



Ergonomics in the Development and Prevention of Musculoskeletal Injury in Interventional Radiologists

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Interventional radiology is a constantly evolving specialty overlapping with multiple other specialties, including cardiology, vascular surgery, orthopedic surgery, urology, and minimally invasive surgery. Unique ergonomic considerations for interventional radiology include utilization of intraoperative viewing monitors and personal radiation protection equipment. Work-related injuries are common in interventional radiologists,¹ often leading to pain while performing procedures or during time away from work. This review article aims to identify the ergonomic challenges related to interventional radiology and provide background, guidelines, and specific recommendations for prevention of musculoskeletal injury.

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Introduction

Injuries in Interventionalists

Interventional radiologists specialize in minimally invasive procedures utilizing ultrasound, computed tomography, and fluoroscopic guidance. Aside from the inherent risks of surgery and the operating room setting, such as injuries from sharp instruments, interventionalists have the added concern of specialized and complex angiographic suites. The routine use of imaging guidance places the interventionalist at risk for ergonomic strain and specific workplace injuries.

Recurrent radiation exposure is the most obvious and studied risk to the interventionalist population. Time-tested adages of interventional radiology include radiation time minimization, distance, and shielding. However, this type of universal education and recognition has not been developed for interventional ergonomics.

Current evidence connects interventionalists to a high prevalence of orthopedic injuries (Tables 1 and 2), particularly in the spine. These injuries are thought to be secondary to the daily use of personal protective garments. Additionally, it has been theorized that high daily ergonomic demand and poor angiographic suite design continues to contribute to an elevated risk of orthopedic complications.

Injuries in Interventional Cardiologists

Early insights into orthopedic injuries within the interventional population came from interventional cardiology literature. Interventional cardiologists (IC) predominately use fluoroscopy and experience similar mechanical stressors as interventional radiologists (IR), due to the routine use of personal protective garments. In the IC cohort, spinal complaints were the most common. About 42% of IC surveyed, with greater than 10 years of experience, developed lumbosacral or cervical spine problems.² In addition to the high prevalence of spinal injuries, 28% of interventionalists complained of hip, knee, or ankle problems. IC physicians who reported hip, knee, or ankle problems also had increased rates of spinal complaints. About 33% of those with spinal complaints also stated that their spinal disease had caused absences at work. A statistically significant ($P < 0.05$) relationship was noted

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Table 1 Orthopedic Complications in Interventionists

Study	Methods	Findings
Ross et al ⁶	Survey of interventional cardiologists (852 surveys, 385 responses), orthopedists (577 surveys, 131 responses), and rheumatologists (978 surveys, 198 responses)	Increased spine problems in interventionists (75% incidence) vs orthopedists and rheumatologists
Goldstein et al ²	Survey of 1600 interventional cardiologists (424 responses)	Prevalence of orthopedic complaints: spine, 42%; hip, knee, ankle, 28%; spine problem limited work in one-third
Machan ¹	Survey of interventional radiologists (308 responses)	60% reported spine complaints; spine problems limited work in 25%
Moore et al ³	Survey of 608 radiologists (236 responses)	50% prevalence of back pain

between the number of years performing invasive procedures and the likelihood of having spine problems.

Extrapolation to Interventional Radiology

Preliminary studies in the IR literature^{1,3} suggest that the IC literature is directly applicable. In a survey of 308 IR physicians,¹ approximately 20% of the respondents reported lumbar or thoracic pain while 24% endorsed neck pain. These injuries limited their ability to work.¹ In the same study, appropriate positioning of fluoroscopy monitors was found to help prevention of neck pain. Appropriate positioning of monitors included maintaining the operator's neck in the neutral position.

Recently, ergonomics literature in IR has focused on specific procedures, such as hepatic artery arteriography and biliary stenting.⁴ This article noted that neuromuscular fatigue is an important ergonomic concern causing improper catheter movement. In addition to the known stressors of lead garments, IR physicians must also combat eyestrain secondary to dim lighting, impaired maneuverability of operators and devices due to room design, and neuromuscular fatigue (particularly

of the hands and back). IR physicians, anecdotally, have complained of repeated ergonomic strain at the beginning of most procedures due to an unfavorable arrangement of the ultrasound system. Poor posture is exacerbated by lack of intuitive usability and standardization of devices.⁴

Spinal Disease in Interventionalists

Back pain is a common medical problem affecting the US population. In a 2012 survey of Americans aged 18 and over, 27% of respondents had experienced back pain in the past 3 months.⁵ The rate of back pain was higher in advanced ages than younger cohorts. The rates of neck and back disease are increased in interventional physicians. The idea of "interventional disc disease" was first proposed in the late 1990s.⁶ This study compared work-related injuries and trends of disease among different specialties, such as rheumatology, orthopedic surgery (OS), and IC. IC physicians were significantly more likely to report axial skeleton complaints. Additionally, the greatest frequency of missed work days secondary to back and neck pain was found in IC physicians. Increased neck and back pain in IC

Table 2 Ergonomics in Surgeons

Study	Methods	Findings
AlQahtani et al ¹⁶	Survey of Canadian orthopedic trauma surgeons (593 surveys, 86 responses)	67% of respondents reported a musculoskeletal disorder, of which 27% required time off work. Most common complaint was low back pain (26.7%) followed by wrist/forearm tendinitis (17.4%). Age and caseload had no association with prevalence of injury.
Davis et al ²⁰	Survey of Tennessee Chapter of the American College of surgeons (793 surveys, 260 responses)	40% of surgeons reported at least one or more workplace injuries. 22% of injured surgeons missed work. 53% of injured surgeons stated pain from injury had at least a minimal effect on OR performance
Wauben et al ⁸	Survey of minimally invasive European surgeons and residents (1292 surveys, 284 responses)	80% of respondents reported neck, shoulder, or back discomfort. 89% of surgeons were unaware of proper ergonomic recommendations.
Sutton et al ⁹	Survey of currently practicing laparoscopic surgeons and fellows (2,000 surveys, 314 responses)	86.5% of female surgeons attributed physical discomfort to laparoscopic operating. Female surgeons are more likely to undergo treatment for their hands (odd ratio 3.5). Female surgeons with the same glove size as their male counterparts reported significantly more neck, shoulder, and upper back pain.

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