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Eye lens exposure to medical staff during endoscopic retrograde cholangiopancreatography

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A B S T R A C T

The paper presents a study of the radiation doses to eye lens of medical staff during endoscopic retrograde cholangiopancreatography (ERCP) procedures performed in a busy gastroenterology department. For each procedure the dose equivalent to the eye, exposure time, dose rate, Kerma Area Product and fluoroscopy time were recorded. Measurements were performed for a period of two months in four main positions of the operating staff, and then extrapolated to estimate annual doses. The fluoroscopy time per ERCP procedure varied between 1.0 min and 28.8 min, with a mean value of 4.6 min. The calculated mean eye dose per procedure varied between 34.9 μSv and 93.3 μSv. The results demonstrated that if eye protection is not used, annual doses to the eye lens of the gastroenterologist performing the procedure and the anesthesiologist can exceed the dose limit of 20 mSv per year.

Introduction

Endoscopic retrograde cholangiopancreatography is a common interventional image guided procedure performed to diagnose conditions of the biliary and/or pancreatic systems, in which the bile and pancreatic ducts are visualized using radiocontrast medium [1]. When carried out with therapeutic intent, it plays an important role in reducing the number of surgeries.

ERCP is most often performed in gastroenterological departments by staff with insufficient knowledge on the radiation protection measures for patient and staff dose reduction, and not necessarily in the presence of a radiologist [1]. The procedure requires the operator and other medical staff to stand in close proximity to the patient, resulting in possible higher radiation doses to the whole body and particularly to the lens of the eye. Published data for eye lens doses during the ERCP are scarce. These studies show wide variations in terms of dose, fluoroscopic time, equipment, workload, applied working practices and measurement methods [2–6]. The topic became of increased importance after the International Commission on Radiological Protection recommended the annual dose limit for equivalent dose to the lens of the eye to be reduced to 20 mSv [7]. The recently published International Atomic Energy Agency (IAEA) report recommended investigations to be performed to identify whether workers receive significant dose to the lens of the eye [6]. According to the new EURATOM Directive 2013/59, all members of staff who can potentially receive an equivalent dose to the eye lens greater than 15 mSv per year should be under occupational dose monitoring [8]. The purpose of this work is to collect data on the radiation doses to eye lens of medical staff working in a busy gastroenterology department during ERCP procedures, to compare them with the new annual limit for the lens of the eye, and to explore the potential for optimization of clinical practice.

Materials and methods

The study was performed in the procedure room of a busy gastroenterology department. ERCP procedures were performed using a C-arm fluoroscopy system Arcadis Varic, Siemens Healthcare, with a 23 cm diameter image intensifier. The half value layer of the system was 3.1 mm Al at 80 kV. A standard vascular mode with continuous fluoroscopy, and vertical X-ray beam with a X-ray tube under the patient couch were used for all procedures.

ERCP procedures involved the following medical specialists: one or two gastroenterologist, one or two nurses and an anesthesiologist.

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Only therapeutic procedures using a duodenoscope were performed. The patient was placed on a coach in left lateral decubitus position. During the procedure all images were obtained using injection of contrast medium and under local anesthesia. An overview of the staff positions relative to the patient is shown in Fig. 1.

During the procedure the main operator-gastroenterologist stands in position P1, facing the patient, or facing the monitors. The monitors are situated above the patient's head and to the right of the operator. The assistant, who can be either a second gastroenterologist or nurse, stands in position P2 behind the operator. The nurse in position P3 stands near the head of the patient to guide the duodenoscope. The anesthesiologist stands in position P4, next to the head of the patient to monitor the patient's breathing, and may occasionally he leaves his position to administer anesthesia. All members of the team wear apron and thyroid shields with 0.50 mm lead equivalent. No ceiling suspended shields or radiation protection couch drapes were available.

Patient doses were measured with an integrated Air kerma-area product (KAP) meter. Eye-dose to the medical staff was measured with EDD-30 active electronic dosimeter (Unfors, Sweden), calibrated in terms of operational quantity personal dose equivalent $H_p(0.07)$ in mSv, using N-80 X-ray beam [9] and traceable to Secondary Standards Dosimetry Laboratory – Sofia, Bulgaria. In addition, EDD 30 was tested for angular response in laboratory conditions using N-60 X-ray beam. The response of the dosimeter was within the range 0.80–0.97 for angles up to 60° and as required in the IEC 61526 standard [10,12]. Due to the specific nature of the work the readings of the EDD-30 were not corrected for angular response. The detector was placed at the level of the eye closest to the X-ray tube side. For the main operator and nurse this was the left eye, and for anesthesiologist - the right eye. All measurements were performed without any protective eye shielding. As only one active dosimeter was available, the measurements for different staff members were performed consecutively, i.e. for different procedures. Trial version SPSS Statistics desktop for Windows software was used for the statistical analysis. A Spearman's test was used due to number of measurements in each position and a lack of normal distribution of the data.

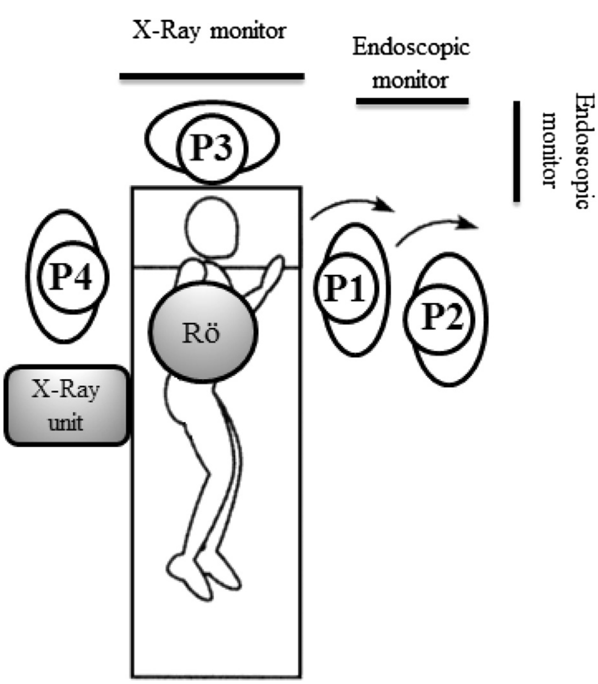

Figure 1. Patient and staff positions, Position 1: gastroenterologist (P1), Position 2: gastroenterologist or nurse (P2), Position 3: nurse (P3), Position 4: anesthesiologist (P4).

For each procedure the following information was recorded: dose equivalent to the eye, dose rate and exposure time (ET) from the EDD-30 dosimeter, and patient dose in terms of Kerma Area Product (KAP), fluoroscopy time (FT) and tube voltage, as displayed on the fluoroscopy system console.

Using the departmental records, the total annual workload was estimated to be 800 procedures in 200 working days, and this value was used to estimate the annual dose to the eye lens. All procedures were performed by two gastroenterologists acting as main operators. The workload for the anesthesiologist was assumed to be the same as for the gastroenterologists, and for the nurses – half that of the gastroenterologist, as they change their position to operate monitoring equipment or to assist in other medical procedures not involving X-ray. Additionally, the daily workload was assumed to be two ERCP procedures for the gastroenterologist and anesthesiologist, and one for the nurses.

Results

Data collection was performed during a period of two months. Forty-nine therapeutic ERCP procedures were included. In each of these the eye lens dose was measured for one of the available positions (P1–P4). The eye lens dose was measured in position P1 (main gastroenterologist) for 15 procedures, in position P4 (anesthesiologist) for 14 procedures, in position P3 (nurse) for 13 procedures, and in position P2 (nurse or second gastroenterologist) for 7 procedures. The results for dose, dose rate, exposure time to the eye lens per procedure and FT for the main positions of the staff members in endoscopic room are presented in Table 1. For each quantity, mean values, minimum and maximum (in parentheses) and standard deviation (SD) are presented.

The first, third and fourth columns in Table 1 show the mean eye dose, exposure time and fluoroscopy time respectively, averaged from the measurements in each position. The fluoroscopy time per ERCP procedure varied between 1.0 and 28.8 min, with a mean value of 4.6 min.

Table 2 presents mean eye lens dose per procedure calculated by multiplying the mean dose rate in each position by the mean FT and ET respectively, obtained by averaging all measurements. The annual dose was calculated as the product of the mean eye dose per procedure and the typical workload of 400 procedures for the main operator and anesthesiologist and 200 procedures for the assisting staff and nurses. The real exposure time measured by the EDD 30 varied between 0.0 and 27.0 min, with a mean value of 3.5 min.

Discussion

The equivalent dose $H_p(3)$ is considered to be the most accurate method for monitoring the equivalent dose to the eye lens [6,11]. It is recommended that dosimeters should be type tested and calibrated in terms of $H_p(3)$ using an appropriate phantom. At the time of this study methodology for calibration in terms of $H_p(3)$ was not available. According to the IAEA recommendations, if a dosemeter calibrated in $H_p(3)$ is not available, a dosemeter calibrated in terms of $H_p(0.07)$ can be used to assess the eye dose from photon radiation with sufficient accuracy [6].

A limitation of this study was that measurements in different positions were performed during different procedures, due to the availability of only one direct dosimeter. Because of the variation in complexity of different ERCP procedures, resulting from the individual patient's pathology, the fluoroscopy time varied from 1.0 min to 28.8 min. Estimated mean eye dose per procedure in Table 1 was performed on the base of measurements in each