

## CLINICAL REVIEW

OPEN

Review of Musculoskeletal Injuries and Prevention  
in the Endoscopy Practitioner

Glenn Harvin, MD

**Abstract:** Practitioners of endoscopy often experience musculoskeletal pain and injury (most often in the back, neck, shoulders, hands, wrists, and thumbs) that are associated with the minute and repetitive strain that is placed on these areas during endoscopic procedures. This review of the current documentation of endoscopy-related pain and injuries among practitioners finds that such problems are widespread and specific in kind as well as strongly correlated with high procedure volume and procedure duration. Research on the nature and impact of cumulative trauma and overuse syndromes in other professions such as dentistry, pianists, production labor, and athletics is brought to bear on the work of the endoscopist. A more thorough understanding of the nature and prevalence of work-related pain and injury sustained by endoscopists should inform further development of ergonomic practices and equipment design. This article reviews current recommendations for ergonomic design in the endoscopy procedure space and finds that reported compliance with those recommendations is quite low. Strategies for the management of the risk of musculoskeletal injuries related to the practice of endoscopy include compliance with currently recommended ergonomic practices, education of trainees in ergonomic technique when practicing endoscopy, and research toward the modification and development of more ergonomic endoscopes and procedure spaces.

**Key Words:** musculoskeletal injury, ergonomics, endoscopy, cumulative trauma disorders, occupational diseases

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The practice of endoscopy exposes physicians, nurses, and technicians to multiple documented risks such as potential contact with infectious agents through bodily fluids (blood, respiratory secretions, and stool), needlesticks, and radiation exposure. Fortunately, research has well understood the exposure risks for endoscopists to pathogens such as HIV, hepatitis B, hepatitis C, *Helicobacter pylori*, *Salmonella*, and others and has proved such exposure to be most often preventable. What is less well understood, and what this article will discuss, is the potential for musculoskeletal injuries that are particular to those working in endoscopy.

Musculoskeletal pain has been shown to affect up to 20% of adults in the general population and to heavily burden the workforce through both direct and indirect

costs.<sup>1</sup> Reporting on the cost and prevalence of musculoskeletal pain in the workplace can be elusive as there has been shown to be a cultural variant in the ways work-related pain and injury are perceived and reported, even within the same occupation.<sup>2</sup> The association of particular musculoskeletal complaints in particular occupations such as production laborers, physical therapists, pianists, athletes, and others including laparoscopic surgeons and dentists has been studied.<sup>3–9</sup> Musculoskeletal injuries related to endoscopy have been much less studied. Gastroenterologists in the United States perform, on average, 12 endoscopies and 22 colonoscopies per week according to a survey,<sup>10</sup> although other surveys have reported much higher procedural demands, including a Korean study reporting 270 endoscopic procedures per month.<sup>11</sup> As procedural demands are unlikely to decrease for gastroenterologists, recognition of the potential for injuries is an extremely important step toward the discovery of preventative practices. The repetitive and cumulative nature of the physical maneuvers involved in the work of an endoscopist is spread over his or her career. For a gastroenterologist who hopes to practice for 30 years or more, understanding and prevention of injuries is very important, and well-informed ergonomic practices should be integrated into the teaching of endoscopic technique during fellowship.

## SEARCH CRITERIA

A comprehensive search conducted on Ovid Medline 1946 to present using the keywords “endoscopy” and “occupational diseases” yielded 192 articles with limits for “English language” and “Humans” resulting in 148 articles. A search of “endoscopy” and “cumulative trauma disorders” yielded 75 articles. A search of “endoscopy” and “musculoskeletal diseases” yielded 39 articles. All the articles were reviewed and duplicates were removed, resulting in a total of 236 articles. These articles were individually reviewed resulting in a total of 62 articles that were relevant to the topic. Each of their bibliographies were reviewed to evaluate other relevant articles.

## PREVALENCE

Musculoskeletal complaints are extremely common among gastroenterologists. Studies have reported the prevalence of musculoskeletal pain or injuries to range from 29%<sup>12</sup> up to 89%<sup>11</sup> (other studies 43%,<sup>13</sup> 39%,<sup>14</sup> 74%,<sup>15</sup> 67%<sup>16</sup>). Other frequent injuries or pain reported included low back pain (6% to 27%), thumb pain (5% to 19%), shoulder pain (9% to 32%), elbow pain (8% to 15%), hand pain (9% to 17%), neck pain (9% to 28%), and hand numbness (12%).<sup>11–17</sup> Other injuries noted have included cervical disk and carpal tunnel. In a survey of colorectal surgeons performing colonoscopy, 6 of 226 physicians

From the Brody School of Medicine at East Carolina University, Greenville, NC.

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Reprints: Glenn Harvin, MD, Brody School of Medicine at East Carolina University, 521 Moye Boulevard, Greenville, NC 27834 (e-mail: [harving@ecu.edu](mailto:harving@ecu.edu)).

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required surgery for colonoscopy-related injuries including cervical disk and carpal tunnel.<sup>14</sup> These musculoskeletal complaints have been shown to both bother the endoscopist at work and interfere with their work: a total of 84.6% in one study reported that they were bothered by their condition at work and 37.8% reported that the pain interfered with work and other activities.<sup>17</sup> The musculoskeletal pain to endoscopists has been shown not only to be frequent but in some cases severe: in a survey of musculoskeletal complaints of Korean endoscopists, 89% reported musculoskeletal pain in at least 1 site with 47% reporting severe musculoskeletal pain.<sup>11</sup> Other injuries such as carpal tunnel syndrome were seen and were believed to be the result of the right hand torquing the shaft of the colonoscope.<sup>14</sup> Overall, musculoskeletal complaints and pain are common among endoscopists, frequently involving the low back, shoulder, thumb, elbow, hand and neck, sometimes severe, and have been shown to interfere with work and other activities.

Injury and pain can lead to loss of productivity and can possibly shorten a career. Because even general information regarding physician disability pertaining to gastroenterology is considered proprietary to insurance carriers, very little is written about short-term and long-term disability from physician injuries related to endoscopy. In a survey of Korean endoscopists, 16% reported modifying their practice or reducing the number of procedures secondary to musculoskeletal pain.<sup>11</sup> Many of these studies likely underestimate the presence of severe disabilities as they were sent to active gastroenterology and surgical society members and do not capture disabled practitioners who have dropped out of the workforce. In a Mayo clinic survey of gastroenterologists/hepatologists, 13% reported missing days of work and 2/72 of the gastroenterologist/hepatologists reported long-term disability from their endoscopy-related pain or injury.<sup>15</sup>

### RISK FACTORS

Of particular concern to endoscopists are musculoskeletal injuries associated with cumulative trauma and overuse. Work-related factors that have been associated with cumulative trauma disorders include repetition, high force, awkward joint posture, direct pressure, vibration, and prolonged constrained posture.<sup>18</sup> Overuse syndromes have been recognized in laborers and athletes and are often due to repetitive microtrauma leading to collagen failure and damage to connective tissues leading to further weakening of the tissues.<sup>17</sup> These can lead to permanent injury if the tissue is not allowed to heal.<sup>17</sup>

Maneuvers specific to endoscopy such as adjusting tip angulation controls, torquing with the right hand, and standing for prolonged periods are known to contribute to musculoskeletal pain and injury and are noted as possible causes of thumb/finger/hand pain/injuries and back/neck pain/injuries.<sup>15</sup> Some studies have shown that the thumb pain, hand pain, elbow pain, low back pain, and possibly shoulder pain seemed related to performing more endoscopies and to greater hours spent performing endoscopy.<sup>17</sup> In a survey of surgeons there was a risk of injury of 47% for those who performed >30 colonoscopies per week.<sup>14</sup> Others have not shown an association between endoscopic procedural time or procedural numbers and injuries,<sup>13,15</sup> which differs from other reports.<sup>14,16,17</sup> Some have theorized that perhaps this was due to previously injured

endoscopists decreasing their procedural volume in response to their injury.<sup>15</sup>

In the Korean study, the most commonly reported areas of pain during procedures were the right shoulder, followed by left shoulder, left finger, and then right wrist.<sup>11</sup> It is significant that the average age reported in this study was 39 years with median of time in practice as 39 months, that is, early in their career. Elbow pain is often seen on the right with thumb and hand pain seen on the left reflecting the maneuvering of the left hand in holding the endoscope and manipulating the wheels while the right hand is used to advance and torque the scope.<sup>17</sup> Long periods of standing and the often-awkward positioning required of the endoscopist can lead to back pain, which is frequently reported as reported in the studies above. Prolonged standing, bent-over postures, and twisting and bending movements increase forces on the spine and have been associated with low back pain.<sup>16</sup> Other injuries such as carpal tunnel syndrome were seen and were believed to be the result of the right hand torquing the shaft of the colonoscope.<sup>14</sup>

In a survey of ERCP endoscopists, very high rates of back pain (57%), neck pain (46%), and hand pain (33%) were observed with 79% reporting being bothered by their symptoms while performing ERCP.<sup>16</sup> A study looking at injuries among ERCP endoscopists showed a higher proportion of injuries in the physicians who have been practicing ERCP longer and who performed more procedures per year.<sup>16</sup> ERCP often entails longer procedure times, unusual positioning, and the added stress of protective lead aprons. It also has the added stress of the elevator on the left thumb. Low back injury has been shown to correlate with lead aprons.<sup>19,20</sup> Often ERCP rooms are radiology room that were not originally designed for this purposes and have poor ergonomic design and lack height-adjustable tables.<sup>16</sup> Some ERCP endoscopists continue to wear a one-piece lead apron, which has been shown to induce higher pressure on the intervertebral disks and has been associated with more disk disease and more back pain.<sup>20,21</sup>

A number of injuries have been described that are specific to the practice of endoscopy. One is "endoscopist's thumb," or DeQuervain's tenosynovitis of the left thumb due to repeated abduction and extension of the left thumb to manipulate the dials of the colonoscope.<sup>22</sup> Another is a traumatic arthritis of the right metacarpophalangeal joint of the right hand producing a joint deformity known as "biliary endoscopist's knuckle" due to repeatedly pushing biliary prostheses through tight strictures and the tight grip required on the pusher catheters.<sup>23</sup> Other issues including left sided thumb, hand and wrist pain, as well as carpal tunnel syndrome have been noted.<sup>17</sup>

Activity of the left abductor pollicis longus muscle and the left and right extensor carpi radialis muscles during colonoscopy has been observed to exceed the American Conference of Industrial Hygienists hand activity level action limit.<sup>24</sup> This same study determined the hand forces and muscle loads experienced during colonoscopy and shows the right thumb peak pinch force often exceeding 10 N, a threshold that is associated with increased risk of injury to the thumb and wrist.<sup>24</sup> It also demonstrated that the pinch forces and forearm muscle activity generated during colonoscopy pose a risk for overuse injuries of the elbow and wrist.<sup>24</sup> Others have looked at the forces generated during colonoscopy to include push forces up to 4.4 kg (9.7 lb) and up to 1.75 N m of clockwise torque.<sup>25</sup> In addition, as many endoscopists have changed from

note-dictation to the typing of electronic medical records, higher numbers of carpal tunnel syndrome may result. Computer work has been shown in some studies to have an increased risk of carpal tunnel syndrome, as well as the risk of neck, shoulder, and upper back musculoskeletal disorders.<sup>26,27</sup>

In studies that have differentiated between male and female physicians, female physicians tended to report more pain and more severe pain. It has been noted that hand size is a significant determinant of difficulty using laparoscopic surgical instruments.<sup>28</sup> Other studies have considered hand size as a factor in the performance of endoscopy. In a survey among endoscopists in fellowship, 41% reported that they consider their hand size to be too small for standard endoscope handles.<sup>29</sup> Sixty-three percent of respondents to this survey with a glove size < 6.5 would opt for an endoscope with smaller handle if available compared with 28% of those with a large glove size.<sup>29</sup> Ninety-seven percent of the respondents with small hands were women. Many of the fellows from this study believe that hand size affects their ability to learn (78%) and perform (62%) endoscopy. These findings raise important questions regarding the ergonomics of procedural rooms and the design of the endoscope itself.

## PREVENTION

Studies regarding ergonomic practices in endoscopy facilities show poor compliance overall. Only 30.6% of GI subjects in the Hansel study, above, made any changes to their endoscopic practice; only around one third stood on cushioned mats, only 43% wore athletic shoes during endoscopy, and only 5.6% took scheduled breaks during endoscopy.<sup>15</sup> In a study that looked at the ergonomics of ERCP facilities, 67% had poor ergonomics, and despite the majority (64%) of respondents being interested in an ergonomic evaluation of the endoscopy unit, only 1% actually had the evaluation completed.<sup>16</sup>

Standards for ergonomic practices recommend procedural mats to decrease stress on the lower back. Monitor height needs to be adjusted around 15 degrees below the horizontal visual field to decrease the neck strain.<sup>30</sup> The optimal monitor distance has been estimated between 52 to 182 cm (20.5 to 63.8 inches) depending somewhat on monitor size.<sup>31</sup> The monitor should be located directly in front of the endoscopist at a height that allows the neck to remain in neutral position.<sup>32</sup> The bed height needs to be adjusted to allow the colonoscope shaft to be held by the right hand between elbow height and 10 cm below elbow height to allow neutral positions of back, elbow, and shoulders.<sup>31</sup> Adequate break time between procedures allows for recovery and potentially reduces injuries.<sup>32</sup> With ERCP, split lead aprons help to distribute the weight over the hips and less on the neck/lower back. Lighter weight 2-piece lead aprons have been shown to decrease the pressure on the lumbar and cervical spine, which can apply a load as high as 300 lb per square inch to the intervertebral disk space with 1-piece aprons.<sup>21</sup> Fluoroscopy and endoscopy monitors should be positioned to prevent torsion of the neck. Proper positioning of the fluoroscopy and video monitors so that the operator's eyes are  $\frac{3}{4}$  way up the screen has been recommended to minimize eye strain and neck torsion.<sup>16</sup>

Other injuries have been documented including tripping on exposed wires, hands crushed against doorways

when moving patients, slips/falls on wet floors/spills, and musculoskeletal injuries related to turning patients.<sup>33</sup> Some of these injuries are at least partially inherent to the designs of the procedure rooms. Doors should be widened to easily accommodate beds up to 43 inches wide, and 2 staff should be utilized to move heavier patients.<sup>25</sup> Studies have documented injuries from tripping over cords/cautery cords, oxygen tubing, etc.,<sup>33,34</sup> which accounts for an estimated 450 to 600 falls/year in the United States.<sup>34</sup> Nonslip flooring should be utilized. Pneumatic beds that require repetitive pushing on a pedal to raise the bed could be switched to electrical to minimize repetitive strain on assistants and physicians. Floor padding to reduce pressure on the spine during standing has also been recommended.<sup>16</sup> Ergonomic design in the workplace is shown to be paramount in the prevention of low back injuries on the job.<sup>35</sup> Others have suggested bundling wires, covering wires on the floor with a nonslip mat, and running wires from ceiling outlets to equipment above the ground.<sup>34</sup> Designs in the future may need to utilize wireless capability to minimize the risk of tripping over cords/wires.

Studies of workers whose professions, like the practice of endoscopy, place them at a high risk of neck pain have shown a protective benefit from exercise. Workers who exercised or engaged in sporting activities had a better prognosis and were more likely to recover from neck pain than their nonexercising colleagues,<sup>36</sup> and exercise has been shown to help prevent neck pain in office workers.<sup>37</sup>

The 3 factors that have been shown to contribute the most to pain and injury with endoscopy are manipulation of the angulation controls, torqueing with the right hand, and prolonged standing.<sup>15</sup> These are 3 of areas that should be targeted with prevention.

Although ergonomic positioning along with adequate breaks are likely to reduce some back and neck injuries, hand and wrist injuries due to the repetitive nature of procedures that involve torqueing of the scope and turning of the dials must be addressed in other ways. Maneuvers such as the "left-hand shaft grip" and "pinkie maneuver" free the right hand to assist with turning of the dials while stabilizing the shaft of the colonoscope.<sup>31</sup> With the "left hand shaft grip," the fourth and fifth fingers of the left hand hold the shaft of the scope freeing the right hand to assist with turning the knobs.<sup>38</sup> Some have suggested performing colonoscopy in the sitting position and assisting with the stabilization of the scope through the SET (scissors finger, elbow, thighs) maneuver.<sup>39</sup> Although sitting is a potential option to reduce strain on the low back, it is not commonly performed (4.2% in one study).<sup>15</sup> Although techniques such as these can help, there are still limited options for reducing forces encountered by the hands and wrists during procedures, and this opens the way for more ergonomically designed endoscopes.<sup>30</sup> This is more important for colonoscopy than for upper endoscopy, considering the longer procedural times and the higher forces generated during the procedure including advancement of the scope and torqueing of the shaft. Scopes such as the Aer-O-Scope and the Sightline ColonoSight that are self-propelled and the "motor-driven" Invendo colonoscope that are not "pushed" into the colon will eliminate many of the forces that occur with torqueing and insertion of the endoscopes.<sup>40-42</sup> Other technologies such as the computer-assisted NeoGuide colonoscope utilizes sensors that form a computerized map of the colonic during insertion and maintaining these curves as the scope is advanced

potentially decreases looping and tension forces in the colon.<sup>43</sup> Although many of these technologies under development are likely aimed at trying to eliminate the need for sedation or make advancement of the scope easier for the proceduralist, they will possibly decrease the musculoskeletal strain to the endoscopist. Some have expressed concern that motorizing hand-controlled movements would rob endoscopists of the “feel” that is important for accuracy and precision in endoscopy.<sup>44</sup> Other technologies under development include capsule endoscopy or even the robotically controlled capsule endoscopy.<sup>45</sup> When endoscopists have been asked how to improve endoscopic design, many requested a smaller and lighter operating part to the scope with smaller angulation controls with less resistance.<sup>13</sup>

Proper procedural technique to minimize strain as mentioned has been documented in studies, but little instruction is provided at most institutions during training. This is important as procedural technique during training is likely to carry over long term during an endoscopist’s career. Not only do fellowship programs need to focus on competency, but a trainee’s emerging technique should be critiqued from an ergonomic standpoint in an effort to decrease the repetitive injuries that are associated with the work of an endoscopist. This has led for the call to establish ergonomic guidelines for GI endoscopy.<sup>46</sup>

### CONCLUSIONS

Practitioners of endoscopy do sustain the risk of particular musculoskeletal injuries, and this risk is documented. The risk is shown to be heightened by the volume of procedures performed and by lengthier procedures. It is notable that several joint-injury syndromes, “colonoscopist’s thumb” and “biliary endoscopist’s knuckle” have been identified because of their particular prevalence among endoscopists. The most common problems reported are low back pain, shoulder pain, elbow pain, hand pain, and neck pain. These are shown to correlate with the minute, repetitive and strenuous maneuverings required to perform endoscopic procedures and the high force exerted on joints and connective tissues through these maneuvers. Research on overuse syndromes in similar professions is brought to bear on injuries sustained by practitioners of endoscopy. Documented pain and injuries range in severity among practitioners surveyed, but the high prevalence, early emergence, and negative impact on productivity presented by these problems make the issue worthy of attention from GI physicians, GI physician-educators, and administrators of endoscopy labs.

Once recognized, this risk can be addressed and minimized as other risks that affect health care providers in GI labs have been addressed with much success. This review finds that the management of the risk of musculoskeletal injuries related to the practice of endoscopy falls into 3 categories: compliance with currently recommended ergonomic practices, education of trainees in ergonomic technique when practicing endoscopy, and research toward the modification and development of more ergonomic endoscopes and procedure spaces and toward the better accommodation of practitioners with smaller hand sizes.

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