



Society of Interventional Radiology: Occupational Back and Neck Pain and the Interventional Radiologist

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ABBREVIATION

LBP = lower back pain

INTRODUCTION

Interventional radiology is a unique specialty that involves vascular and nonvascular procedures involving virtually every patient population. Currently, most interventional radiologists perform several procedures per day, some lasting hours, and also typically provide on-call coverage for hospitals 24 hours a day, 7 days a week. The physical demands are distinctly different from those of diagnostic radiology, as interventional radiology requires standing while wearing heavy personal protective garments, performing technically complex procedures, moving equipment, and changing positions to accomplish the task at hand. An interventionalist who has spent a career providing procedural care for patients and is affected by occupational musculoskeletal problems ought to be able to refer to a corresponding topic-specific societal document. As no such official Society of Interventional Radiology (SIR) document exists, it is hoped that this document will fill that void.

Standing occupations are associated with higher levels of low back pain (LBP) compared with sitting occupations (1). In addition, the use of ionizing radiation requires personal protection, typically in the form of heavy protective garments. This, combined with standing for most of the day and performing procedures with repetitive motions in awkward positions, has been associated with occupational neck and back pain (2). Whereas the hazards of radiation and bloodborne pathogen exposure are well established (3–5), the musculoskeletal

consequences of a career in interventional radiology are less well recognized. The purpose of this review is to discuss the epidemiology and risk factors for neck and back pain in interventional radiologists, briefly review the topic of disability coverage, and present options for the prevention and treatment of pain associated with the practice of interventional radiology.

EPIDEMIOLOGY

Back pain is a very common problem, with a worldwide mean overall prevalence of 31% (6). Comparing studies of LBP is challenging because of the heterogeneity of the methods used and the varied prevalence periods reported (6,7). Published studies have shown that the point prevalence of LBP ranges from 9.4% to 33%, the 1-year prevalence ranges from 22% to 65%, and the lifetime prevalence ranges from 11% to 84% (6–8) (Table 1). With a global point prevalence of 9.4%, LBP ranked highest in terms of years lived with disability and sixth in terms of overall disease burden (8).

Neck pain is also very common (8,9), with an overall prevalence range in the general population of 0.4%–86.8% (mean, 23.1%), a point prevalence range of 0.4%–41.5% (mean, 14.4%), and a 1-year prevalence range of 4.8%–79.5% (mean, 25.5%) (9). With a global age-standardized point prevalence of 4.9%, neck pain ranks fourth in terms of overall disability and 21st in terms of overall disease burden (8).

LBP is the most common workplace musculoskeletal disorder (10). Worldwide, it is estimated that 37% of LBP is occupational. Work-related LBP has been estimated to cause 818,000 disability-adjusted life-years lost annually (11). As such, LBP is an economically important problem in industrialized societies. The prevalence among interventional radiologists is less well understood. Moore et al (12) surveyed 688 radiologists (response rate, 34%) to investigate the possibility of a link between lead apron use and LBP. Although their data did not show a statistically significant association, back pain was reported by 52% of those who used lead aprons frequently. Machan and Haskal (13) performed a Web survey of interventional radiologists, with 308 respondents. A total of 60.7% reported occasional neck or back pain. Work as an interventional radiologist was limited by back pain (20.1%) and neck pain (24%) among respondents.

The prevalence of neck and back pain has also been studied in other specialties whose work conditions are similar to those of the interventional radiologist, most notably interventional cardiology. Ross et al (2) performed a comparative survey among interventional cardiologists who wore protective garments and stood throughout most of the day, orthopedic surgeons who stood during procedures but did

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Table 1. Prevalence of Back Pain (6–8)

Prevalence Type	(%)
Mean overall	31
Point	9.4–33
1-y	22–65
Lifetime	11–84

not frequently wear protective garments, and rheumatologists who stood only briefly during their work day. Axial skeletal symptoms were reported significantly more often by the interventional cardiologists than by other physicians, with 52.7% of the interventional cardiologists requiring treatment for neck and back pain symptoms, versus 40.5% of orthopedists and 31.8% of rheumatologists ($P < .0001$). In addition, the percentage of respondents reporting missed days from work secondary to back or neck pain was greatest in the cardiologists (21%) compared with the orthopedists (11%) and rheumatologists (14%; $P < .002$) (2). Ross et al (2) coined the phrase “interventionalist’s disc disease,” referring to the increased occupational hazard of back pain related to the rigors of the interventional practice. Of note, the prevalence of cervical disc disease was much greater in the cardiologists (6.5%) than in the orthopedists (0.3%) and rheumatologists (0%) (2).

The prevalence of LBP and neck pain among interventional cardiologists (14,15), interventional electrophysiologists (16), and endoscopists (17) is summarized in Table 2 (2,12–17). The incidence of orthopedic problems has been shown to increase with age and the number of years in practice performing invasive procedures (14,15). Of note, the incidence of musculoskeletal pain has recently been found to be highest in the ancillary staff, with technologists (62%) and nurses (60%) reporting higher incidences than attending physicians (44%) and trainees (19%) (18). This may be related to a more constant exposure to physical stresses among the ancillary staff (18).

RISK FACTORS

The relationship between the physical demands of work and LBP are complex and inconsistent (19). As a result, the relationship has been difficult to measure. Although associations can be identified, true causation is difficult to demonstrate because of the prevalence of neck and back pain and the complex biologic, psychologic, and social influences involved (19,20). Causes of LBP are multifactorial, with age, sex, genetics, obesity, environment, and occupation each playing a role (21,22). Occupational factors that are associated with LBP include rapid work pace, repetitive motion patterns, insufficient recovery time, heavy lifting, other forceful manual exertions, nonneutral body postures, mechanical pressure concentrations, bending, twisting, vibration, and low temperature (11,19). Specific factors that are associated

with back pain in interventionalists include repetitive motion patterns, insufficient recovery time, prolonged standing, axial loading of the spine, and awkward body postures (1,2,11,16,23). A survey among surgical specialists (who also spend most of their day standing in the operating room) found that the lifetime prevalence of LBP was 84.8%, with the most prevalent aggravating factors being prolonged standing, repeated movements, and awkward postures (85.2%, 50.2%, and 48.4%, respectively) (24).

Cervical pain is associated with the use of ceiling-mounted monitors and the repetitive head and neck movements required to view these monitors while performing invasive procedures (flexion, extension, lateral rotation, and lateral flexion) (2,16). In the study by Ross et al mentioned previously (2), a significant difference in the prevalence of cervical disc disease was noted between the interventional cardiologists and the other two groups ($P < .001$). Twenty-five cardiologists and one orthopedic surgeon reported cervical disc herniation, with all being lead apron-wearers. In their discussion, Ross et al (2) postulated that this is a result of a combination of the increased axial load from the protective garments and the need to alternate viewing between interventional devices and patient monitors, with resultant repeated extension and rotation of the cervical spine. Birnie et al (16) also speculated that the higher incidence of cervical spondylosis identified in electrophysiologists was secondary to poorly positioned monitors in the interventional suite, requiring repetitive spine rotation to view multiple monitors.

Animal and epidemiologic studies have supported the concept that repetitive motion and overuse can accelerate cervical spondylosis (25–27). Rabbits exposed to repetitive neck extension and flexion showed early development of osteophytes (25). A study of patients with movement disorders supports the relationship between repetitive motion and the development of degenerative changes. For example, patients with dystonic cerebral palsy and a long history of involuntary cervical spine movements show the development of cervical spondylosis and secondary myelopathy (26). In addition, motion analysis of patients with athetoid cerebral palsy, who have a characteristic high-velocity “whip” movement of the cervical spine, found that this repeated bending of extraordinary magnitude was a precipitating factor for premature disc degeneration and osteophyte formation (27).

The heavy shielded garments for protection from ionizing radiation increase axial loading, which may be a significant contributor to LBP. It has been estimated that a 15-pound lead apron can exert a load of 300 pounds per square inch on the intervertebral discs (28). A multisite case-control study by the Mayo Clinic (18) surveyed 1,543 employees, including technologists, nurses, attending physicians, and trainees, who were involved with procedures that use radiation. These employees reported musculoskeletal symptoms more often than the control group (54.7% vs 44.7%; $P < .001$). Two factors significantly associated with work-related pain were having more time per week exposed to radiation (median, 15 vs 5 h/wk; $P < .001$) and more time using lead aprons (median, 4 vs 1 h/wk; $P < .001$) (18).

Table 2. Prevalence of LBP and Neck Pain among Interventional Radiologists, Interventional Cardiologists, Interventional Electrophysiologists, and Endoscopists (2,12–17)

Study	Specialty	LBP (%)	NP (%)	Both (%)	Control*(%)
Moore et al (12)	Radiologists	52	–	–	46
Machan and Haskal (13)	Interventional radiologists	–	–	60.7	–
Ross et al (2)	Interventional cardiologists	–	–	52.6	40
Goldstein et al (14)	Interventional cardiologists	70	40	42	–
Klein et al (15)	Interventional cardiologists	34.4	24.7	–	–
Birnie et al (16)	Interventional electrophysiologists	25.9	20.7	–	16.7 (LBP), 5.5 (NP)
O’Sullivan et al (17)	ERCP endoscopists	57	46	–	–

ERCP = endoscopic retrograde cholangiopancreatography; LBP = low back pain; NP = neck pain.

*Minimal or no protective garment requirement.

DISABILITY ASPECTS

The repetitive stress injuries described here result in missed days of work, self-imposed reduction of time in the interventional laboratory, and even reclassification as a diagnostic radiologist (18,29). Alternatively, the interventional radiologist may choose to adjust their workflow to include more ultrasound (US)- or magnetic resonance (MR) imaging-guided procedures, which do not require protective garments. Although this may be an easy transition for younger interventional radiologists, older and more experienced interventional radiologists may be unable to adapt their established duties or recreate themselves as diagnostic radiologists.

Following an acute back injury, restricted activity may require the worker to take paid sick leave. For more prolonged periods of recovery, provisions under the Family Medical Leave Act apply in the United States. The Family Medical Leave Act allows a maximum of 12 work-weeks of unpaid leave in a 12-month period for any serious health condition rendering the employee unable to perform his or her job (30).

If chronic musculoskeletal or spinal conditions render an employee unable to work, long-term disability programs can provide benefits to the worker. In the United States, Social Security insurance will provide benefits for spine disorders, but only under highly restricted conditions (www.ssa.gov/disability/). Similarly, the workman's compensation program provides benefits for lost wages, reimbursement for medical bills, and compensation for permanent or partial disability caused by workplace injuries. Workman's compensation has been successfully applied to workers injured by repetitive stress injuries, including back problems, carpal tunnel syndrome, and neck pain caused by repetitious use of certain muscles and tendons injured as a result of awkward posture (31–33). In exchange for such payments, the worker forgoes the right to sue his or her employer for negligence unless the injury was intentional.

In addition, an interventional radiologist may obtain private disability insurance, which may cover a physician who becomes unable to practice his or her subspecialty. These are known as “own-occupation” policies and provide specific coverage for an individual's particular occupation. Enrollment in such policies, however, does not ensure disability coverage for musculoskeletal or spinal stress injuries (personal communication, J.D.S., April 13, 2015).

PREVENTION

There now is a growing body of evidence to support the link between neck and back pain and working as an interventionalist (1–3,11–16,18,29,34,35). As previously mentioned, the incidence of neck and back pain increases with hours of apron use and years of practice, and may be the result of a combination of axial load (ie, prolonged standing in protective garments), awkward or poor posture (necessitated by leaning or bending to accomplish procedures), and repetitive injury accumulated over years of practice (14,15,36,37). The interventional radiologist may not be aware of his/her posture while performing complex procedures. As a result, the interventional radiologist may spend long periods of time in an awkward position capable of causing pain (10). These contributing factors for back and neck injury may be compounded by common preexisting causes of mechanical neck and back pain such as spondylosis, spondylolisthesis, disc disease, and facet arthropathy (38), and by age-related changes in the muscles, vertebrae, and intervertebral discs (19).

Several steps can be taken to prevent or mitigate back pain for the interventional radiologist. The most basic method of prevention is to identify and stop performing the activity responsible for the pain. Although changing work/rest schedules and avoiding certain interventional procedures may not be practical, the simple act of taking a break between long cases can interrupt the cycle of pain. Eliminating repetitive painful motions is crucial for pain management. Physicians with pain should avoid moving patients if at all possible, as this has been linked with back injury in health care workers (39–41). Operators

should always consider alternative guidance, as the use of US or MR guidance eliminates the need for protective aprons.

The SIR Safety and Health Committee (part of the SIR Standards Division) is interested in recognizing and ultimately reducing the orthopedic risks inherent to the interventional radiology community. In 2005, SIR joined with cardiology and other specialty groups to form the Multispecialty Occupational Health Group (3). This group authored a position statement in 2009 that was published in the radiology and cardiology literature (35) calling for hospitals and industry to invest in equipment that reduces radiation exposure and enhance the ergonomic and functional design of interventional suites.

Procedure rooms should be designed to foster proper ergonomic positioning of the equipment with respect to the operator and patient (35). This will decrease the risk of posture-related and repetitive-stress injuries. Monitors should be positioned within the physician's direct field of view to prevent unnatural positioning of the operator's head, neck, and shoulder during the case (2,15,35). C-arms and other imaging equipment should be positioned to allow the operator to stand comfortably, without bending, leaning, or reaching. Expansion monitors can eliminate awkward viewing positions in instances when the C-arm must be positioned between the physician and the ceiling-mounted monitors.

Floor space should be clear to allow the operator to change positions during the case, eliminating the strain of standing in a fixed position for prolonged periods. Some authors advocate the use of a footstool to allow for simple change in posture during the case (42). There are many commercially available cushioned floor mats; however, these may alter the room mechanics, interfering with free movement of the C-arm. In addition, there is insufficient evidence to recommend for or against insoles, soft shoes, soft flooring, or floor mats (43–47).

Careful selection of personal protective garments is important, as many options are available. Two practical aspects of protective garments are design and radiation protection. The design should be such that the garment fits properly. All individuals who routinely participate in interventional procedures “should be provided with custom-fitted protective garments to reduce ergonomic hazards and to provide optimal radiation protection” (5,48). Many workers prefer a two-piece wrap-around skirt and vest combination that distributes the weight of the garment, with less weight supported by the shoulders and more weight supported by the pelvis (5).

The radiation protection of garments is indicated by lead equivalence, with 0.5-mm lead aprons historically considered the standard, as they attenuate more than 95% of incident radiation (48). A lighter, thinner lead-equivalent garment made of materials other than lead may provide adequate protection, as a 0.3-mm lead-equivalent apron will result in only a modest increase in effective dose (7%–15%) compared with a 0.5-mm lead-equivalent garment (48). The wrap-around skirt is typically 0.25 mm lead equivalent, so that, when it is worn, the two overlapping layers provide 0.5 mm lead equivalence anteriorly (5). Greater lead equivalence increases protection, but does so at the cost of increasing weight (49).

Freestanding and suspended shields may provide radiation protection similar to lead aprons. Commercially available floating radiation protection systems (50) are claimed to remove all axial load caused by lead apron use while providing more protection than a standard lead apron (51). A case report of a hanging apron system (52) showed that, after an initial adjustment period, the practitioner was able to return back to work performing neurointerventional procedures with the use of the weightless apron system 5 weeks after his own lumbar discectomy. Robotic systems are being introduced that could remove the operator from the area of scatter radiation, eliminating the need for any protective garments (53).

When considering prevention, two important points need to be understood. First, given the prevalence of neck and back pain, it is unrealistic to expect prevention of the first episode of back pain; however, it is reasonable to aim for the prevention of recurrent pain (19,54). Second, the nature of neck and back pain is complex, and requires a biopsychosocial model to fully understand all the

Table 3. Practical Recommendations for Pain Prevention (19)

1. Keep your spine supple.
2. Keep your back muscles strong and fatigue-resistant.
3. Avoid spending long periods of time in lordotic or fully flexed positions.
4. Sleep on your side rather than your back.
5. Avoid rapid and awkward bending movements, especially in the early morning.
6. Lift slowly, with the spine balanced and slightly bent, muscles relaxed and the weight close to and in front of the body.
7. When starting an arduous job or sporting activity, build up your back's strength slowly.

This table was published on page 240 in Adams MA. *Biomechanics of Back Pain*. 3rd ed. Edinburgh: Churchill Livingstone/Elsevier; 2013 (19).

components that influence the experience of pain. It is very difficult to identify the underlying cause in many cases. Acknowledging the lack of evidence for a true understanding of the cause and the lack of evidence for scientifically proven methods of prevention of recurrent pain, we can nonetheless employ some practical (if unproven) techniques that hold promise for pain prevention (Table 3) (19). There is modest evidence that exercise may help to treat (54–59) and prevent (54) back pain. However, the type of exercise, such as aerobic, strength/resistance, and coordination/stabilization, is still debated (56,57).

TREATMENT

Just as the causes of occupational LBP are multifactorial, the treatments require a multidisciplinary approach. The most important treatment may be the most difficult to achieve: rest. Relative rest, activity modification, and medications such as nonsteroidal antiinflammatory drugs, acetaminophen, muscle relaxants, and oral analgesic agents are treatment options for acute and subacute back pain (60). Removing the operator from the source of pain is the first step in breaking the cycle of pain. Interventionalists may be able to rotate into assignments that do not require protective garments, such as outpatient settings or diagnostic radiology assignments. This may allow less required standing in the workplace and avoidance of pain-provoking activities.

Other treatments may also bring substantial relief for the worker with back pain. Therapeutic massage is an effective means of controlling musculoskeletal pain (61), and has been shown to have other far-reaching effects, including stress reduction (62). Stretching and the routine performance of core exercises have been shown to alleviate LBP and promote overall health (63). For more severe cases, physical therapy may be indicated (64). Alternative therapies such as yoga and acupuncture are known to be effective treatment for LBP (65). Finally, individuals diagnosed with a specific underlying cause for LBP may benefit from directed therapies such as facet blocks, nerve root block/ablation (66), epidural steroid injections (67), or surgery (19,68).

CONCLUSION

The high prevalence of neck and back pain among interventional radiologists is likely the result of a combination of the chronic effect of wearing protective garments, standing for long periods of time, and maintaining awkward, ergonomically unsound positions. The resultant repetitive stress injuries may be disabling. Interventionalists should be aware of this occupational hazard and embrace actions that reduce the risk, including careful design and planning of the interventional suite, attention to monitor and table position, use of shielding systems that reduce or eliminate the need for protective garments, and implementing the practical prevention tips, including exercise, described in this document. With careful planning and conscious effort, the career of an interventionalist can be healthier, longer, and more fruitful, with reduced occupational neck and back pain.

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