The Need for Ergonomics Training in Interventional Pulmonary Fellowship

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The study of ergonomics and its relation to medicine has gained importance over the past decade in various medical and surgical specialties. Ergonomics is defined as the study of the interaction and efficiency between a person and their workplace (1). With the increase in technological advances in medicine, including the more frequent use of robotics and growing need for procedures, it is more important now than ever to emphasize ergonomics in the medical workplace (1, 2). Although the ergonomic relationship between procedures in surgical specialties and gastroenterology have been explored, there is a paucity of data outlining ways to improve ergonomics in bronchoscopy (3–6).

The need for ergonomic advancement in bronchoscopy has been defined before. In 2011, an online survey was sent to pulmonologists regarding pain during bronchoscopy, with 39% of respondents experiencing pain (7). In 2012, an editorial was published identifying either the need for improved bronchoscope design or further efforts toward an improved work environment for

(Received in original form August 5, 2023; accepted in final form October 24, 2023)

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This article has a data supplement, which is accessible at the Supplements tab.

ATS Scholar Vol 5, Iss 1, pp 45–52, 2024

DOI: 10.34197/ats-scholar.2023-0098BR

pulmonologists performing bronchoscopy (8). Finally, in 2013, another survey was distributed to members of the American Association for Bronchology and Interventional Pulmonology, which revealed that musculoskeletal pain was present in 51% of respondents, of which 49% were interventional pulmonary (IP) trained (9). Despite these findings, further research in the education of bronchoscopy ergonomics is lacking.

Here, we present the results from a survey of IP fellows and program directors (PDs) to assess the need for ergonomics education early in bronchoscopy training.

METHODS

Survey Design

Two preliminary surveys were developed by C.D., P.S., and M.M. The survey instruments were constructed using Research Electronic Data Capture (REDCap) and approved by our local institutional review board (10). The IP fellow survey was conceptualized based on the principles of physical ergonomics, a domain of ergonomics focused on mitigating work-related injuries through workplace design and evaluation (11). Three primary ergonomic risk factors known to cause work-related injuries, including high force, awkward posture, and high or long frequency, were emphasized in the survey design. The survey framework was further supported by prior ergonomic questionnaires in the bronchoscopic and endoscopic literature (9, 12). A separate two-item questionnaire was designed for fellowship PDs. The PD was considered a highly experienced operator, for whom prior survey-based studies have already established the prevalence and practice implications of bronchoscopy-related injuries (7, 9). The primary focus of the PD survey was to determine whether or not ergonomics was perceived as important or applicable in bronchoscopy and if fellowship programs were formally incorporating training in bronchoscopy ergonomics.

An initial survey draft was reviewed by multiple faculty members and fellows within the Department of Pulmonary and Critical Care Medicine at University Hospitals Cleveland Medical Center. Iterative changes in question flow, content, and length were made based on their feedback. The survey was then reviewed by members of the Association of Interventional Pulmonary Program Directors. The feedback of all investigators including junior and senior IP faculty, Pulmonary and Critical Care Medicine and IP PDs, and fellows, was incorporated into a final version of the survey. At the conclusion of the 2022 fellowship appointment year, the Association of Interventional Pulmonary Program Directors e-mailed surveys to 51 IP fellows and 63 PDs across North America. Two reminder e-mails were sent 1 week apart.

Statistical Analysis

All participant responses were collected anonymously. Descriptive statistics were performed using R software version 4.1.3 (13).

RESULTS

Demographics, Procedure Volume, and Training Techniques

Sixteen trainees (31.3%) completed the IP fellow survey. Most fellows (68.8%) reported spending between 31 and 50 hours per week performing bronchoscopy. In addition, most fellows (62.5%) estimated spending >90% of their time using robotic bronchoscopy during peripheral lung biopsy. Nearly all trainees (87.5%) reported not having a designated break period. Half of fellows indicated receiving training in posture awareness (Table 1).

Table 1. Fellow survey responses

Participant demographics and procedure volume	
Characteristic	
Male	13 (81.2)
Female	3 (18.8)
Height, cm	175.44 ± 8.40
Weight, pounds	172.27 ± 26.12
Glove size	7.12 ± 0.43
Hours per week performing bronchoscopy	
10–20	2 (12.5)
21–30	3 (18.8)
31–40	5 (31.2)
41–50	3 (18.8)
>50	3 (18.8)
Number of flexible bronchoscopies per week	
10–20	7 (43.8)
21–30	4 (25)
31–40	4 (25)
>50	1 (6.2)
Number of EBUS per week	
<10	3 (18.8)
10–20	11 (68.8)
21–30	2 (12.5)
Number of navigational bronchoscopies per week	
<10	11 (68.8)
10–20	4 (25.0)
21–30	1 (6.2)
Number of rigid bronchoscopies per month	
<5	5 (31.2)
6–10	7 (43.8)
10–15	4 (25)

Table 1. *Continued.*

Preferred navigational bronchoscopy platform in fellowship training, %	
Robotic bronchoscopy	
10–30	1 (6.2)
30–50	2 (12.5)
50–70	2 (12.5)
70–90	1 (6.2)
>90	10 (62.5)
Electromagnetic navigation	
<10	13 (81.2)
10–30	2 (12.5)
30–50	1 (6.2)
Extended working channel without EMN	
<10	15 (93.8)
10–30	1 (6.2)
Thin or ultrathin bronchoscope	
<10	9 (56.2)
10–30	5 (31.2)
30–50	1 (6.2)
70–90	1 (6.2)
Techniques taught during bronchoscopy training	
Posture awareness	8 (50)
Adjustment of bed height	12 (75)
Adjustment of monitor height and/or position	10 (62.5)
Special maneuvers to reduce the risk of musculoskeletal pain or injury	3 (18.8)
Stretching or strengthening activities to reduce the risk of musculoskeletal pain or injury	1 (6.2)
Design of bronchoscopy suite or workspace	
Bed height	
At waist level	9 (56.2)
Below waist level	7 (43.8)

Table 1. *Continued.*

Monitor height	
Above eye level	6 (37.5)
At eye level	9 (56.2)
Below eye level	1 (6.2)
Monitor location	
Centered	5 (31.2)
Off-center right or left	6 (37.5)
Not applicable because of multiple monitors	5 (31.2)
Fellow-driven interventions to improve workplace efficiency	
Adjustment of bed height	15 (93.8)
Adjustment of monitor height and/or position	9 (56.2)
Use of rotational head during flexible bronchoscopy	12 (75)
Use of bronchoscope holder/stabilization system	1 (6.2)
Sitting when performing rigid bronchoscopy	2 (12.5)
Stretching or strengthening exercises	5 (31.2)
Cushioned floor mats	3 (18.8)
Use of orthopedic or soft insole shoe	6 (37.5)
Use of brace or supportive prosthetic device	1 (6.2)
Use of compression stockings	4 (25)
No adjustment	1 (6.2)

Definition of abbreviations: EBUS = endobronchial ultrasound; EMN = electromagnetic navigation.
N = 16 respondents. Summary statistics are presented as mean ± standard deviation or *n* (%), as appropriate.

Assessment of Bronchoscopy-related Injuries, Workspace Design, and Fellow-Driven Interventions to Improve Workplace Efficiency

Twelve fellows (75%) reported experiencing pain related to performing bronchoscopy (Figure 1). The most common sites of pain were the left thumb (37.5%) and lower back (31.2%). The median number of pain sites was 2.5 (interquartile range, 0.75–4). Two fellows (12.5%) reported taking time off or reducing the number of bronchoscopies performed because of pain. Most fellows reported adjusting the bed height (93.8%) and/or monitor location (56.2%) and use of the rotational head (75%) during flexible bronchoscopy (Table 1).

Fellows' and PDs' Perceptions of Ergonomics Training in Bronchoscopy

Twenty-five PDs (39.6%) completed the PD survey. All fellows, together with 96% of PDs, agreed or strongly agreed with the question, "Do you think ergonomics is important or applicable in bronchoscopy training?" Five PDs (20%) reported incorporating ergonomics training for bronchoscopy in their fellowship programs.

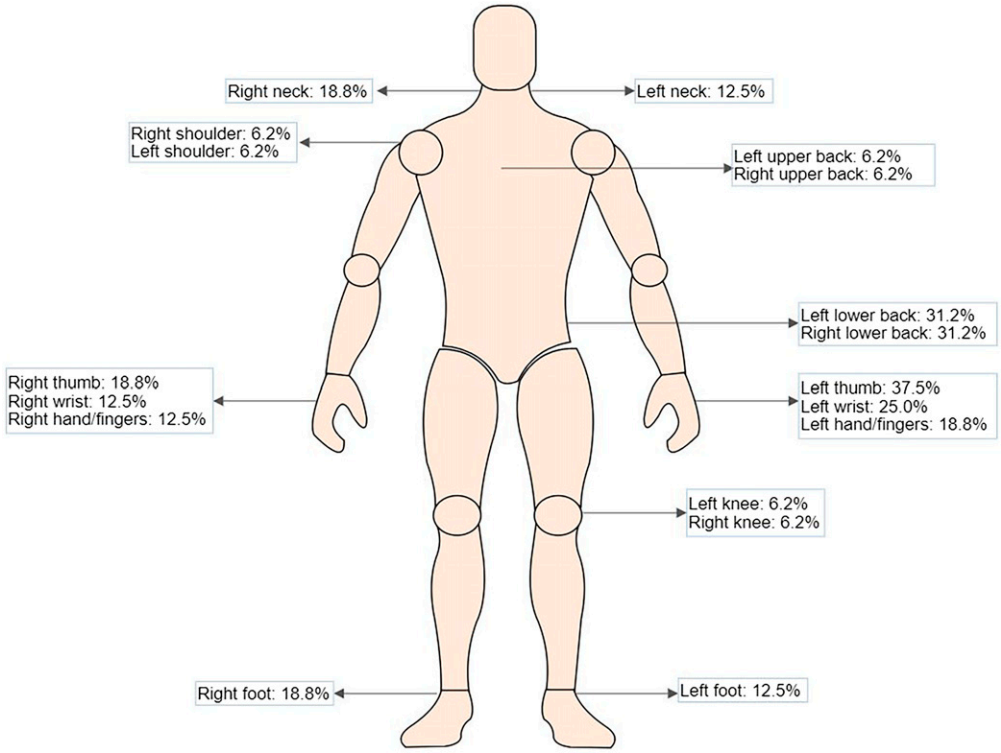

Figure 1. Fellow-reported sites of bronchoscopy-related pain.

DISCUSSION

This cross-sectional survey is the first to describe the high prevalence of bronchoscopy-related injuries among IP trainees. The percentage of respondents endorsing procedure-related pain surpasses that of other survey-based studies in bronchoscopy ergonomics, a finding likely attributed to the experience level of our cohort (7, 9). Gilbert and colleagues identified younger age and fewer years in practice as risk factors for bronchoscopy-related musculoskeletal pain (9). The same group illustrated in a feasibility study of ergonomic strain that beginner-level bronchoscopists demonstrated greater muscle usage and worse ergonomic positioning (14). The results of our survey support the observation that novice bronchoscopists appear more susceptible to procedure-related injuries.

How Do We Prevent Bronchoscopy-related Injuries?

A systematic approach to mitigating the risk of work-related injuries is recommended by the National Institute for Occupational Safety and Health (15). The "hierarchy of ergonomic controls" outlines the most- to least-effective methods of reducing or eliminating hazards in the workplace. The least-effective strategy involves personal protective equipment or modifying the bronchoscopist's technique. Eliminating or substituting the hazard from the process, in this case the bronchoscope, is the preferred method of reducing risk to the operator. The following lists each ergonomic control, in order of effectiveness, applied to bronchoscopy (3–6, 16):

1. Elimination: Redesigns the bronchoscope to fit all users

2. Substitution: Replaces the technology (e.g., robotic bronchoscopy)
3. Engineering controls: Isolates the hazard through changes in the *workplace* (e.g., adjustable monitors and beds) or *work process* (e.g., bronchoscope stabilization system)
4. Administrative controls: Modifies the duration, intensity, or frequency of the hazardous exposure (e.g., scheduled breaks, equipment maintenance)
5. Personal protective equipment: Protects the worker from the hazard (e.g., anti-fatigue floor mats, insoles, two-piece lead apron)

Limitations

There are some limitations to our work. The small sample size limited our analysis of factors that might increase or reduce the risk of procedure-related pain. In addition, inherent to the design of any survey-based study, there is the potential for biases, including participation bias (17); however, even if we considered a scenario where all nonresponders denied pain, there is still nearly one-quarter of IP fellows who are experiencing injuries related to performing bronchoscopy. Finally, because participants are not followed over time, we cannot estimate the incidence of developing long-term injuries.

Conclusions

These survey data provide further evidence that procedure-related musculoskeletal pain is common among bronchoscopists and occurs as early as fellowship training. The practice of interventional pulmonology is physically demanding, underscoring the importance of instilling proper ergonomic technique early in bronchoscopy training. It is incumbent on program educators to standardize the teaching of ergonomics in bronchoscopy to trainees. By adopting these principles, the program will cultivate a culture of safety and prevention that is likely to span the bronchoscopist's career.

Acknowledgment

The authors thank the Association of Interventional Pulmonary Program Directors for distributing this survey. They also thank the fellows and program directors for their tireless commitment to advancing the specialty of interventional pulmonology.

Author disclosures are available with the text of this article at www.atsjournals.org.

REFERENCES

1. Stone R, McCloy R. Ergonomics in medicine and surgery. *BMJ* 2004;328:1115–1118.
2. Mansoor SN, Al Arabia DH, Rathore FA. Ergonomics and musculoskeletal disorders among health care professionals: prevention is better than cure. *J Pak Med Assoc* 2022;72:1243–1245.
3. Matern U, Faist M, Kehl K, Giebmeyer C, Buess G. Monitor position in laparoscopic surgery. *Surg Endosc* 2005;19:436–440.
4. Shergill AK, McQuaid KR. Ergonomic endoscopy: an oxymoron or realistic goal? *Gastrointest Endosc* 2019;90:966–970.
5. Park AE, Zahiri HR, Hallbeck MS, Augenstein V, Sutton E, Yu D, *et al.* Intraoperative "micro breaks" with targeted stretching enhance surgeon physical function and mental focus: a multicenter cohort study. *Ann Surg* 2017;265:340–346.
6. Scheidt S, Ossendorf R, Prangenberg C, Wirtz DC, Burger C, Kabir K, *et al.* The impact of lead aprons on posture of orthopaedic surgeons (in German). *Z Orthop Unfall* 2022;160:56–63.

7. Brar N, Miller J, Brito V, Ilowite J, Chawla S. Bronchoscopy and overuse injury [abstract]. *Chest* 2011;140:492A.

8. Nair GB, Chawla S, Ilowite JS. Ergonomics in bronchoscopy: is there a need for better design or a change in the work environment? *Expert Rev Respir Med* 2012;6:1–2.

9. Gilbert CR, Akulian JA, Feller-Kopman D, Yarmus L. Ergonomics and bronchoscopy: a survey of the American Association of Bronchology and Interventional Pulmonology. *J Bronchology Interv Pulmonol* 2013;20:113–120.

10. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap): a metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform* 2009;42:377–381.

11. Bridger RS. Introduction to human factors and ergonomics, 4th ed. Boca Raton, FL: CRC Press; 2018.

12. Pawa S, Martindale SL, Gaidos JKJ, Banerjee P, Kothari S, D'Souza SL, *et al.* Endoscopy-related injury among gastroenterology trainees. *Endosc Int Open* 2022;10:E1095–E1104.

13. R Core Team. R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing; 2021 [accessed 2023 Jul 24]. Available from: https://www.R-project.org/.

14. Gilbert CR, Thiboutot J, Mallow C, Chen A, Pastis NJ, Argento AC, *et al.* Assessment of ergonomic strain and positioning during bronchoscopic procedures: a feasibility study. *J Bronchology Interv Pulmonol* 2020;27:58–67.

15. The National Institute for Occupational Safety and Injury (NIOSH). Hierarchy of controls. 2015 [accessed 2023 Jul 19] Available from: https://www.cdc.gov/niosh/topics/hierarchy/default.html.

16. Speed G, Harris K, Keegel T. The effect of cushioning materials on musculoskeletal discomfort and fatigue during prolonged standing at work: a systematic review. *Appl Ergon* 2018;70:300–314.

17. Wang X, Cheng Z. Cross-sectional studies: strengths, weaknesses, and recommendations. *Chest* 2020;158:S65–S71.