Original Article

Radiation Exposure Affecting Anesthesia Personnel during Endoscopic Retrograde Cholangiopancreatography Is a Lead Apron Necessary for X-Ray Protection?

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Objective: To find out the amount of radiation affecting anesthesia personnel, the appropriate positions that lowers the risk of radiation exposure during endoscopic retrograde cholangiopancreaticography [ERCP], and the necessity to wear lead apron for protection.

Materials and Methods: Two hundred twenty-two patients that underwent ERCPs with sedation were allocated to the present study. Four pocket dosimeters [PDSs] were placed at points A and B, 96.5 cm and 204 cm from the fluoroscopy tube, respectively with A being PDSal and PDSa2 on the outside and inside of the lead apron-covered box, and B being PDSbl and PDSb2 on the outer and inner parts of the glass shield of the fluoroscopy control room. Data were expressed as means and standard deviations, analyzed with SPSS version 18.0. Categorical data were compared by using a Chi-square and dependent t-test. A *p*-value lower than 0.05 was considered statistically significant difference at the 95% confidence interval.

Results: The fluoroscopy average time was 13.7±14.11 minutes with a median of 10.1 minutes. The degrees of radiation at the outside and inside of positions A and B, measured at $5.3\pm7.9 \times 10^{-3}$ mSv and $0.2\pm0.6 \times 10^{-3}$ mSv, and $4.4\pm5.9 \times 10^{-3}$ mSv and $0.2\pm0.7 \times 10^{-3}$ mSv, respectively, were statistically significant different. Thus, the lead apron and glass shield prevented X-ray exposure by up to 96.2% and 95.5%, respectively, without any statistical significance. The radiation at position A and B were shown to decrease 2,000 to 16,000 and 2,500 to 20,000 times from the origin respectively.

Conclusion: The degree of radiation affecting anesthesia personnel during an ERCP was so small that a lead apron was not needed for protection. Yet, one who monitors patient sedation should stay as far as possible from sources of scattered rays since radioactive emission could yield cumulative harmful effects.

Keywords: Anesthesia, Radiation exposure, Lead apron, Endoscopic retrograde cholangiopancreatography

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Dealing with making surgeries painless for patients, anesthesiology provides continued post-operative care up to 24 hours. A team, including anesthesiologists, nurses, residents, and student nurses, works together under standard anesthesia care.

Anesthesia personnel on duty are subjected to hazardous environments, such as latex allergy, pressure, noise, chemical matters, inhalation, electrical burn, and radiation in the operating room(1,2). Radiation, in particular, has a dreadful effect for its detrimental outcomes. Unfortunately, the effect is not immediately felt, but rather, accumulate over time. Low-dose X-ray emission can cause skin rash, hair lost, vomiting, barren, or even glaucoma, while high doses can cause grave cancerous conditions and interfere with the process of baby growth and the formation of the central nervous system(3-10).

Doses of 0.2 Sv (20 rem) or above increase the cancer risk. One sievert is at the lower end of a range of doses that are likely to cause a complication such as nausea and blood changes, known as radiation sickness. Doses above 6 Grays (600 rads) are almost always fatal, leading to death within months. A chest X-ray yields 25 mrem per exposure, whereas fluoroscopy provides over 1 rem or 10 mSv. Normally, a human being should not be exposed to radiation more than 5 rem or 50 mSv per year of radiation(11).

Since fluoroscopy has been used worldwide in patients undergoing endoscopic retrograde cholangio-pancreaticography [ERCP], all medical personnel on duty are bathed by radiation. Anesthetists have become an inevitable exposure target since they have to closely

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monitor patients during interventional procedures. They are normally positioned less than one meter away from the fluoroscopy tube. Despite their wearing lead aprons and collar shields to protect themselves, the practice does not guarantee a lesser effect of exposure.

Since radiation exposure is inversely proportional to the distance between the origin and the target[12], the investigators strive to find the amount of radiation affecting anesthesia personnel and appropriate positions that ease the risk of X-ray exposure during ERCPs.

Materials and Methods

Approved by the Siriraj Ethical Committee: IRB (Si270/2558) and registered to the ClinicalTrials.gov (NCT02985164), the present study's inclusion criterion was for patients undergoing the routine ERCP procedure between September 5, 2015 and September 1, 2016 at the Siriraj GI Endoscopic Centre in Honor of Professor Vikit Viranuwatti, Faculty of Medicine Siriraj Hospital, Mahidol University. The exclusion criteria were not determined. Two hundred twenty-two cases (121 males, 101 females) were included. Informed consent was not required.

At the endoscopic unit

In the present study, a nurse anesthetist performed venous cannulation on the right forearm of each patient and then transfused the patient with 5% dextrose in ½ strength normal saline. Then, each patient was transferred to the ERCP room and had non-invasive blood pressure [NIBP], percutaneous arterial oxygen saturation [SpCE], and electrocardiogram [EKG] monitored, and administered with 3 LPM oxygen via nasal cannula.

A co-researcher prepared and reset four pocket dosimeters [PDSs] labeled as PDSal, PDSa2, PDSbl and PDSb2. PDSal and PDSa2 were placed at position A (96.5 cm from the tube) on the outside and inside of a lead apron-covered box. At position B (204 cm from the tube), PDSbl and PDSb2 were placed on the outer and inner side of the glass shield of the fluoroscopy control room respectively. Both A and B were 160 cm above the floor (Figure 1).

After an anesthesia officer administered a narcotic and an induction agent (total intravenous anesthesia, TIVA) to the patient, an endoscopist started the procedure. A co-researcher turned on all PDS devices as soon as the surgeon started the fluoroscopy, and turned it off whenever the use of the radiative source was over. When the study was completed, the PDS devices were kept in a solid and dry place, and the lead apron was hung in a specific area and covered with a bag.

The devices

As a rule, a lead apron is 0.5 mm thick on the front and 0.25 mm on the back, and a thyroid shield is 0.5 mm thick (Shielding International Inc., 2150 Andrews Drive, Madras, Oregon, USA). A paper box (30×15×10 cm) was used. A radiative dosimeter (Ludlum model 25-IS & 25-IS-l Personal Radiation Monitor, 501 Oak Street, Sweetwater, Texas, USA) bore the following characteristics:

Ludlum model: 25-IS & 25-IS-l

Radiation detected: Gamma (X-ray) typically <18 cpm per mR/hour

Beta response: Typically <0.10 mR/hour

Display range: For 25-IS: 0.01 mR/hour to 10 Sv/hour; for 25-IS-l: 0.01 mSv/hour 10 Sv/hour

Size: 7.6×5.4×1.7 cm (height × width × thickness)

Weight: 158.6 g including batteries

Linearity: Reading within 10% of true value within calibration range

Note: For equivalent doses, the unit corresponding to rads is the rem (roentgen equivalent man, R). If the absorbed dose is in grays [Gy], the unit for dose equivalent is sievert [Sv]. Thus, 1 Sv = 100 rem (or 1 mSv equals 0.1 rem) and 1 Gy = 100 rad.

Statistical analysis

Data were expressed as means and standard deviations, analyzed with SPSS version 18.0.

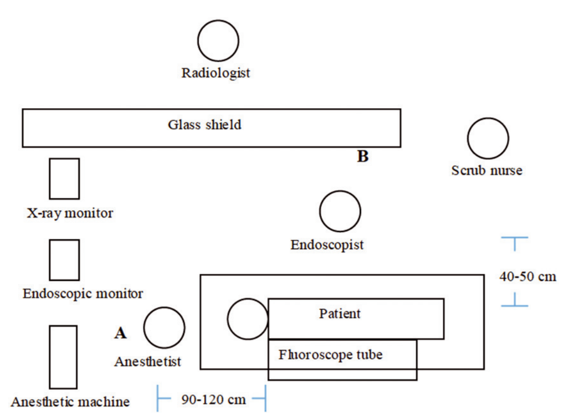

Figure 1. Floor plan in the ERCP room. In the ERCP theatre, an anesthetist stood near the patient's head, 90 to 120 cm from the fluoroscope tube. An endoscopist located on the left side of the patient, 40 to 50 cm from the tube. Position A was the lead apron-covered box, whereas position B was the glass shield of fluoroscopy control room.

Categorical data were compared by using a Chi-square test, and the recorded data, a dependent t-test. A *p*-value smaller than 0.05 was considered statistically significant difference at the 95% confidence interval.

Results

Other than average parameters such as 48.1±32.3 minutes operation time, 67.4±35.3 minutes anesthesia time, 72.8±37.9 minutes operating-room time, and 86.2±39.0 minutes recovery-room time, the average fluoroscopy time of all ERCP participants was 13.7±14.11 minutes, with a median of 10.1 minutes (Table 1).

The measured radiation amounts at the outside and inside of the shirt-covered box (A) and the glass shield (B) of 5.3±7.9 $\times 10^{-3}$ mSv and 0.2±0.6 $\times 10^{-3}$ mSv, and 4.4±5.9 $\times 10^{-3}$ mSv and 0.2±0.7 $\times 10^{-3}$ mSv, respectively, were statistically significant different ($p<0.001$) (Table 2). Thus, positions A and B prevented up to 96.2% and 95.5% of ray emission respectively. These number were statistically insignificant. The radiation at position A and B were shown to decrease 2,000 to 16,000 and 2,500 to 20,000 times from the origin, respectively.

Discussion

The present study revealed the amounts of radiation recorded on the outside of the shirt-covered box and the glass shield were significantly higher than those on the inside. Thus, the apron effectively blocked 96.2% and 95.5% respectively of emission. In addition, the fluoroscopic exposure time was 13.7±14.11 minutes, with a median of 10.1 minutes.

Table 1. Demographic characteristics of 222 (121 males:101 females) participants

	Mean ± SD
Age (year)	61.6±15.7
Weight (kg)	57.8±14.1
Operation time (minute)	48.1±32.3
Anesthesia time (minute)	67.4±35.3
Fluoroscopy time (minute)	13.7±14.11
Operating-room time (minute)	72.8±37.9
Recovery-room time (minute)	86.2±39.0

Table 2. The degrees of radiation at the outside and inside of the shirt-covered box and the glass shield

	Outside ($\times 10^{-3}$ mSv) mean ± SD	Inside ($\times 10^{-3}$ mSv) mean ± SD	Absorption (%)	*p*-value
Shirt-covered box	5.3±7.9	0.2±0.6	96.2	<0.001
Lead glass shield	4.4±5.9	0.2±0.7	95.5	<0.001

To obtain a more accurate result for scientific purposes, we applied two dosimeters to estimate the effective doses of radiation exposure as mentioned by Dumonceau et al[12]. Interestingly, our 0.5 mm aprons blocked more than 95% of scattered X-rays. This number exceeded that found by Hyun et al, who studied adult patients with degenerative lumbar disorders scheduled to undergo posterior lumbar interbody fusion, and stated that the radiation blocked by the 0.5 mm aprons was only 37.1%[13].

Our fluoroscopy time was comparable with a study performed by Heyd et al[14], who matched dosimetry for two image-captured systems and determined the effectiveness of shielding in reducing stray radiation in 72 patients undergoing ERCPs. They reported that the mean fluoroscopic exposure time was 13.6 minutes[14].

Interestingly, since fluoroscopy could provide 10 to 80 mSv for each ERCP procedure[11,15], the degrees of X-rays at the outside of the shirt-covered box and the glass shield, 96.5 cm and 204 cm from the fluoroscopy tube, were only 5.3±7.9 $\times 10^{-3}$ mSv and 4.4±5.9 $\times 10^{-3}$ mSv, respectively. Thus, the radiation at position A and B were shown to decrease 2,000 to 16,000 and 2,500 to 20,000 times from the origin, respectively. This implied that the distance from the fluoroscopic source to the target was critical in determining the degree of radiation emission. Importantly, it might be inversely proportional to the square of the gap from the X-ray tube, as mentioned by Dumonceau et al[12]. However, the present study exposure dose was significantly different from those study by Ismail et al who reported that the averaged dose to anesthetists was 0.28 mSv in the ERCP procedure[16].

Since a human being could be exposed to up to 50 mSv of radiation annually[11] and the absorbed dose for the whole body of an anesthetist was very little, the necessity of a lead apron for protection during interventional procedures was questionable. This agreed with Rhea et al, who conducted a systematic review of the degree of radiation that anesthetists were exposed to in the orthopedic operating room, and claimed that at 1.5 m from the source of radiation, anesthesia personnel received no radiation or exposure degrees so small that there was no need to wear lead protection[17]. This has become controversial, as people in many studies still recommended wearing a lead apron to protect radiation during interventional procedures[12,18].

Despite the questioned of lead-apron protection, an anesthetist at a point of care, closer to the fluoroscopy tube, was inevitably vulnerable to higher radiation exposure. Therefore, one who monitors patient sedation should stay as far as possible from sources of scattered rays. In addition, the authors supported Kong et al, who suggested that setting anesthesia devices and other monitoring equipment as far from the patient as possible to provide changed positions did not affect patient care during interventional procedures[19]. As advancement in technology, we also recommend using a portable monitoring device that proves as effective as a conventional one to be adequately arranged in the fluoroscopy control room. In addition, a ready anesthetic machine placed next to the wall of the ERCP room would allow more free space for an anesthetist to move around. This way, radiation hazards are eased, since dose reduction is a more appropriate strategy than any shelter[13].

Again, under the limit of occupational exposure of 50 mSv per year[11], while fluoroscopic time takes about 10 minutes for each procedure, an anesthetist could theoretically serve 9,000 patients a year ($50/5.3 \times 10^{-3}$ mSv) or 750 patients a month. However, workload should be given careful consideration among medical personnel working in the ERCP room, since X-ray exposure could yield cumulative harmful effects.

Weaknesses in study

Not randomizing the patient population with specific inclusion and exclusion criteria became limitations of the analytic test. Nevertheless, we recorded only the absorbed radiation dose without much concern about scattered rays in the theatre, particularly the eye lens dose.

Future studies

Future studies should verify the necessity of a lead apron for protection during interventional procedures. Not only the degree of radiation affecting anesthesia personnel as a whole, but also that affecting their eye lenses should be validated in detail. In addition, the effectiveness of a portable, modem monitoring device adequately arranged in the fluoroscopy control room should be verified for patient care.

Conclusion

Since the degree of radiation affecting anesthesia personnel was so small, the necessity of wearing a lead apron for protection during an ERCP was questionable. However, one who monitors patient sedation should stay as far as possible from sources of scattered rays, since its emission could yield cumulative harmful effects.

What is already known on this topic?

Radiation exposure has cumulative adverse effects on medical personnel. Protective equipment and distance from the emission tube can ease its sequelae. In the ERCP room, anesthetists always wear lead aprons and collar shields during interventional procedures, since they are normally positioned close to the fluoroscopy tube.

What this study adds?

In the ERCP room, the 0.5 mm lead apron effectively prevented more than 95% of scattered X-rays. The ERCP fluoroscopic exposure time was about 10 minutes. Since the degree of radiation affecting anesthesia personnel was negligible, the investigators questioned the need for wearing a lead apron for ERCP protection. However, one who monitors patient sedation should stay as far as possible from sources of scattered rays, since their emission could yield cumulative harmful effects.

During an ERCP, a portable, modern monitoring device should be adequately arranged in the fluoroscopy control room, and a ready anesthetic machine placed next to the wall of the ERCP room. This would allow more free space for an anesthetist to move around and remotely monitor patients during the interventional procedures.

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Potential conflicts of interest

The authors declare no conflict of interest.

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