate of occurrence are functions of the intensity or quantity of radiation (mA) incident on the film.

Milliampere and exposure time are useful in controlling average image density. While the mA is an indication of the number of electrons flowing per second across the X-ray tube during an exposure[7], the exposure time measures the duration of this electron flow. Hence, higher mA exposures produce greater beam intensities[2].

Interaction of X-rays with the imaging device results in formation of the latent image which formation depends, apart from the intensity of the beam, on the average grain size of the film emulsion and the speed[7]. It is for this reason that the same make of films, of the same set and date of manufacture, were used for this work. Similarly, to rule out the effects of old or oxidized developer, new developer and fixer solutions were used. The expected effects of storing exposed films with or in close association with intensifying screens (as possibly being the cause of the decreasing optical density with duration of pre-processing storage), is ignored since this effect occurs in all cases of film-screen contact, and therefore, in all the film strips used.

Increase in mA, (beam intensity) increasingly prevents the onset of image combination as is shown from the results. This result suggests that radiographs of high mA examinations like chest and abdominal radiographs, could be processed about 24hours after exposure, without appreciable loss in image quality. The converse is the case with low mA techniques, in which case the films must be processed before the 8th hour after exposure.

TABLE 1: EXPOSURE FACTORS

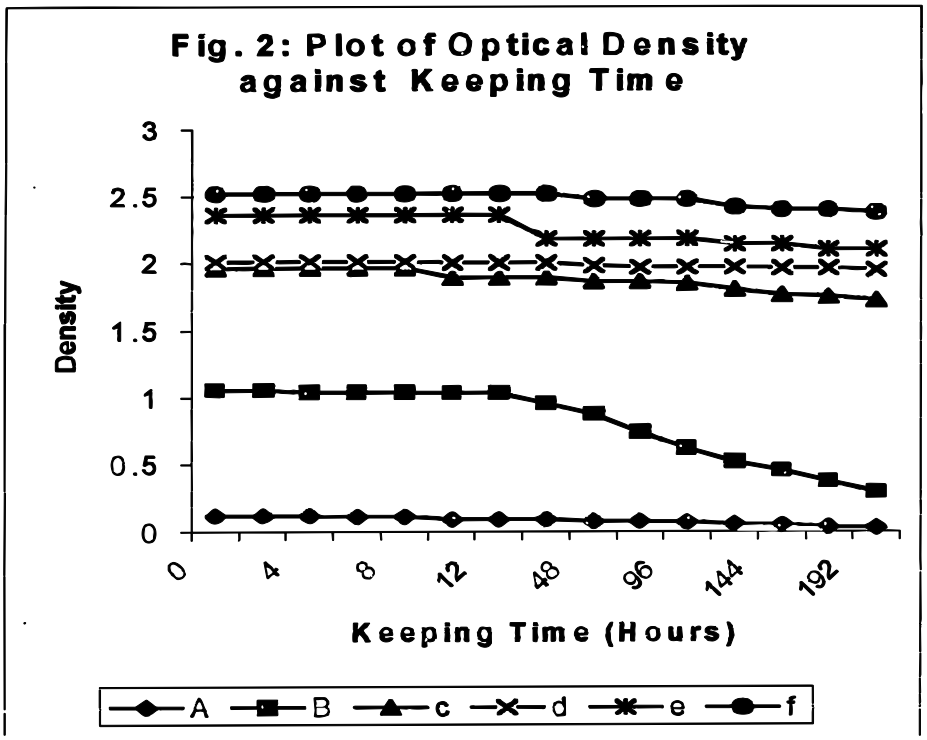
Batch Number	Kilovoltage (KV)	Milliampere (MA)	Focus to Detector Distance (FDD) cm	Exposure time (Seconds)	mAs
A	60	50	90	0.02	1.00
B	60	100	90	0.02	2.00
C	60	200	90	0.02	4.00
D	60	300	90	0.02	6.00
E	60	400	90	0.02	8.00
F	60	500	90	0.02	10.00

Table 2: Procedure for Processing of Film strips

No. of films	Groups A B C D E F	Time of Exposure	Time/Days before processing
6	1111 1 1	8.00 8.05am	Control (0hrs)
6	”	”	2 hrs.
6	”	”	4 hrs.
6	”	”	6 hrs.
6	”	”	8 hrs.
6	”	”	10 hrs.
6	”	”	12 hrs.
6	”	”	16 hrs.
6	”	”	24 hrs (1day)
6	”	”	Up to the 7th day

Table 3: Mean Optical Densities obtained

Film Strip	A-50mA	B-100mA	C-200mA	D-300mA	E-400mA	F-500mA	Time before processing (HRS)
1	0.12	1.05	1.96	2.01	2.36	2.52	0
2	0.12	1.05	1.96	2.01	2.36	2.52	2
3	0.12	1.04	1.96	2.01	2.36	2.52	4
4	0.11	1.04	1.96	2.01	2.36	2.52	6
5	0.11	1.04	1.96	2.01	2.36	2.52	8
6	0.09	1.03	1.89	2.00	2.36	2.52	10
7	0.09	1.03	1.89	2.00	2.36	2.52	12
8	0.09	0.95	1.89	2.00	2.18	2.52	24
9	0.08	0.87	1.86	1.98	2.18	2.48	48
10	0.08	0.74	1.86	1.97	2.18	2.48	72
11	0.07	0.62	1.85	1.97	2.18	2.48	96
12	0.06	0.52	1.80	1.97	2.14	2.42	120
13	0.05	0.45	1.76	1.96	2.14	2.40	144
14	0.04	0.37	1.75	1.96	2.10	2.40	168
	0.03	0.29	1.72	1.95	2.10	2.38	192



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