Radiation exposure to personnel performing endoscopic retrograde cholangiopancreatography

L S Naidu, S Singhal, D E Preece, A Vohrah, D E Loft

Background: Endoscopic retrograde cholangiopancreatography (ERCP) relies on the use of ionising radiation but risks to operator and patient associated with radiation exposure are unclear. The aim of this prospective study was to estimate the radiation dose received by personnel performing fluoroscopic endoscopic procedures, mainly ERCP.

Methods: Consecutive procedures over a two month period were included. The use of thermoluminescent dosimeters to measure radiation exposure to the abdomen, thyroid gland, and hands of the operator permitted an estimation of the annual whole body effective dose equivalent.

Results: During the study period 66 procedures (61 ERCP) were performed and the estimated annual whole body effective dose equivalent received by consultant operators ranged between 3.35 and 5.87 mSv. These values are similar to those received by patients undergoing barium studies and equate to an estimated additional lifetime fatal cancer risk between 1 in 7000 and 1 in 3500. While within legal safety limits for radiation exposure to personnel, these doses are higher than values deemed acceptable for the general public.

Conclusions: It is suggested that personnel as well as patients may be exposed to significant values of radiation during ERCP. The study emphasises the need to carefully assess the indication for, and to use measures that minimise radiation exposure during any fluoroscopic procedure.

**Abbreviations:** ERCP, endoscopic retrograde cholangiopancreatography; ED, effective dose

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**Original Article**

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METHODS
Local research ethics committee approval was obtained. Consecutive endoscopic procedures requiring fluoroscopy (usually ERCP) over a two month period starting November 2000 were included in the study. During the study period one of three consultants (each with similar endoscopic experience) and/or one of two specialist registrars with access to a total of three fluoroscopy sessions per week either performed or assisted at each procedure.

The three consultant operators had one session per week with three to four ERCP/session. There was no deviation from standard unit practice either with regard to patient consent or in terms of the procedures performed.

The procedures were performed in the radiology department using (for fluoroscopy purposes) a CGR Prestilix 1600-exponent 100 IST (Campagnia Generale Di Radiologia, Monza, Italy). An “over-couch” Comet 150 kV x ray emitter tube (Comet AG, Switzerland) was used for image intensification and for the purposes of taking plain films. The automatic pre-set values for fluoroscopy voltage and current were 80 kV and 400 mA respectively with an exposure time in the range 0.04–0.1 seconds. These values are adjusted automatically (for example, according to patient build) to maintain a constant radiation dose entering the image intensifier.

The operator wore a 0.25 mm lead equivalent thick apron and three thermoluminescent dosimeters (Lithium Fluoride (for example, according to patient build) to maintain a constant radiation dose entering the image intensifier. The operator wore a 0.25 mm lead equivalent thick apron and three thermoluminescent dosimeters (Lithium Fluoride TLD 100, Regional Radiation Physics and Protection Service (RRPPS), Birmingham, England) at the following sites: beneath lead apron, left collar, and left middle finger, to measure radiation exposure respectively to the abdomen, thyroid gland, and extremities.

For each examination the type of procedure, total fluoroscopy time, total number of radiographs taken, and fluoroscopy tube voltage and current were recorded. Previous studies have estimated radiation dose emission from the x ray source directly using a DAP meter (see above) but, as in many units undertaking ERCP the equipment we used was not fitted with a DAP meter at the time of this study. We therefore estimated the emitted radiation dose indirectly from the fluoroscopic exposure time, the fluoroscopy tube current, and the number of radiographs taken. The thermoluminescent dosimeters were analysed by the RRPPS and the ED for each operator during the two month study period was calculated. These figures were extrapolated to estimate the annual whole body ED equivalent received and the data were compared with legal safety limits for maximum annual exposure as defined by the Royal College of Radiologists and the National Radiological Protection Board (Ionising Radiation Regulations, 1999; table 1).

RESULTS
During the study period 66 fluoroscopic endoscopic procedures were performed on 66 patients, of whom 61 underwent ERCP (23 diagnostic, 38 therapeutic), four underwent oesophageal procedures, and one underwent a pancreatic biopsy.

The mean (SD) fluoroscopic time was 3.55 (1.81) minutes for diagnostic and 5.67 (4.09) minutes for therapeutic ERCP. Mean fluoroscopic times for therapeutic ERCP with and without papillotomy were 5.97 (3.75) and 4.28 (3.41) minutes respectively.

Table 2 shows the mean number of radiographs taken by each operator.

Table 3 shows the estimated radiation exposure (annual ED extrapolated from two month figures as calculated by the RRPPS) to the abdomen, thyroid gland, and extremities for each operator.

Webster’s formula was then used to estimate the annual whole body ED equivalent (He):

\[
He = \frac{(1.51 \times H1) + (0.04 \times H2)}{1.48}
\]

where H1 is the annual exposure to the abdomen and H2 is the annual dose to the thyroid gland. Table 4 shows the annual whole body ED equivalent for each operator.

DISCUSSION
The findings from this prospective study suggest that the operator at ERCP is exposed to significant doses of radiation. The estimated annual whole body ED equivalent values calculated for the three consultant operators (3.35–5.87 mSv) are similar to those received by patients undergoing fluoroscopic procedures including barium studies (estimated additional lifetime fatal cancer risk between 1 in 7000 and 1 in 3500). While these values are within the legal safety limits for whole body radiation exposure to personnel, they are higher than the levels deemed acceptable for “public
visitors" (table 1). The dose limits shown are legal limits and staff who are likely to exceed 30% of any of the annual dose limits (that is, 6 mSv for whole body ED equivalent) should be designated as “classified”. All classified persons are required to wear personal dosimeters while undertaking fluoroscopic procedures and their dose and medical records should be kept centrally by the Health and Safety Executive for 50 years after the last entry.

Radiation exposure to the thyroid gland seems to be of particular concern (23.8–85.2 mSv estimated annual ED received by the three consultant operators, table 3), although the values recorded are within the legal safety limits for radiation exposure to the eyes, extremities, and other organs (table 1). Furthermore, the contribution to the whole body ED equivalent is adjusted for each tissue or organ according to Webber’s formula (see results). This formula uses a tissue weighting factor (see above) to take account of non-uniform irradiation and in particular reflects the fact that radiation exposure to particular tissues (for example, intra-abdominal organs) contributes disproportionately heavily to the total estimated additional lifetime fatal cancer risk. Thus, radiation exposure to the thyroid gland is “scaled down” by a factor of 25 while that to the abdomen is “scaled up” by a factor of 1.51.

Few data exist regarding the radiation related risks to personnel performing ERCP. It is known that the patient is a source of scattered radiation and that the radiation dose received by the operator is proportional to that received by the patient. Studies confirm that the radiation exposure to personnel undertaking ERCP is related to the duration of fluoroscopy, 4, 5 and that this exposure may be reduced by the use of protective lead shielding 6, 7 and by the use of higher voltage and lower current for fluoroscopy. 8

Larkin et al did attempt to estimate the ED of ionising radiation received by patients (but not by personnel) undergoing ERCP. 9 In that study the radiation dose emitted by the x ray source was estimated from the dose area product (DAP, Gray per cm²), measured using a transmission ionising chamber attached to the collimator box of the x ray fluoroscopy tube. The ED for each procedure was estimated from the DAP, the fluoroscopy tube voltage and current, and the number of radiographs taken. For 20 consecutive ERCPs the mean ED was 3.1 mSv (estimated additional lifetime fatal cancer risk 1 in 6700) for diagnostic and 12.4 mSv (estimated additional fatal lifetime cancer risk 1 in 1700) for therapeutic procedures. Importantly, the radiation dose received showed a linear correlation with fluoroscopy (screening) time but not with the number of radiographs taken.

The International Commission on Radiological Protection emphasises the need for carefully assessing the indication for any fluoroscopic procedure (“justification”) to ensure that the benefit of the procedure is perceived to be greater than the risk (to staff, visitors, or patients) from radiation exposure. This study suggests that personnel as well as patients can be exposed to significant levels of radiation during ERCP. Personnel during interventional ERCP at a teaching institution. Radiation exposure to patients and personnel during interventional ERCP at a teaching institution. Gastrointest Endosc 1996;44:287–92.


CONCLUSION

We suggest that personnel as well as patients may be exposed to significant levels of radiation during ERCP. We emphasise the need to carefully assess the indication for, and to use measures that minimise radiation exposure during any fluoroscopic procedure.
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doi: 10.1136/pgmj.2004.031526

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