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FULL PAPER

Electronic collimation of radiographic images: does it comprise an overexposure risk?

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Objective: To investigate whether electronic collimation software, which is available in all digital X-ray systems, may comprise an overexposure risk.

Methods: In the context of surveys on Diagnostic Reference Levels carried out in two radiographic facilities, along with data on exposure factors, the radiographic field sizes were also recorded. In one facility (Unit A), a wireless flat panel detector is used with a conventional X-ray unit, while in the other, a fully digital system is installed (Unit B). The electronically collimated image sizes were compared with the original radiation field sizes. The differences between these two systems concerning the field sizes and the mode of electronic collimation utilization were investigated.

Results: In Unit A, manual electronic collimation was extensively used and cases where the radiation field size was up to three times larger than that electronically

collimated, were identified. On the contrary, in Unit B radiation fields were smaller and electronic collimation was automatic.

Conclusion: When electronic collimation is used in manual mode instead of proper pre-exposure collimation, then it does comprise an overexposure risk. The risk is larger in radiographic units where the field size is not automatically selected according to the examination protocol and no interlocks against oversized collimation settings exist.

Advances in knowledge: When radiologists review masked images to make the diagnosis, possible suboptimal X-ray field collimation practices may go unnoticed for long. Therefore, radiologists and medical physicists should periodically survey the original images to determine the actual radiation field sizes used for each radiographic examination type.

INTRODUCTION

The advent of computed radiography (CR) and digital radiography (DR) has been a major breakthrough in radiology. It is common knowledge, that the image processing capabilities that digital imaging systems offer may facilitate the diagnosis and reduce the reject/retake rates, not to mention the ease that they offer for archiving, distributing and retrieving radiographic images, especially when used in conjunction with picture and archiving communication systems (PACS).¹⁻⁴

However, DR also has potential pitfalls. Unlike radiographic films which become black if the exposure is higher than required, digital detectors present better image quality (statistical noise reduction) with increasing dose (up to the point where saturation of the detector occurs) and thus, radiologists may tend to prefer overexposed images.²⁻⁴ This has been reported in the literature as "the exposure factor creep".⁵

Another potential pitfall is the image processing and editing capabilities.¹⁻³ An image that has not been properly

windowed, may result in loss of diagnostic information, especially if diagnosis is not performed on a diagnostic workstation but on printed film. A related problem that has been reported in the literature, is electronic collimation, also referred to as electronic masking, cropping or shuttering.^{4,6,7} Improper electronic collimation can both hide diagnostically useful details, but may also hide the actual size of the irradiated anatomy, creating thus a risk of concealing systematic overexposure of patients due to poor collimation practices. The latter issue was revisited in this study.

METHODS AND MATERIALS

This study was carried out in two radiographic facilities, in the context of Diagnostic Reference Levels (DRL) surveys. The aim of the surveys was to calculate the average values of entrance skin dose (ESD) for some of the most commonly performed radiographic projections and to compare them with the respective national DRLs. For this purpose, data on the exposure factors and the geometrical setup of each projection were recorded, including field size, as required

by the Greek Atomic Energy Commission instructions regarding DRL surveys.

In the first facility located in a private diagnostic centre (Unit A), a conventional radiographic unit is used in conjunction with a wireless flat panel detector of $35 \times 43 \text{ cm}^2$ size, which is fitted interchangeably into the horizontal table and the chest stand bucky. In the second facility located in a large public hospital (Unit B), a fully digital X-ray unit is installed with two flat panel detectors of $43 \times 43 \text{ cm}^2$ size, one integrated in the horizontal table bucky and the other integrated in the chest stand bucky. In both units, the same flat panel detectors are used for all radiographs, irrespectively of the size of the imaged anatomy, which may range from the size of a finger to the size of an abdomen, which may cover the whole detector area.

Unit A is equipped with a digital control console, incorporating preset anatomic protocols and automatic exposure control (AEC) system. However, as the digital detector is not an integral part of the unit, the X-ray field position and collimation are manually set and the exposure parameters are not captured by the digital detector software and thus no record of them is kept in the Digital Imaging and Communications in Medicine (DICOM) header of each digital image. Providentially, the detector's image viewer software provides an exposure indicator for monitoring the detector's exposure level. This type of digital radiographic systems, *i.e.* common X-ray units equipped with a digital cassette, will be henceforth referred to as *hybrid*, to differentiate them from digital radiographic units with integrated digital image detectors.

Unit B is also equipped with a digital control console, incorporating preset anatomic protocols and AEC system, but it has two major differences compared to Unit A. First, in Unit B depending on the examination protocol selection, the respective image detector and AEC chamber set are automatically activated (in the chest stand or the horizontal table) and the collimation is automatically adjusted to the protocol's preset, while the X-ray tube follows the image detector's movements in alignment. Although manual adjustment of the collimation size prior to the exposure is allowed, there is an interlock that prevents setting the collimation size larger than the image detector size, for any selected focus-to-detector distance. Second, all the parameters relevant to the exposure factors and the geometrical setup used for each radiograph are automatically stored in the DICOM header of each digital radiographic image. It must be clarified that none of the units had a dose-area product (DAP) meter installed; however, in Unit B there is a DICOM tag designated for automatic recording of the DAP meter reading when this is installed.

In Unit A, exposure factors were manually recorded by radiation technologists immediately after the exposure, along with the exposure indicators of each digital image. However, no record of the radiation field sizes used was found on the relevant forms. For this reason, the digital images of the recorded examinations were retrospectively reviewed in order to record the radiation field size. During this procedure, it was noticed that all images have been electronically collimated. The specific software doesn't

offer the automatic recognition of collimation edges and automatic masking utility, which is available in some other digital and CR systems. For this reason, in the original images, apart from the patient anatomy delimited by the primary collimation, non-irradiated areas of the image detector and areas where shadows of anatomy are casted due to scatter radiation (henceforth, all referred to as *background noise*), were also imaged. As a result, manual electronic collimation was routinely performed by radiation technologists. Therefore, in the masked images, which are those reviewed by the radiologists for making the diagnosis, the limits of the original X-ray field collimation were concealed.

Conveniently, the image review workstation has a special tool that removes masking and presents the original image with a dashed-line frame around the electronically collimated field size. The frame dimensions are given in inches and when this frame is fitted around the irradiated area of the detector, the original radiation field size can be determined. Using this tool, data regarding original and electronically collimated field sizes for a total of 92 cervical spine anteroposterior (AP) and lateral (LAT), chest posteroanterior (PA) and LAT, abdomen erect AP, lumbar spine AP and LAT radiographic projections were recorded and analysed.

In Unit B, the collection of these data were easier and more automated. Using a free software called DICOM Info Extractor,⁸ all DICOM data of 507 images of various radiographic projections, which had been written on a DVD-rom for the purposes of the DRL survey, were extracted and stored in a spreadsheet for further analysis. Within these images, 160 images of the aforementioned projections were included.

The DICOM Info Extractor was customised to read all DICOM tags which are relevant to the field collimation and are tabulated in Table 1. A brief description of these tags was found in the DICOM Conformance Statement of the specific unit but in order to understand and verify what these tags represent, some additional test images with automatic and manual primary and electronic collimation were acquired. Furthermore, images were reviewed using a DICOM viewer and manual field size measurements were made using the tool available for distance measurements.

RESULTS

In Unit A, the use of the unmasking tool made evident that electronic collimation was not only used to mask the background noise, but also parts of the irradiated anatomy. In some images, the area of masked anatomy was rather limited, as in the case of a cervical spine AP projection shown in Figure 1. In this figure, the electronic collimation frame appears to be relatively close to the original collimation, but in fact the radiation field area is 25% larger than the electronically collimated image area. It must be noted that as some of the surplus radiation field is in the air, the actual patient dose increase is not directly proportional to this difference.

At this point, it should be clarified that when it is stated that the patient dose increases with increasing field size, what is meant is

Table 1. DICOM tags relevant to image and collimation size description

No	Attribute name	Tag	Notes
1	Rows	(0028,0010)	Image size depends on collimation, max. 3072
2	Columns	(0028,0011)	Image size depends on collimation, max. 3072
3	Overlay rows	(0028,0010)	Same as "Rows" (0028,0010)
4	Overlay columns	(0028,0011)	Same as "Columns" (0028,0011)
5	Active image rows	(0025,1016)	– ^a
6	Active image columns	(0025,1015)	–
7	Image rows	(0025,1013)	–
8	Image columns	(0025,1012)	–
9	Collimator manual	(0025,0002)	–
10	Collimator up left X percentage	(0025,0003)	Percentage offset from 3 × 3K image
11	Collimator up right X percentage	(0025,0004)	Percentage offset from 3 × 3K image
12	Collimator low left X percentage	(0025,0005)	Percentage offset from 3 × 3K image
13	Collimator low right X percentage	(0025,0006)	Percentage offset from 3 × 3K image
14	Collimator up left Y percentage	(0025,0007)	Percentage offset from 3 × 3K image
15	Collimator up right Y percentage	(0025,0008)	Percentage offset from 3 × 3K image
16	Collimator low left Y percentage	(0025,0009)	Percentage offset from 3 × 3K image
17	Collimator low right Y percentage	(0025,010A)	Percentage offset from 3 × 3K image
18	Imager pixel spacing	(0018,1164)	"0.143", "0.143"

^aDenotes that no additional information is given for the specific DICOM tag in the DICOM Conformance Statement document.

the effective dose (E), which is the weighted sum of the doses to the organs and tissues of a patient. Tabulated ESD to E conversion factors given for various radiographic projections have been calculated for a specific radiation field size.⁹ It is evident that when a larger radiation field is used, more tissues and organs are irradiated and therefore the actual ESD to E conversion coefficient also increases.¹⁰ Specialised programs that calculate E using Monte Carlo techniques for nonstandard radiographic techniques, including different field sizes, as well as, different patient sizes and ages are commercially available. As a crude approximation, however, it may be considered that the ESD to E conversion factors increase proportionally to the increase of the area of tissues irradiated.¹⁰ Finally, it must be noted that the increase of field size will also result in a small increase of ESD, due to the increase of the backscatter factor (e.g. if the field size is doubled the ESD will increase by about 2%).¹¹

In contrast to the case presented in Figure 1, there were cases where the extent of masking observed was alarming, as this shown in Figure 2. In this figure, a cervical spine LAT projection is shown, where the radiation field area was about three times that of the electronically collimated image. Though again part of the unnecessarily exposed area is in the air, it is obvious that a large part of the head and the upper chest were unnecessarily exposed.

In 53 out of the 92 images studied (58%), one or more of the four edges of the original collimation could not be identified, indicating that the radiation field size was set larger than the digital detector size. Such a case can be seen in Figure 3, where

a lumbar spine AP projection is shown. In this case, the exposed area, though maybe not evident at first glance, is at least 90% larger than the electronically collimated image. The exact size of the radiation field size cannot be determined, as the upper and lower diaphragms are not discernible, but it is evident that all this surplus radiation was delivered to patient tissues.

In Unit B, the image field size was determined by multiplying the DICOM tags # 1 (rows) and # 2 (columns) by the pixel size (0.143 mm) and dividing by 10, to express the field dimensions in cm. DICOM tags # 3 and # 4 were either blank or equal to DICOM tags #1 and #2, respectively. DICOM tags # 5 and # 6 were usually similar (± 2 pixels) to DICOM tags #1 and #2, respectively, except when the DICOM tag #9 was 1 (manual electronic collimation) and when DICOM tags #10 to # 17 were 0. In either of these cases, they both had a value of 3121. However, it was also observed that there were many cases where one or both of these tags had much different values than tags #1 and #2. By reviewing the respective images and using the distance measurement tool to measure the field size dimensions, it was verified that the correct field size was that determined using DICOM tags # 1 and #2, so tags #5 and #6 were considered unreliable.

DICOM tags # 7 and # 8 always had a value of 3121, which when multiplied by pixel size result in an image frame size of 44.6 cm (3121×0.0143 cm), which is larger than the nominal detector size. Finally, it was found that DICOM tags #10 to #17 give the positions of the four corners of the X and the four corners of the Y jaw of the electronic collimation frame (skewed collimation is allowed), as percent coverage of the maximum image frame

Figure 1. An example of cervical spine anteroposterior projection performed in Unit A (hybrid unit) is shown. In this case, the X-ray field collimation was only slightly suboptimal and electronic collimation was used for masking mainly the background noise.

size (44.6 cm). It was understood that the upper left corner of the image frame (as shown on the PC screen) is the origin of the co-ordinates system. Multiplying these tag values by 44.6 cm the position of each jaw is determined and by subtracting the left from the right jaw value and the upper from the lower jaw value, exactly the same field size dimensions were deduced as those derived from calculations based on tags #1 and #2. However, there were eight cases where tags #10 to #17 had a zero value, for no obvious reason.

The results regarding the minimum, maximum and mean dimensions of masked images and the respective dimensions of radiation field sizes recorded in Unit A are shown in Table 2. In the same table, the results regarding the masked field size dimensions for the images acquired in Unit B are also tabulated, along with the preset collimation dimensions of the respective examination protocols. In this table, the results of comparisons between Units A and B and between radiation field sizes and masked image sizes are also given.

As can be seen in Table 2, though in the fully digital unit the collimation is preset, variations in the field size were indeed observed. It was mentioned before that the radiation technologist is free to modify the default collimation prior to exposure. After the exposure, the electronic collimation is automatically adapted closely around the irradiated field area, leaving a space

Figure 2. An example of cervical spine lateral projection performed in Unit A (hybrid unit) is shown. In this case, the X-ray field collimation was extremely oversized and electronic collimation was used not only for masking the background noise but also for extensive cropping of the unwanted anatomy imaged, in all four directions.

of up to 5 mm (as seen from viewing the images). Whether the electronic collimation has been automatically or manually adjusted, it can be deduced from the value of the DICOM tag #9 assigned for this purpose. In the sample studied, only one case was found where manual collimation was applied. This was a lumbar spine LAT projection, shown in Figure 4, where the image was acquired with the collimator rotated. In this case, the original field size could not be determined using the unmask tool (also available in the acquisition workstation of Unit B), as the raw image was no longer available at the time of data analysis. This is because the images that have been sent to PACS are periodically deleted (every week), to free hard disk space in the acquisition workstation. When an image is retrieved from PACS, certain image processing features, like digital image processing filters and unmasking, can no longer be applied (they appear inactive).

In Figure 5, an example of a cervical spine LAT projection performed in unit B is presented. In this case, the automatic electronic collimation, for some reason, has failed to detect the lower edge of the primary collimation. So, although from the DICOM data it seemed that the radiation field height was about 9 cm larger than usual, review of the respective image showed that it didn't correspond to any patient overexposure.

Figure 3. An example of lumbar spine anteroposterior projection performed in Unit A (hybrid unit) is shown. The X-ray field collimation was severely suboptimal and electronic collimation was used for extensive cropping of the unwanted anatomy imaged (apart from masking the background noise) in three out of four directions. The upper and lower edges of the original collimation are not discernible.

It must be noted that in Unit B, a field size dimension equal to the maximum image size (42.8 cm), was observed in 10 abdomen AP, 5 chest LAT and 1 lumbar spine LAT examinations. While this may suggest that the X-ray field may have been set larger than the detector size, it must be reminded that in this particular digital system, there is an electronic interlock that limits the collimator to the digital detector size. So the problem of using a radiation field size larger than the digital image detector, which was very common in the hybrid unit, is not a reason for concern in the specific fully digital unit.

DISCUSSION

As can be seen in Table 2 for Unit A, the actual radiation field area could be determined only for the cervical spine projections. For all other projections, in the majority of the images, one or more of the original collimation edges could not be identified, suggesting that a radiation field larger than the detector has been used. For the cervical spine projections in Unit A, the radiation field size was on average about 40% larger than that used in Unit B and about twice that of the area of the electronically collimated image.

In Unit B, the image size was similar to the default collimation size (differences were less than 10%), except for the cervical spine LAT projection where it was 22% larger, and the chest posteroanterior

projection where it was 13% smaller. On the other hand, the electronically collimated image sizes in Unit B were on average smaller than those in Unit A for all projections. This may seem to suggest that smaller fields than those used in Unit A are needed for the diagnosis. However, it should be reminded that in Unit B, the field size selection has to account for possible anatomic variations between different patients, since in some projections, the actual position of the structures of interest cannot be known *a priori*. For example, the use of smaller field sizes in chest radiographs of large patients may jeopardise the proper imaging of lungs bases and apices. Similarly, the use of a smaller field width in lumbar spine radiographs could jeopardise the proper imaging of the spine, in the case of patients with scoliosis. In Unit A, where larger radiation field sizes are routinely used, it is certain that all the anatomic structures of interest are included in the original image and any of the aforementioned anatomical variations is managed post-exposure, with cropping of the imaged anatomy to the size that is considered necessary for diagnosis.

The results of the survey performed in Unit A with regard to collimation practices, clearly exhibited that though radiation technologists are trained in the use of X-ray collimation, in practice this basic As Low As Reasonably Achievable requirement is not always fulfilled. In the specific hybrid X-ray facility, which started its operation only a few months before the sample collection, the problem of oversized collimation had been identified during the early stages of the data collection procedure performed for the purposes of the DRL survey. Initially, the assessment was focused on the radiation technologist practices concerning the exposure factors used and the resulting exposure indicator values and image quality. However, in view of the poor collimation practices observed, radiation technologists were instructed to carefully collimate the light field around the anatomy necessary for diagnosis and never exceed the image detector physical dimensions. Nevertheless, in the examination sample collected after this briefing, cases of poor collimation were again observed. When the radiation technologists were informed about the final results of this survey regarding collimation, they argued that their main concern was to assure that the whole anatomy of interest is imaged and avoid repeating radiographs. However, this argument cannot disprove the fact that the presence of electronic collimation may easily lead to over-relaxation regarding collimation practices. Indeed, Zetterberg et al⁷ have also reported a 46% increase in the radiation field area used for the lumbar spine AP projection, when digital images were compared with film-screen images performed in the same facilities prior to the installation of digital radiographic units.⁷

Electronic collimation is a useful tool especially in the case of a single size digital detector, where a wide range of field sizes are used depending on the size of the examined anatomical region, which may leave a large part of the detector area unexposed and/or exposed by shadows cast by scatter radiation. Therefore, this area has to be masked for removing this background noise, before the image is presented to the radiologist for diagnosis and before it is handed out to the patient, whether on film or in electronic format. In many CR and DR systems, the detection and masking of the background is automatic (as in Unit B), but in the specific hybrid unit studied it is only manual.

Table 2. Analysis of image field size data for a hybrid (Unit A) and a fully digital radiographic unit (Unit B)

Anatomy	Projection	Unit	Sample	Field dimensions				Ratios of mean values of image areas			
				Range width (cm)	Range height (cm)	Mean width (cm)	Mean height (cm)	RF/EC (A)	EC/PS (B)	EC (A/B)	RF (A/B)
Cervical spine	AP	A	14	11.2–17.8 (17.5–29.7)	16.3–32 (23.9–38.9)	14.4 (22.3)	22.2 (28.7)	2.00	1.06	0.76	1.51
		B	30	16–21	25–33	16.6 (16)	25.5 (25)				
	LAT	A	14	8.6–21.3 (15.5–28.7)	18.8–32.5 (22.9–40.1)	14.2 (21.4)	24.5 (30.8)	1.89	1.22	0.72	1.36
		B	35	15.8–30.3	21.3–36.4	19.0 (16)	25.6 (25)				
Chest	PA	A	12	33.3–40.1 (38.6–MAX)	31.2–35.6 (35.6–MAX)	37.4 (MAX 9) ^a	33.9 (MAX 11)	>1 ^d	0.87	0.85	>1
		B	16	28.9–40.4	33.9–41.9	38.5 (40)	38.7 (43)				
	LAT	A	12	23.1–35.6 (38.6–MAX)	35.1–40.1 (38.1–MAX)	29.8 (MAX 10)	38 (MAX 11)	>1	1.07	0.72	>1
		B	15	28.1–42.8	40.9–41.9	37.5 (34)	41.8 (43)				
Abdomen erect	PA	A	10	30.7–35.6 (MAX–MAX)	39.4–42.7 (MAX–MAX)	33.8 (MAX 10)	41.6 (MAX 10)	>1	1.05	0.91	>1
		B	23	35–42.8	42–42.8	36.7 (35)	42.2 (42)				
	AP	A	15	14–35.6 (16.3–MAX)	29.2–42.7 (38.9–MAX)	19 (20.4) ^b	35.6 (MAX 9)	>1	0.95	0.89	>1
		B	19	18.6–20	30.7–40.4	19.7 (20)	38.6 (40)				
Lumbar spine	LAT	A	15	13.5–35.6 (21.6–35.6)	33.8–42.7 (40.4–MAX)	19.2 (27.5) ^c	38.1 (MAX 12)	>1	1.01	0.90	>1
		B	22	18.9–25.7	33.6–42.8	20.4 (20)	39.8 (40)				

AP, anteroposterior; LAT, lateral; RF, Radiation field; EC, electronically collimated field; PA, posteroanterior; PS, preset radiation field.

For Unit A the values refer to the electronically collimated (EC) field dimensions and respective values in parenthesis denote the radiation field (RF). For Unit B the values refer to the EC image size (roughly equal to radiation field dimensions). Numbers in brackets refer to the preset values of collimation dimensions (PS) for each examination protocol.

^aThe word MAX denotes that the radiation field size was larger than the image detector. The number after the word MAX denotes the number of images where the radiation field size was larger than the detector, and is given instead of the mean value in samples where more than half of the images had a MAX radiation field size.

^bThe mean was determined from 14 images (1 was MAX).

^cThe mean was determined from 11 images (4 were MAX).

^d>1 means that as the mean radiation field size could not be determined (MAX) the ratio would be larger than unity.

Figure 4. An example of lumbar spine LAT projection performed in Unit B (fully digital unit) is shown. This was the only case in the sample studied where electronic collimation was used and the only case where the actual radiation field size used could not be determined.

According to the instructions published on the American Society of Radiologic Technologists website, it is within the scope of practice of a radiation technologist to determine and apply appropriate pre-exposure collimation, as well as, post-exposure electronic collimation to remove the background noise, when automatic processing fails to do so.¹² However, when it comes to the masking of imaged anatomy, it has been argued that radiation technologists may occasionally mask diagnostically useful information.⁶ According to the aforementioned instructions of the American Society of Radiologic Technologists, cropping of anatomy is not within the scope of their practices and should be a medical decision.¹²

Bomer et al⁶ have proposed that the image that is sent to PACS for review should be the original image, electronically collimated to remove the background up to a few mm around the radiation field, so that the “silver lining” (representing the edges of the initial collimation) is visible. This is the safest way in order to avoid concealing

Figure 5. An example of cervical spine LAT projection performed in Unit B (fully digital unit), where automatic electronic collimation partly failed, revealing the background noise in the lower part of the image and resulting in a calculated field larger than the actual radiation field size used.

a systematic overexposure of patients due to suboptimal collimation practices, which otherwise may go unnoticed for a long time. Radiologists should be aware that it is their responsibility to assure that any collimation errors are only occasional and not a systematic malpractice of radiation technologists.

Despite the official instructions of the American Society of Radiologic Technologists,¹² electronic collimation in clinical practice is most probably performed by radiation technologists rather than by radiologists. This comprises a certain risk, as apart from masking useful information, radiation technologists may be accustomed to relying on electronic collimation rather than being meticulous about the original collimation, something which in turn may lead to a systematic overexposure of patients. It must also be reminded, that since the larger the field size is the more the scatter radiation is, the degradation of image quality is another side effect of oversized collimation.

In fully digital systems, where the X-ray field collimation is usually integrated in the examination protocol, if the default value is appropriately set, extreme cases of oversized collimation are expected to be only occasional. However, this cannot always

be taken for granted and therefore, field size should be periodically surveyed in fully digital units too.

In Unit A, a short summary review of a sample of about 30 images followed 2 months after the end of the collection of the official data sample and the consequent discussions with the radiation technologists regarding collimation practices. While the qualitative assessment of this small sample suggested that there has been a great improvement, a follow up survey will be needed a few months later, to determine whether this improvement will be permanent or only temporary.

Unfortunately, a short summary review of about 20 images in two other facilities (located in two different private diagnostic centres) where CR systems are used, was sufficient to suggest that poor collimation practices may not be the exception but the rule. While the assessment was purely qualitative and no measurements of the field sizes of masked and original images were performed, the fact that primary collimation was not discernible in chest, abdomen and lumbar spine projections and that extensive manual cropping was utilised in cervical spine projections, implied that collimation practices in these CR facilities resemble those observed in Unit A.

It is, therefore, ironic the fact that although medical physicists try to adjust the AEC so as to reduce the exposure factors while maintaining the diagnostic confidence, any reduction obtained in ESD may be easily cancelled out by an unnecessary increase in the radiation field size. For this reason, medical physicists should be always alert concerning primary collimation and inform radiation technologists and radiologists thoroughly and repeatedly about its importance.

The results of this study also bring up the usefulness of DAP meters, whose readings incorporate both dose (air-kerma) and field size. In the EC report RP-162,¹³ it is stated that radiographic and fluoroscopic equipment without a device (where practicable)

to show the quantity of radiation is unacceptable. Currently in Greece, DAP meters are compulsory only for fluoroscopic, angiographic and C-arm units and this is why the national DRLs for radiographic examinations are given in terms of ESD. DAP meters would be useful in radiographic units too, provided that a record of DAP meter reading could be automatically captured and stored in the DICOM header of the digital image, to allow easy access to its value for survey purposes.¹⁴ However, since the DAP value is a product of the dose and the field size (at any given distance from the tube focus), if a common DAP meter is used, it cannot be determined whether a given high DAP value is due to a high dose value or a large field size, or both. To differentiate between dose and field, the field size information in the DICOM data can be used when available. Special DAP meters which provide readings of both DAP and dose are commercially available and would be the ideal instrument in the case where both the DAP and the dose values are stored in the DICOM header of each image.

CONCLUSION

The main purpose of this study was to stress the fact that overexposure risks due to electronic collimation may be more frequent and intensified in hybrid units, because the primary collimation is purely manual. In such systems special attention is required, as suboptimal radiation technologist practices regarding primary collimation, can be concealed by electronic collimation and result in a systematic patient overexposure that may go unnoticed for long.

Concerning the manually applied electronic collimation, whether for fully digital or hybrid units, it is mandatory to ensure that it is used with caution and only for masking the background noise and not areas of diagnostic interest, leaving the original radiation field edges discernible. The regular refresher training of radiation technologists on collimation practices and the frequent audit of these practices are essential in order to assure that patient radiation protection is optimised.

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