ADVANCES IN ENDOSCOPY

Current Developments in Diagnostic and Therapeutic Endoscopy

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Ergonomics in Endoscopy

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G&H What is the study of ergonomics as it relates to endoscopy?

AS Ergonomics is the study of how work affects people, and it takes into account physical and cognitive factors in order to design jobs that best fit within human capabilities as well as limitations. In other words, rather than forcing an individual to fit into a job, a job is designed to suit an individual. Endoscopy ergonomics focuses on understanding the endoscopist's interaction with the endoscope and endoscopy unit and redesigns endoscopic tasks to minimize the risk of endoscopy-related injury.

G&H How prevalent are endoscopy-related injuries?

AS Data on this topic are mostly survey-based, with the oldest surveys dating back to the 1990s. The number of survey respondents who report experiencing some injury that they perceive to be related to endoscopy ranges from 37% to 89%. Although this is a wide range, it is fair to say that endoscopy-related injuries are quite common.

G&H What are the risk factors for these injuries?

AS Risk factors for injury can be extrapolated from the ergonomics literature, where there is evidence for causal relationships between certain physical work factors and the development of work-related musculoskeletal disorders. The main factors relevant to endoscopy that predispose individuals to developing work-related musculoskeletal disorders are awkward posture, high force, static loads, and repetition. In endoscopy, holding and manipulating the endoscope repetitively throughout the day requires nonneutral postures and high forces, and introduces biomechanical risk factors. Those elements, combined with an endoscopy suite that has not been designed with the user in mind (eg, the monitor might be too high or off to the side), can predispose endoscopists to injury.

G&H What are the limitations of the current endoscope designs?

AS Despite technical advances made to the endoscope over the years, the basic design of the endoscope's control section and insertion tube has remained relatively unchanged since the 1980s. The biggest limitation right now is that endoscopes have a one-size-fits-all design. For example, I use the same endoscope as my male colleagues despite the differences in our hand size and hand strength. Because we are holding and manipulating endoscopes that were not designed with the range of physician hand sizes and strength in mind, some physicians may have to assume an awkward posture in order to reach the dials of the control section. This can be particularly problematic for female endoscopists. The control sections of the endoscope may be too big to be held comfortably by the smaller female hand size, and the resulting nonneutral postures decrease force

generation ability. However, in terms of sheer muscle mass and muscle strength, women are already at a disadvantage. Men in general have over 20 pounds more muscle mass than women do, and women on average have approximately 50% to 60% of the strength of men. Ninety percent of females have a maximal pinch force that is less than 95% of males. Lastly, females at their strongest, at 20 to 30 years of age, are only as strong as 70- to 80-year-old males.

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Research has been able to demonstrate high-risk exposures for both the right and the left upper extremities during routine colonoscopy. Muscle loading for the right and left forearms is in the moderate- to high-risk category, and the thumb forces required to manipulate the dials and insertion tube during colonoscopy result in high-risk exertions. Interestingly, the pattern of biomechanical exposures appears to be different for male vs female endoscopists, and suggests female endoscopists guide the insertion tube by supplementing dial control by their left thumb with torque control by the right hand. It is not known if this can be accounted for by differences in hand size, with smaller hands having greater difficulty in reaching the right or left dial.

In short, the endoscope is poorly designed and, when considering biomechanics and anthropometrics, potentially places female endoscopists at greater risk of injury.

G&H How can the design of endoscopes or endoscopy suites be improved to incorporate endoscopists' safety?

AS One of the basic principles of ergonomics is to incorporate a user-centered design that accommodates the breadth of its users, rather than employing a one-size-fits-all approach. Ideally, new endoscope control sections would be designed to accommodate the hand span and hand strength of a 5th-percentile female as well as a 95th-percentile male. The difficulty in designing the endoscope control section lies with incorporating both the anthropometrics and the biomechanics of the end user. If anthropometrics are not taken into account in the design process, not only is the user forced to awkwardly hold the tool or instrument, but this results in suboptimal biomechanics.

With respect to the endoscopy suite, equipment that is designed to be adjustable would allow endoscopists to alter the height and position of the monitor and patient bed in order to attain a neutral posture. The monitor should be placed directly in front of the endoscopist at or below eye height to minimize neck and upper body rotation, and the patient bed should be placed at or slightly below elbow height to minimize upper body flexion or upper extremity abduction.

G&H What are the challenges of implementing new endoscope designs, and what steps can be taken to overcome them?

AS Several endoscope companies have researched potentially redesigning the endoscope, and the main issue with adopting a new design into practice is physician willingness to relearn how to perform endoscopy. Despite the challenges, most physicians learn to perform endoscopy proficiently, and muscle memory is a huge factor in that. When companies test new designs, endoscopists often struggle to perform the procedure with the new design and then prefer to work with the standard design, regardless of how poorly it may have suited them. The learning curve associated with the new technology or instrument seems to be a major barrier to acceptance.

A colleague and I wrote an article in which we delved into the idea of what is needed for the field to accept a new type of endoscope design, especially one that is designed with the physician in mind. We describe that, depending upon the technology and physicians' interaction with it, there are essentially 4 categories that a new tool or technique can fall into: one that uses the current technology with the same hand-tool interaction as past tools, one that employs the same technology but implements a different hand-tool interaction, one that introduces new technology but relies on current hand-tool interaction via muscle memory, or one that uses new technology with new hand-tool interaction. Incremental changes that build on muscle memory while at the same time optimizing hand-tool interactions are likely to be the easiest to introduce to and receive acceptance from physicians, hopefully opening the door for techniques and hand-tool interactions that mitigate and eliminate the risks associated with performing endoscopy.

G&H What techniques or strategies can endoscopists or practices implement to minimize the risk of endoscopy-related injuries?

AS There are several strategies that can be used to minimize the risk of developing work-related musculoskeletal disorders. In ergonomics, there is a framework called the hierarchy of controls, which is used to determine effective methods of mitigating the risk of work-related injury. At the top of this hierarchy are elimination and substitution, or figuring out how to physically remove or replace the hazards that are associated with performing endoscopy. The premise is "prevention through design." These types of controls are necessarily delegated to endoscope and device companies, and require taking into account the anthropometrics and biomechanics of the end user.

The next most effective control is engineering controls, which can be applied to the endoscopy suite design and controls for the endoscope, such as the dial controls. The endoscopy suite should be engineered such that it can accommodate that 5th-percentile female as well as that 95th-percentile male. This includes requiring monitors that can be adjusted to the different resting eye heights of the users, providing adjustable beds, and ensuring that endoscopists begin their procedures in as neutral a position as possible. Use of the endoscope can be improved by optimizing hand-tool interaction and incorporating right-left dial adaptors for endoscopists who have difficulty reaching the right-left dials, or endoscope support stands to decrease the static load of the endoscope. Also, decreasing the time spent during a procedure will decrease exposures and mitigate risk. For instance, use of a cap during colonoscopy has been shown to decrease cecal intubation time, and certain distal scope attachments have been shown to reduce withdrawal time without affecting adenoma detection rate.

The next layer is administrative controls, which focuses on changing the way people work. In regard to endoscopy, this can involve proactively maintaining the endoscopes for optimal performance, implementing an ergonomic training program for all staff, and ensuring that providers take an ergonomic timeout before starting a procedure. During an ergonomic timeout, endoscopists should take a moment for themselves to neutralize their postures and adjust the monitor and bed to the proper height. This allows them to start a case in the most comfortable position possible.

Thinking about how the workday as well as the work week is scheduled is also important. A recent survey of endoscopists from the American Society for Gastrointestinal Endoscopy (ASGE) found that endoscopists are currently spending over 40% of their work week performing endoscopy. When this survey had been conducted in the 1980s, most endoscopists were spending less than 40% of their time performing endoscopy. Despite more time being spent in the endoscopy unit, there is a lack of data to inform endoscopists about the optimal number of endoscopic procedures to perform per day. Most of the studies conducted to date that have looked at physician performance have correlated it to outcomes related to patients, such as physician fatigue and adenoma detection rate. No studies have evaluated physician fatigue and the risk of work-related musculoskeletal disorders, making it difficult for providers to understand what an optimal work week should look like. The aforementioned ASGE survey found that only 10% of endoscopists were regularly taking breaks, and approximately one-third of endoscopists were never taking breaks. The best advice that can be given is to make sure to build a rest period into the workday, including microbreaks during the procedure. Most importantly, endoscopists should give themselves enough time between endoscopy sessions in order to fully recover. For example, endoscopists should not start their second endoscopy session of the week while still recovering from their first endoscopy session, as they risk straining their muscles and ligaments, which can lead to degenerative changes, inflammation, and potentially injury.

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Lastly, at the bottom of the hierarchy of controls is the endoscopist. Anything that is left to the individual to implement falls into the category of personal protective equipment and will be the least effective in controlling exposures. Unfortunately, it is often left to the providers to figure out how to lessen their own risk. During cases, endoscopists can try to optimize their technique by having a colleague observe and provide feedback regarding their postures and how they are holding and manipulating the control section and insertion tube. They can consider using antifatigue mats or cushioned insoles to decrease the static loading on the lower extremities, and use compression stockings if they anticipate prolonged

standing. Between cases, endoscopists can consider stretching exercises.

G&H How can the principles of ergonomics be incorporated during fellowship?

AS According to earlier survey-based studies, less than 10% of fellowship programs were incorporating a formal ergonomics curriculum into their training. More recent surveys suggest that that number has since increased, but is still less than 50%. It is imperative to introduce ergonomics as a concept to fellows so that they understand the importance of neutral postures and minimizing force. More work is needed to understand how best to teach and train in endoscopy. Although it is still unclear what the optimal technique is, teaching fellows the technique that best suits their hand span and ability to manipulate the endoscope is going to be necessary.

G&H Are there any designs or innovations in development that may improve endoscopic ergonomics in the future?

AS This is a really exciting time because with the development of disposable endoscopes, people are seeing the potential for designing endoscopes that are more customizable or modifiable for the end user. Some companies have looked at novel control mechanisms or different propulsion systems, and there are even wireless-controlled capsules. There is a lot of activity in this field, but we are still a long way from having something that is ready for widespread implementation that can be accepted by all endoscopists.

Disclosures

Dr Shergill serves as a consultant for Boston Scientific and has received a research gift from Pentax.

Suggested Reading

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