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How safe is ERCP to the endoscopist?

R. V. Cohen, M. A. Aldred, W. S. Paes, A. M. F. Fausto, J. R. Nucci, E. M. Yoshimura, E. Okuno, M. E. Garcia, L. M. Maruta, E. M. C. Tolosa

Division of Surgical Endoscopy, Health Physics, Occupational Medicine and Dosimetry Laboratory, University of São Paulo, São Paulo, Brazil

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Abstract

Background: Interventional techniques in endoscopy such as endoscopic retrograde cholangiopancreatography (ERCP) have greatly increased since laparoscopic cholecystectomy has become widespread; mainly these techniques deal with common bile duct stones. Fluoroscopy is usually employed, and chronic exposure to X-ray, in spite of the relative low dose, can lead to potentially unhealthy conditions such as malignancies like bone marrow and other solid cancers. A median of 18 years of life is lost per fatal cancer, including the time of latency since exposure. Nor should one forget benign condition such as cataracts that can lead to partial or complete blindness and which surely impair life's quality.

Methods: Simulated examinations were carried at the University Hospital (São Paulo, Brazil) using an anthropomorphic phantom in place of the physician. Four sets of dosimeters were placed in the forehead, neck, torso, and lower abdomen (with and without a lead apron) and standard ERCP fluoroscopic techniques were employed.

Results: The dose equivalents were calculated and compared to the recommended exposure doses of national and international boards of radiation protection.

Conclusions: Based on the results found and compared to standards, working safely means: (1) A lead (0.5 mm thickness) apron is fundamental. Without it less than one ERCP\month should be performed. (2) With an apron, 23 examinations/month are allowed. (3) No thyroid protection grants only 19 exams/month. (4) Performing ERCP without lead glasses is hazardous to the eye, allowing only seven ERCPs monthly.

Key words: ERCP — Radiological protection — Radiation exposure protection — Interventional laparoscopy — Common bile duct stones management

Correspondence to: R. V. Cohen, Rua Wanderley, 1482 ap. 53, 05011-001 São Paulo SP, Brazil

The combination of endoscopic retrograde cholangiopancreatography (ERCP) with endoscopic sphincterotomy and stone extraction has acquired an expanded role in the management of choledocholithiasis in the minimal access surgery era [1, 2, 3]. During those procedures, fluoroscopic and radiographic images are taken with paramedical and medical staff near the patients. Even if the level of exposure to X-rays during ERCP is low, it is important to stress that it is a chronic exposure that can lead to potentially unhealthy conditions such as malignancies and benign conditions such as eye disorders (cataract) [7].

The goal of this paper is to evaluate the dose equivalent that the medical staff is exposed to during exams (ERCPs) performed at the Division of Surgical Endoscopy, University Hospital, University of São Paulo, Brazil. The equivalent dose resulting from staff exposure was compared to recommended limits issued by international boards of radiation protection [8] and to Brazilian national standards [4]; then an ideal maximum number of examinations allowed per month and year was established in order to assure to the medical team the best protection against deleterious effects of ionizing radiation.

Methods

The endoscopic procedures were simulated by employing a recipient containing water as the patient and an anthropomorphic phantom (Alderson phantom) as the endoscopist who has control of the fluoroscopic equipment (wearing a 0.5-mm-thickness lead apron). The position of the phantom was chosen to achieve the maximum exposure during ERCP, using data calculated by a radiation monitor (Radcal Corporation, model 9015; Washington, DC) on radiation exposure. The phantom was set up in an upright position at a distance of 55 cm from the examination table. Each dose equivalent was calculated from the measurements of four thermoluminescent dosimeters (TLD 100) located in different sites of the phantom: the forehead, neck, torso and lower abdomen (under and over the apron). The dosimeters were calibrated at the Dosimetry Laboratory, Physics Institute, University of São Paulo [9, 12].

Measurements were performed for fluoroscopic and radiographic exposures, using four sets of TLDs. During fluoroscopy three sets were submitted to three different irradiation times (20, 40, and 60 min). Fluoroscopy was simulated with consecutive displays of 85 kVp and 2.2 mA, breaking each 5 min. The last set of TLDs was submitted to an irradiation

Table 1. Equivalent doses for medical and paramedical staff; fluoroscopy and radiographs

Dosimeters site	Equivalent doses HT (mSv) for 1 h fluoroscopy	Equivalent doses HT (mSv) 6 films
Forehead	4.35	0.33
Neck	5.50	0.31
Torso (inside apron)	0.15	0.03
Torso (outside apron)	4.79	0.32
Lower abdomen (inside apron)	Nonmeasurable	Nonmeasurable
Lower abdomen (outside apron)[a]	0.20	0.07

[a] Located below the table. Works as protection from ionizing radiation.

Table 2. Equivalent doses per procedure; calculated from Table 1

Site/organ	Equivalent doses (fluoroscopy, mSv)	Equivalent doses (radiographs, mSv)	Equivalent doses (total)
Crystalline	1.45	0.22	1.67
Thyroid	1.84	0.21	2.05
Whole body—apron	0.050	0.02	0.07
Whole body—no apron	1.60	0.22	1.82
Gonads—apron	Nonmeasurable	Nonmeasurable	Nonmeasurable
Gonads—no apron[a]	0.067	0.05	0.12

[a] Located below the table. Works as protection from ionizing radiation.

equivalent to six plain radiographic films. The plain films were obtained at 85 kVp and 100 mA.

The quantity ‘‘dose-equivalent’’ (H) is limited to radiation protection applications and is calculated as the product of the absorbed dose (D) by a quality factor (Q) that takes into account the type of radiation (α, β, γ, or n). Dose equivalent is measured in units of Sievert (Sv), e.g., 1 mSv—one milliSievert—is equivalent to an energy of 10^3 Joules per 1 kilogram of tissue mass.

Results

The average dose equivalent, measured during fluoroscopy and performing the six static films, is shown on Table 1.

The estimated time of exposure to ionizing radiation during the performance of ERCPs at the Division of Surgical Endoscopy, University of São Paulo, is 20 min and generally four films are taken. Bearing in mind that the points of measurement can be analogous to some anatomic parts, respectively the crystalline, thyroid, gonads, and whole body (torso + abdomen), the total equivalent-dose was calculated (Table 2).

Limits established by Brazilian standards (National Commission of Nuclear Energy, CNEN, São Paulo, Brazil) and international boards (International Commission of Radiation Protection—ICRP, London, England) are shown on Table 3. Considering the limits of dose equivalents as a standard of working safely, according to CNEN-NE 3.01 and ICRP 60, and the total doses obtained per procedure at the Division of Surgical Endoscopy (Table 2), the maximum number of procedures that the staff can perform safely was determined (Table 4).

Table 3. Occupational limits of doses; yearly basis

Organ/site	Occupational limits CNEN (yearly) mSv	Occupational limits ICRP-60 (yearly) mSv
Whole body	50	20 (5-year basis)
Crystalline	150	150
Skin	500	500

Table 4. ERCP’s maximum number (monthly/yearly) where CNEN and ICRP-60 limits are respected

	Maximum allowed exams (CNEN, Brazil)		Maximum allowed exams (ICRP-60)	
Organs	Year	Month	Year	Month
Crystalline	89	7	89	7
Thyroid	243	19	—	—
Whole body (with apron)	714	57	285	23
Whole body (without apron)	27	2	10	0.8

Discussion

The combination of endoscopic retrograde cholangiopancreatography (ERCP) with endoscopic sphincterotomy (ES) and stone extraction has acquired an expanded role in the management of choledocolithiasis. With the rapid growth of laparoscopic cholecystectomy (LC), the evaluation and treatment of suspected common bile duct stones have been limited, and the main approach combined to LC to common duct stones has been until now in many centers the combination of ERCP and ES [1, 6, 11]. To perform those procedures, exposure of the medical and paramedical staff to ionizing radiation is required. Even though the exposition is low, it is continuous and may lead to hazardous consequences.

Information on the risk of cancer following radiation exposure comes from a large number of epidemiological studies and has recently been reviewed by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) and by the US Committee on the Biological Effects of Ionizing Radiation (BEIR V)[5, 14]. The populations that have been studied include:

1. Over 90,000 survivors of the atomic bombings of Hiroshima and Nagasaki
2. 14,000 mostly male patients in the UK treated for ankylosing spondylitis with X-rays
3. 83,000 women in eight countries treated for cervical cancer with X or gamma radiation

Very few studies have followed the entire population until the end of life. The temporal pattern of risk was assessed in studies as the Life Span Study [10] of A bomb survivors. Those studies showed that for the main cancer secondary to radiation exposure—leukemia—the peak is about 7 years of exposure followed by a tailing off in risk. The relative risks depend on the age at the time of exposure, dose level and rate, and if the individual who was dealing with ionizing radiation got a specific oncogen in his genoma. No one should forget that there are different temporal patterns of risk for different cancer types. For leukemia, after adjustment for age at exposure, the relative risk appeared to be constant over time, mainly if the subject is constantly exposed as the staff that performs endoscopic procedures under fluoroscopy. For solid cancers, such as lung, breast, thyroid, and GI (colon and stomach) cancers, the relative risk decreases about 10 to 20 years following exposure [13]. Following leukemia, solid GI cancers, breast, lung, and thyroid malignancies are the commonest neoplasias following radiation exposure.

It is important to stress that those data are only relative to deaths secondary to ionizing-radiation-induced cancers. Quality of life tends to decrease to important levels, if it's considered the time taken for the diagnosis and treatment of secondary cancers. Besides neoplastic affections, in spite of the lack of significant statistical data, crystalline injury was described [14], and this benign condition can lead to a feared situation that may follow chronic exposition to radiation—complete blindness.

Keeping in mind all the potential hazards related to chronic exposure to ionizing radiation, and comparing the dose equivalent taken by the phantom to international standards (Table 3), it is concluded that working safely means:

1. Wearing a lead apron (0.5-mm thickness) is fundamental: without it, less than one ERCP should be performed per month; only four examinations should be performed in a period of 5 months.
2. With an apron, 23 exams/month are allowed.
3. No thyroid protection grants only 19 exams per month.
4. Performing ERCP without lead glasses is hazardous to the eye, allowing only seven ERCPs per month.

Besides lead aprons, glasses and thyroid shields are important protective devices and should allow an increased number of safe monthly examinations.

It must always be emphasized that radiation carcinogenic induction is a process with no threshold dose, e.g., even for small doses the probability of ocurrence is not zero. Specialists set limits as a way to keep the incidence of malignancies at acceptably low levels. However, focusing on benign effects such as cataracts, the limiting doses might be adopted as threshold doses.

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