Occupation-associated health hazards for the gastroenterologist/endoscopist

Emmanuel Ofori[a], Daryl Ramai[a,b], Febin John[a], Madhavi Reddy[a], Vishal Ghevariya[c]

The Brooklyn Hospital Center, Academic Affiliate of The Icahn School of Medicine at Mount Sinai, Clinical Affiliate of The Mount Sinai Hospital, New York; St George's University School of Medicine, True Blue, Grenada, W.I.; Eden Medical Center, Castro Valley, CA, USA

Abstract

Advances in the field of endoscopy have allowed gastroenterologists to obtain detailed imaging of anatomical structures and to treat gastrointestinal diseases with endoscopic therapies. However, these technological developments have exposed endoscopists and staff to hazards such as musculoskeletal injuries, exposure to infectious agents, and ionizing radiation. We aimed to review the occupational hazards for the gastroenterologist and endoscopist. Using PubMed, Medline, Medscape, and Google Scholar, we identified peer-reviewed articles with the keywords "occupational hazards," "health hazards," "occupational health hazards," "endoscopy," "gastroenterologist," "infectious agents," "musculoskeletal injuries," and "radiation." Strategies for reducing exposure to infectious agents, radiation, and the risk of musculoskeletal injuries related to gastroenterology include compliance with established standard measures, the use of thyroid shields and radioprotective eyewear, and ergonomic practices. We conclude that educating endoscopic personnel and trainees in these practices, in addition to further research in these areas, will likely lead to the development of more efficient and user-friendly workspaces that are safer for patients and personnel.

Keywords Occupational hazards, health hazards, occupational health hazards, endoscopy, gastroenterologist, infectious agents, musculoskeletal injuries, radiation

Ann Gastroenterol 2018; 31 (4): 448-455

Introduction

Endoscopists and staff are exposed to potential health hazards during diagnostic and therapeutic procedures. These include bodily and infectious fluids, exposed wires, radiation, and musculoskeletal injuries. Consistent adherence to safety protocols and practices must be followed to ensure that endoscopy personnel are protected against these hazards. The

[a]Division of Gastroenterology and Hepatology, The Brooklyn Hospital Center, Academic Affiliate of The Icahn School of Medicine at Mount Sinai, Clinical Affiliate of The Mount Sinai Hospital, New York (Emmanuel Ofori, Daryl Ramai, Febin John, Madhavi Reddy); [b]St George's University School of Medicine, True Blue, Grenada, W.I. (Daryl Ramai); [c]Eden Medical Center, Castro Valley, CA (Vishal Ghevariya), USA

Conflict of Interest: None

Correspondence to: Daryl Ramai, MD, MScBR, The Brooklyn Hospital Center, Academic Affiliate of The Icahn School of Medicine at Mount Sinai, Clinical Affiliate of The Mount Sinai Hospital, 121 Dekalb Avenue, Brooklyn, New York 11201, USA, e-mail: dramai@tbh.org

Occupational Safety Health Administration (OSHA) requires employers to assess the potential risk of each task and provide appropriate training and necessary protective equipment and apparel to reduce harmful exposure [1].

Furthermore, during gastrointestinal procedures, infectious agents may be transmitted from patients to endoscopy personnel or may spread to adjacent tissues breached during the procedures [2,3]. Meanwhile, radiation exposure from the use of fluoroscopy in procedures such as endoscopic retrograde cholangiopancreatography (ERCP) places both patients and personnel at risk for long-term injury. While the exposure to ionizing radiation during one endoscopic procedure is negligible, chronically the effect is cumulative. Moreover, gastroenterologists spend about 45% of their time performing endoscopic procedures and perform an average of 12 esophagogastroduodenoscopies and 22 colonoscopies per week [4]. This number tends to be higher in high-volume teaching institutions [4].

Concurrently, the need for ergonomic evaluation is paramount to avoiding injuries in endoscopy. Risk factors related to strain injury include repetition, prolonged awkward postures, high forces, contact stress, and vibration [5]. Survey-based studies report that the prevalence of musculoskeletal symptoms ranges from approximately 37-89%, with pain in the thumb, hands, neck, and back being the most commonly

reported [6-11]. We aimed to review the occupation-associated health hazards for the gastroenterologist and the evidence-based approaches that can be employed to minimize harm or exposure.

Materials and methods

We conducted an extensive English literature search using PubMed, Medline, Medscape, and Google Scholar to identify peer-reviewed original research and review articles using the keywords "occupational hazards," "health hazards," "occupational health hazards," "endoscopy," "gastroenterologist," "infectious agents," "musculoskeletal injuries," and "radiation." The search period included articles published from January 1, 1992 to January 18, 2018. We selected studies involving human models and manually searched the references to identify additional relevant studies.

Infectious exposure

Infectious disease exposure during endoscopy is a potential risk for both patients and endoscopic personnel. There is ample evidence of transmission of infections to patients undergoing gastrointestinal endoscopic procedures [2,3]. Patients acquire these infections via contaminated equipment, breach of mucosal integrity during the procedure spreading infection into the bloodstream or to adjacent organs, or direct transmission from endoscopy staff [3]. Bacterial transmission during gastrointestinal endoscopy was first reported in the late 20th century and the common organisms identified were *Salmonella, Pseudomonas, Klebsiella, Enterobacter, Serratia,* and *Staphylococcus* [3,12]. These infections were found to be due to lack of proper reprocessing of endoscopes; however, with the adoption of current reprocessing guidelines, the bacterial transmission has become negligible. Transmissions of hepatitis B virus (HBV), hepatitis C virus (HCV), human immunodeficiency virus (HIV), fungi or parasites have not been reported since the adoption of standard reprocessing guidelines [3,13-17].

While reports exist on HIV, HBV, and HCV transmission to healthcare professionals in other healthcare settings, endoscopy is considered low risk for infectious transmission, as there is minimal direct contact with patients' body fluids. However, if precautions are not taken, there is potential for transmission by needle-stick injury, a splash of bodily fluids or inhalation of aerosolized infectious agents. An extensive review of the literature yielded less than 10 reports on the subject, which may reflect either the rarity of infectious transmission during endoscopy or its underreporting [2,3,12,15,16,18-20].

Several reports indicate a high risk of *Helicobacter pylori* (*H. pylori*) transmission among endoscopy staff. In a study involving 122 gastro-endoscopists and endoscopic nurses, *H. pylori* infection was more common in endoscopic

personnel than the general population [19]. No statistical difference was observed with respect to sex, years involved in endoscopy or the number of endoscopies performed monthly, and the investigators concluded that *H. pylori* should be viewed as an occupational hazard. Peter *et al* reported that the incidence of *H. pylori* infection is about 2.6% per year among endoscopists [20]. The same study also reported that compared to non-medical controls, endoscopists had twice as much risk (odds ratio [OR] 1.6, 95% confidence interval [CI] 1.3-2.0) of acquiring *H. pylori* infection [19]. It is likely that the spread of *H. pylori* occurs via oral contamination by microscopic droplets of gastric juice from infected patients [20].

In a survey of endoscopy personnel, the risk of HIV transmission was perceived to be low [16]. In contrast, a study comparing controls (diarrhea and negative Clostridium difficile toxin (CDT) A and B) and cases (positive for CDT A and/or B) showed that the case-group had higher endoscopy exposure and were twice as likely to have *Clostridium difficile* (*C. difficile*) infection within 30 days (OR 2.09, 95%CI 0.98-4.75) [12]. However, the study bordered on statistical significance (P=0.58). The prevention of *H. pylori,* HIV, or *C. difficile* requires the adoption of the well-established infection control guidelines [21]. For instance, the routine use of a facemask during endoscopy has been suggested to prevent transmission of *H. pylori* [20]. Adherence to standard precautions assessed in a survey by Angtuaco *et al* found that only 46% of gastroenterologists and 60% of endoscopy nurses were compliant with standard precaution measures [14]. Survey participants reported that busy practices, interference with skills or decreased efficiency were the common reasons for non-compliance. Kuwabara *et al* reported a lack of adequate training and unavailability of personal protective equipment as reasons for reduced compliance among endoscopy personnel [22].

Decreasing infectious transmission

Adherence to current endoscope reprocessing guidelines is crucial in preventing transmission of infections [23]. Disinfection with 2% glutaraldehyde for 5 and 10 minutes is effective in eliminating *H. pylori* DNA from endoscopes [24,25]. Additionally, 2% glutaraldehyde and peracetic acid can destroy large numbers of *C. difficile* endospores during exposure times of 5-20 min [26-28]. Hand washing before and after each patient encounter, irrespective of the use of gloves, is strongly advised. Proper disposal of sharps and embracing needleless drug delivery systems can also help reduce infectious spread within endoscopy units (Table 1). Adoption of standard precautions during patient care, routine use of a facemask, the inclusion of standard precautions in the training curriculum for endoscopic personnel and ensuring the availability of personal protective gear are also paramount for minimizing infectious spread [3,21]. However, in the event of inadvertent exposure, personnel should follow hospital protocol or those outlined by OSHA and the U.S. Public Health Service.

Table 1 Measures for reducing the transmission of infectious agents

Adherence to endoscope reprocessing guidelines
Hand washing before and after each procedure
Use of gloves
Proper disposal of needles or sharps
Adoption of needleless drug delivery systems
Use of facemasks
Use of disposal aprons

Musculoskeletal injuries

Repetitive work, in addition to prolonged awkward postures associated with endoscopy place gastroenterologists at risk for overuse injuries, such as carpal tunnel syndrome, De Quervain's tenosynovitis, and lateral epicondylitis [29]. Ergonomics, however, continues to be a neglected aspect of gastro-endoscopic training and practice [30]. Only a handful of articles have been published on the subject. Furthermore, the percentage of musculoskeletal complaints surveyed by the American Society for Gastrointestinal Endoscopy increased from 57% in 1994 to 78% in 2006 and is expected to increase still further [6,31]. A survey of 684 endoscopists reported that 362 (53%) experienced a musculoskeletal injury perceived to be definitely (n=204) or possibly (n=158) related to endoscopy [32]. Reported factors associated with a higher rate of endoscopy-related injury included a higher procedure volume (>20 cases/week; P<0.001), a greater number of hours per week spent performing endoscopy (>16 h/week; P<0.001), and the total number of years performing endoscopy (P=0.004). Additionally, the most common sites of injury were the neck and/or upper back (29%) and thumb (28%).

Liberman *et al* reported injuries to the hands, fingers, neck, and back as common occurrences while performing colonoscopy [30]. Cappell described the condition of "colonoscopist's thumb," a result of repetitive abduction and extension of the left thumb in the manipulation of the colonoscope dials [33]. Another such injury of overuse is the "biliary endoscopist's knuckle" which results from the repeated advancing of biliary instruments through often narrow strictures and the tight grip used when handling the pusher catheters [34].

Other studies have highlighted accidents that resulted in musculoskeletal injuries, including crushed hand against the doorway during patient transport, head strike on mounted monitors, slip and fall on wet floors, back and wrist sprain while breaking a fall, and trip and fall over exposed wires, cords and oxygen tubing [35,36]. Moreover, it is estimated that, on average, endoscopic-related musculoskeletal injuries result in 6 lost working days and 9 restricted work days [35,36]. Thus, the need for ensuring proper ergonomic practice impacts endoscopic personnel, patients, and hospital systems.

Treatment

Treatments for the various musculoskeletal injuries sustained ranged from as simple as acetaminophen and ibuprofen therapy for a few days to as severe as open surgical reduction and fixation of fractures. Of 17 endoscopists and staff who sustained endoscopy-associated musculoskeletal injuries, 7 were treated with only acetaminophen or ibuprofen for about 5-10 days; 4 individuals had a combination therapy with acetaminophen or ibuprofen and a plaster cast or digit/wrist splinting; 1 person was treated with a knee immobilizer and 7 days of ibuprofen for her left knee contusion due to a slip and fall on a wet floor; another individual had an open surgical reduction and fixation for right-hand metacarpal and digit fractures sustained after a trip and fall over exposed wires on the floor; and another individual required hydrocodone, corticosteroid injections to a herniated disc and intensive physical therapy for back injury while positioning a patient during endoscopy [35,36]. Ridtitid *et al* reported that only 55% of injured endoscopists applied practice modifications in response to injuries [23]. Specific treatments included medications (57%), steroid injection (27%), physiotherapy (45%), rest (34%), splinting (23%), and surgery (13%).

Decreasing musculoskeletal injuries

To minimize musculoskeletal injuries in endoscopy, routine ergonomic principles should be incorporated. Endoscopy suites should be designed ergonomically to accommodate the variety of body structures of endoscopy personnel. Net neutral body positions allow for maximum force to be applied with minimal energy exertion [37]. Such net neutral body positions prevent strain and injury to body parts. During endoscopic procedures, the monitors should be located directly in front of the endoscopist at a height adjustable to the endoscopist's preference, in order to reduce strain on the back and neck [37] (Fig. 1). The procedure table height should also be adjustable to allow for neutral elbow, shoulder and back postures [17]. Shergill *et al* noted that the endoscope insertion tube should be held in the right hand and 10 cm below elbow height for effective handling [38].

Optimal interaction of the endoscopist and endoscope during procedures decreases the potential for overuse injuries. In a colonoscopy, the repetition and potential for high forces during torques and advancement of the colonoscope tip can lead to an overuse injury in the left thumb on the control dials and to the right hand as it advances the colonoscope [17]. Rex *et al* described the technique of the "left-hand shaft grip" to assist the left thumb in maneuvering sharp turns or difficult polypectomies [38]. The "left-hand shaft grip" thereby frees the right hand to help with controlling the dials and limiting excessive torqueing (Fig. 2). Additionally, Hu *et al* proposed the scissors finger, elbow, and thighs maneuvers for reduction of left-hand strain while doing a colonoscopy in a sitting position [39]. Sitting during colonoscopy reduces strain on the lower back; however, only a few endoscopists do it [8] (Fig. 3).
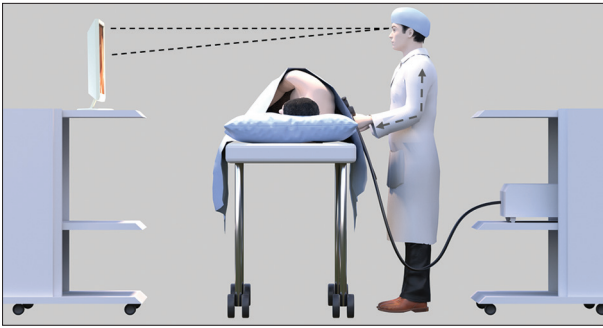
Figure 1 Schematic representation of a monitor located directly in front of the endoscopist, with the height of the patient table adjusted to reduce strain on the arms, back and neck
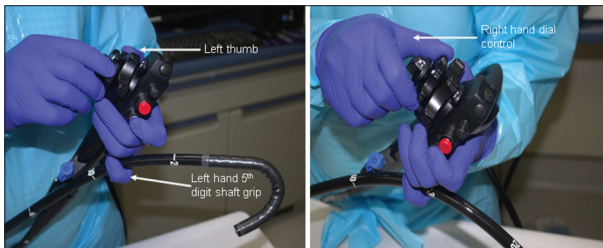

Figure 2 Left-hand shaft grip frees the right hand to assist the left thumb with dial control in maneuvering sharp turns or difficult polypectomies while limiting excessive torqueing
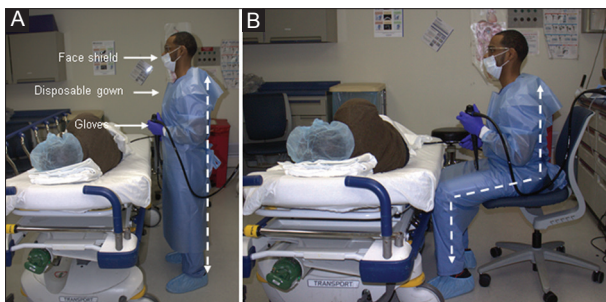

Figure 3 Gastroenterologist wearing protective personal equipment while standing (A) or sitting (B) during endoscopic procedures

In addition, ensuring breaks during multiple procedures to allow for recovery of muscle fatigue is also an important way of preventing overuse injuries [37]. Cushioned mats and insoles have been suggested to improve endoscopist's comfort during long hours of standing while performing procedures [31]. Accidental falls over exposed wires may be prevented by bundling wires, running wires from ceiling outlets or covering them on the floor with non-slip mats [35]. Additionally, the use of wireless medical devices can decrease the risk of tripping over wires in the endoscopy unit [40].

The above techniques reduce the incidence of musculoskeletal injuries to a certain extent but do not eliminate it. Thus, ergonomic endoscope design might minimize the force required to generate adequate torque. Self-propelling scopes, such as the Aer-O-Scope and the Slightline ColonoSight, and the "motor-driven" Invendo colonoscope eliminate the forces

on hands and joints associated with scope insertion, torqueing and advancement [41-43]. Conventional methods, such as reducing the colonoscope to ensure one-to-one transfer in scope advancement, can help to prevent loop formation.

ERCP radiation

Energy transmission from a source via waves or particles is generally referred to as radiation. Ionizing radiation is energy capable of interacting with electrons, which results in charged or ionized particles including alpha-, beta-, gamma- and x-rays. The human cellular injury caused by ionizing radiation has two main outcomes: 1) direct cellular damage; and 2) production of reactive oxygen species, which leads to indirect cell damage [44]. Radiation injury is dependent on the stage of differentiation, type of cell, age, and internal/external microenvironments [45]. Consequently, different tissues display varying sensitivities, as injury may result in two forms: 1) deterministic, and 2) stochastic. The most commonly encountered stochastic injuries are to the skin and lens while the most concerning deterministic injury is malignant transformation [44].

Radiation exposure from ERCP is mainly derived from the use of fluoroscopy, in which both patients and ERCP personnel are at risk [46,47]. Chronically, the cumulative effects of radiation can result in malignancies and benign conditions such as cataracts if adequate protection is not used [48]. To this end, the International Commission on Radiological Protection recommends that total body exposure not exceed 50 mSv per year [49]. The recommended limit for optic radiation by the United States Nuclear Regulatory Commission is 150 mSv.

Whole-body radiation exposure

Naidu *et al* examined 61 ERCP procedures and estimated that the annual whole-body effective dose equivalent received by endoscopists ranged between 3.35 and 5.87 mSv, doses higher than those considered acceptable for the public [50]. Additionally, the estimated radiation exposure to the thyroid gland for endoscopists was between 25.8-85.2 mSv. Sulieman *et al*, in a study involving 57 ERCP cases, reported average exposure rates of 6.2 uSv, 3.81 uSv, 27uSv and 5.4uSv for chest, forehead, hands and thyroid, respectively [51]. Buls *et al* reported 54 ERCP cases with a median dose of 0.30 mSy per procedure to the skin at the level of the thyroid and 0.44 mSv to the skin of the hands [52].

Ocular radiation exposure

The same study by Buls *et al* reported a median ocular dose of 0.34 mSv per procedure [52]. A similar study by Garg *et al* measured optic radiation exposure in attendings and fellows after 187 ERCP cases [53]. The cumulative radiation dose

absorbed per lens dosimeter was 5.35mSv for attendings and 2.55mSv for fellows. The findings project that procedure times of 59.41h for attendings and 88.17h for fellows are needed to reach the lens threshold limit (20 mSv/year) [53]. Zagorska *et al* evaluated 15 ERCP cases and reported ocular exposure between 19.4 and 25.6 mSv, values above or around the annual dose limit [54]. O'Connor *et al* reported after a six-week study that the mean dose of radiation to the left eye was 0.01 mSv, which had a projected annual dose of 1.3 mSv (based on a workload of 130 ERCP cases) [55]. Furthermore, it was noted that patient radiation exposure was significantly higher when ERCPs were performed by a low-volume provider [56]. The difference in exposure time was further augmented after adjusting for procedural complexity. Similarly, Oztas *et al* reported 110 consecutive therapeutic ERCP procedures that measured an average of 72 μSv [57]. The study deduced that an endoscopist would have to perform 1850 procedures annually to exceed the recommended limit.

Decreasing exposure

The effects of radiation exposure are further exacerbated when gastroenterologists or staff do not wear full protective clothing: protective aprons, thyroid shield, and lead glasses (Fig. 4). The studies reported above serve as a reminder of the importance of proper equipment, as well as following "as low as reasonably achievable" (ALARA) recommendations to reduce radiation exposure [58]. The fundamental principle of ALARA implies that if receiving a dose of radiation (even if small) has no direct benefit, then it should be avoided. However, if radiation must be used, ALARA measures should be followed (Table 2) [59].

While whole-body radiation can be easily reduced, the issue of optic radiation exposure remains concerning. The crystalline lens of the eye is regarded as being one of the most radiosensitive tissues in the body and the cumulative effect of optic radiation is a risk factor for the onset of cataracts [60]. To this end, academic societies such as the Cardiovascular and Interventional Radiology Society of Europe strongly advise interventionalists and staff to wear radioprotective glasses at all times [61]. However, the guidelines or current recommendations from American gastroenterology societies only suggest using radioprotection for high case-loads or with over-couch systems. The European Society of Disease Endoscopy's 2012 guideline on radiation protection recommends reducing radiation exposure by positioning the patient as far as possible from the X-ray tube, limiting fluoroscopy time, using pulsed fluoroscopy instead of continuous fluoroscopy, selecting the lowest reasonable image quality, avoiding unnecessary magnification, limiting the number of radiographic still images, and having more experienced endoscopists deal with complex cases [62].

Other factors that can affect radiation dose include the type of X-ray tube used (over-couch C-arm units vs. under-couch units), mobile vs. stationary X-rays and the total time spent in fluoroscopy during the procedure (a collinear

Figure 4 Use of protective equipment to reduce radiation exposure using thyroid shield, lead body apron, and radioprotective eyeglasses (not shown here)

Table 2 "As low as reasonably achievable" (ALARA) recommendations for reducing radiation exposure

Minimize time near a radioactive source
Maximize the distance between personnel and radioactive sources
Use a shield to protect against radiation
Use the lowest needed magnification
Keep angulation to a minimum
Use fluorosave instead of acquisition images
Add 0.1 mm Cu filtration for all protocols
Keep the detector close to the patient
Use beam collimation whenever possible

relationship) [63,64]. Additionally, radiation exposure varies according to physician education and experience, altered anatomy and various procedure-specific factors, including stent insertion, lithotripsy, taking biopsies, and the use of instruments [65-70]. An observational study from Greece reported that fluoroscopy time was prolonged by choledocholithiasis, multiple common bile duct stones, stone size greater than 10mm, needle-knife papillotomy, the presence of periampullary diverticulum and mechanical lithotripsy [71]. Recently, Johawi *et al*, in a retrospective analysis of 299 ERCPs, reported that decreasing the distance between the endoscopist and the fluoroscopy screens in the ERCP suite significantly reduced the total fluoroscopy time and therefore the radiation exposure to staff involved in the procedure [72].

Radiation can be restricted to the smallest possible area by using beam-limiting devices, including aperture diaphragms, cones and cylinders, collimators and grids [73]. Of these, collimation is the most commonly used; it functions by reducing the amount of scattering and aligning radiation waves in a single direction. Thosani *et al* reported a linear

relationship between collimation and radiation dose received during ERCP [74]. The study found that collimation reduced radiation exposure by 50%. Given the rarity of data and lack of information in this area, additional studies are needed to investigate the practical application of-beam limiting devices in ERCP.

The need to reduce the amount of radiation has led to the development of radiation-free techniques such as direct solitary cholangioscopy, endoscopic biliary sphincterotomy plus papillary balloon dilation, and endoscopic ultrasound-based ERCP [75-79]. Initial studies have demonstrated their clinical feasibility and particular relevance to pregnant women, in whom any radiation exposure should be avoided [80-81]. While these radiation-free techniques are promising, they require additional training and commitment towards the evolution of ERCP into a non-radiographic-based procedure [82].

Concluding remarks and future directions

The Centers for Disease Control and Prevention (CDC) recommend the use of personal protective equipment for anticipated exposure. However, as stated earlier, there are no endoscopy-related guidelines for the use of such equipment. Endoscopic personnel must be aware of the risks associated with gastrointestinal procedures and the interventions used. To this end, appropriate precautions should be tailored to the procedure being performed.

The CDC recommends using standard precautions, such as wearing gloves, gowns, and face shields or masks, to minimize the risk of infection. While these are very basic measures, if used appropriately they can protect endoscopic personnel from splashes, sprays of blood, body fluids, secretions or excretions [13]. Surveys among endoscopists report less than 50% compliance with universal precautionary measures [14]. The risk of mucocutaneous exposure to body fluids is greater during an endoscopy. Mohandas and Gopalakrishnan reported that mucocutaneous exposure occurred in approximately 13% of procedures or more [15]. In addition, the study reported a splash rate of 9.5% to the face, forearms, and feet, and 4.1% to the eyes [15].

Lead aprons are indicated for all endoscopy personnel in order to counteract and protect against radiation. Chen *et al* reported that the use of a protective lead shielding reduced radiation exposure from an average of 1.5 mR per diagnostic ERCP and 3.17 mR per therapeutic ERCP (without shielding) to an average of 0.25 mR per diagnostic procedure and 0.28 mR per therapeutic procedure [46]. While it is not a universal requirement, thyroid shields or guards have been shown to reduce the total body effective dose by 46% per year [83]. To avoid ocular damage, recent studies by Garg *et al* recommend the use of radioprotective eyewear by physicians and fellows exposed to radiation for more than 59.4h and 88.2h, respectively [53]. More robust precautions should be taken in centers that utilize more advanced imaging or endoscopic procedures.

Ergonomic measures aimed at reducing strain and other related injuries should be tailored to meet the needs of endoscopists. No study has evaluated interventions to reduce the risk factors associated with endoscopic musculoskeletal injuries. However, lessons and principles can be applied from other workplace interventions. A pilot study reported that a 1-piece lead apron was associated with significantly more neck and lower back discomfort compared with a 2-piece lead apron [84]. Softer flooring has been subjectively associated with less fatigue and reduced lower extremity and back discomfort [85]. A similar finding was reported for the use of insoles [86]. Compression stockings can also offer a potential benefit to personnel with chronic venous insufficiency, or during prolonged standing [87]. However, none of these interventions have been objectively tested in an endoscopic suite. The practicality of certain interventions also warrants further study and discussion.

Acknowledgment

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