

# Aging with Spinal Cord Injury

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## KEYWORDS

- Aging • Consequences of aging • Spinal cord injury
- Quality of life

Traumatic spinal cord injury (SCI) was long ago thought of as “an ailment not to be treated.”<sup>1</sup> Since World War II, this once always fatal condition has reaped the benefits from advances in emergency and acute management, to the extent that people with SCI are surviving the early years posttrauma. Further advances in rehabilitative interventions, assistive technology to enhance independence, and early identification of secondary conditions enables those with SCI to live many years, often into their seventh and eighth decades. Several studies suggest that survival is influenced by the level and severity of injury,<sup>2–4</sup> age at injury,<sup>5–8</sup> and decade of injury.<sup>9–12</sup> Individuals with higher level, more neurologically complete lesions (ie, no or limited motor or sensory preservation below the level of lesion), and those injured at older ages have higher mortality rates in general. Those that live into their middle and older years with relatively stable health and functional abilities, however, experience the physical deterioration that naturally occurs with aging. Of note, the recent pattern of individuals incurring SCI is shifting with the mean age at onset increasing.<sup>13–15</sup> With this trend, the effects of aging may appear more quickly post-SCI.

In addition, there may be numerous psychosocial changes associated with functional decline, alterations in family and social support structures, and potential depletion of economic resources. It is useful for individuals with SCI and their health care team to know what changes may be expected as the individual ages, to identify possible preventive strategies to minimize the effects of aging.

## PHYSICAL AGING

SCI can have a major affect on organ system functioning, both in the acute phase and long-term. Autonomic and somatic nervous system dysfunction may result in lasting impairment of many organ systems. Cumulatively, this is likely to result in the

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development of secondary complications that become increasingly prevalent with longer duration of impairment. This phenomenon has been confirmed in several studies describing health complications associated with aging and SCI.<sup>16–18</sup>

### ***Gastrointestinal System***

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The most obvious alteration in gastrointestinal physiology after SCI is loss of volitional control over bowel emptying. Surveys of people with SCI have documented numerous gastrointestinal complications that accompany the aging process and have been associated with an increased need for assistance with activities of daily living.<sup>19,20</sup> Colorectal function is significantly altered by SCI, typically requiring a “bowel program” that induces (using a combination of various intestinal reflexes, diet, and pharmaceuticals) bowel movements and scheduled, predictable intervals. The altered colorectal function is expected to be a source of problems in the aging SCI population. Specifically, constipation is a problem in individuals with SCI, regardless of age; but when accompanied by the aging process, constipation is likely to be more prevalent in older or longer-injured individuals.<sup>21</sup> For example, one longitudinal study that involved people more than 20 years post-SCI in the United Kingdom indicated that 42% had difficulties with constipation, 27% reported fecal incontinence, and 35% had general gastrointestinal pain.<sup>16,19</sup> An even greater prevalence of constipation and fecal incontinence in up to 86% of individuals with SCI has been reported by others.<sup>22</sup>

Newer modalities, such as transanal irrigation techniques, show some promise in treating bowel evacuation difficulties.<sup>23–26</sup> If other methods become ineffective or difficult to manage for the person with SCI, elective colostomy may be an option, and numerous studies suggest that this approach, although less desirable for some, is not generally detrimental to perceived quality of life.<sup>27,28</sup> Rosito and colleagues,<sup>29</sup> in a study of 27 individuals who had undergone emergency or elective colostomy following injury, reported that colostomy significantly improved perceived quality of life.

Hemorrhoids and periodic rectal bleeding are common complications for those with chronic SCI,<sup>30</sup> which may worsen as the years progress and as the rectal tissue thins. Topical therapy is the least invasive intervention, but surgical options, including banding or hemorrhoidectomy, have shown reasonably good results with few complications.<sup>31</sup>

There is no evidence suggesting that people with SCI are at increased risk of colon cancer, but it is reasonable to assume they are at no less risk than the general population. Periodic screening for colon and rectal cancer, consistent with general population guidelines, is appropriate.<sup>32</sup> This screening can be problematic for the person with SCI, because the typical preparation for colonoscopy is very difficult for those with neurogenic bowel. In addition, insurance may not cover the costs of the colonoscopy preparation and related care. Because of the frequent presence of hemorrhoids, rectal prolapse, and other distal rectal pathology, fecal occult blood may not be a reliable screening tool, and endoscopy may provide more accurate information.

### ***Genitourinary System***

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Diminished bladder capacity and urethral compliance, an increase in uninhibited detrusor contractions and residual bladder volumes, and a gradual decline in kidney function are associated with normal human aging in the general population.<sup>33–35</sup> In addition, elderly individuals seem to be at increased risk for urinary tract infections, presumably related to the decline in immune function, postmenopausal changes, and the effects of prostatism.<sup>36–38</sup>

Genitourinary function following SCI is characterized by the loss of volitional control over micturition and the loss of coordination of detrusor and sphincter reflexes. These

reflexes recover, but over time there is a tendency to develop detrusor sphincter dysynergia and elevated lower urinary tract pressure that can lead to hypertrophy of the detrusor muscle and decreased bladder compliance. Cumulatively, these changes can also result in the development of hydronephrosis and upper urinary tract deterioration.<sup>39</sup> SCI-related changes in urinary tract physiology can be significant risks to health. Urinary tract complications, formerly the leading cause of death in those with SCI, now account for only 3.8% to 5.4% of deaths,<sup>15,40</sup> probably because of advances in urologic management and a wide range of antibiotic treatment options. Nonetheless, urologic complications continue to be common,<sup>41,42</sup> with urinary tract infections among the most frequent reasons for rehospitalization in the years following SCI.<sup>43,44</sup>

Bladder management methods seem to be associated with certain urinary complications. Individuals using indwelling catheters are shown to have higher rates of bladder stones, urinary tract infections, and bladder cancer.<sup>45,46</sup> The use of anticholinergic medications may improve some health outcomes for these individuals.<sup>47,48</sup> For many years, studies have suggested that the incidence of bladder cancer is increased by the presence of SCI,<sup>49–52</sup> although this finding has not been supported by others.<sup>53,54</sup> Bladder management technique is implicated in one study, which showed that indwelling catheter management resulted in a fourfold higher risk for the development of bladder cancer than nonindwelling catheter methods of management.<sup>45</sup> Additional risk factors for the development of bladder cancer likely related to the SCI and consequent neurogenic bladder include irritation to the bladder from recurrent urinary tract infections and bladder stones.<sup>45,55,56</sup> It does seem that malignant degeneration requires the cumulative effects of various risk factor exposure (eg, recurrent infections, indwelling catheter management, urinary tract stones, and cigarette smoking) over a long period of time. SCI survivors who develop bladder carcinoma typically present with hematuria; however, this sign alone is not a reliable indicator of bladder cancer. Bladder tumors are commonly metastatic and invasive at the time of diagnosis in people with SCI; the importance of identifying and using the most effective screening methods available cannot be underestimated. Urine cytology and biochemical markers of urinary tract malignancy are problematic in that they have high false-positive rates, possibly because of concomitant urinary tract infections and related hematuria. Most clinicians agree that screening cystoscopy to detect these tumors in chronically catheterized individuals is an option for early detection of bladder cancer in SCI,<sup>55,57</sup> although there is a lack of evidence that screening by cystoscopy or other methods has had an impact on mortality from bladder cancer in this population.

Other forms of bladder management also may pose difficulties, and it has been shown that those who have used intermittent catheterization for many years may increase their risk for developing urethral strictures and epididymo-orchitis.<sup>58</sup>

Because of the relationship of chronic prostatitis to recurrent urinary tract infection, there may be some added risk of prostate cancer in men with chronic SCI. To date, however, there is no compelling evidence that such an association exists. One study found that there was a lower incidence of carcinoma of the prostate in individuals with SCI.<sup>59</sup> Nonetheless, when prostate cancer is diagnosed in men with SCI, it is usually at a more advanced grade and stage<sup>60</sup>; men aging with SCI should be considered at risk and be provided with the same age-specific prostate cancer screening that is recommended for the general population.

### ***Skin and Subcutaneous Tissues***

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SCI predisposes many individuals to an increased risk for skin trauma, which can result in pressure ulcers. Immobility, lack of sensory protection, and spasticity all contribute to the common occurrence of pressure ulcers in this population. Analysis

of US Model Spinal Cord Injury Systems data showed a statistically significant increase in the average number of pressure ulcers from 5 to 20 years of follow-up.<sup>61</sup> Other investigators using these data found the incidence of pressure ulcers to increase from 15% at 1 year postinjury to nearly 30% at 20 years postinjury.<sup>41</sup> A Canadian study showed similar findings, with the odds ratio for developing pressure ulcers increasing for every year postinjury.<sup>18</sup>

The clinical approach to prevention and management of pressure ulcers in SCI is paramount, given the high economic and personal costs associated with this complication. Primary prevention of pressure ulcers through education focuses on skin protection, pressure relief, hygiene, and routine surveillance. Most studies of preventive interventions are limited by small sample sizes and inconsistent findings, but there is a suggestion that seating assessments and focused educational interventions may be most beneficial.<sup>62,63</sup> Once pressure ulcers occur, the basic principles of pressure relief, debridement, and asepsis are still the foundation of successful conservative management.<sup>64,65</sup> Depending on severity, clinicians may opt to use these conservative approaches, which include dressings, debridement, or electrical stimulation.<sup>65</sup> Anecdotal clinical experience and published data suggest that vacuum-assisted wound closure may help clear drainage from these sites and promote wound healing.<sup>66</sup> Conservative management, however, may not be sufficient for large and deep skin sores, which may require myocutaneous flap closure. Even with successful surgical management, the recurrence rate of pressure ulcers is high, and one of the strongest predictors of having a pressure ulcer is having had a previous ulcer.<sup>67–69</sup> Because of the high frequency of pressure ulcer occurrence in the chronic SCI population, prevention is paramount and periodic assessment should include a thorough evaluation of the skin and reinforcement of prevention education.

### ***Musculoskeletal System***

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In the general population, musculoskeletal system aging is characterized by deterioration of articular cartilage function. This ultimately leads to degenerative arthritic changes, both in the spine and in joints of the appendicular skeleton.<sup>70</sup> People with SCI experience unique physical stresses during mobility activities, and it is not surprising that overuse syndromes and pain in the upper extremities are common in this population. Surveys document that upper extremity pain is reported by more than 50% of SCI survivors.<sup>71</sup> Not only is there a positive association between shoulder pain and age, but pain occurs at a younger age in those with SCI compared with the general population.<sup>72</sup> Maneuvers, such as transfers, wheelchair propulsion, and pressure relief, may contribute to upper extremity discomfort.

When individuals with SCI identify shoulder pain, conservative management includes a review of mobility mechanics and how the individual engages in daily activities, which may result in suggestions for modifying those aspects of functioning and mobility to avoid pain-causing maneuvers.<sup>73</sup> Specific diagnosis of upper extremity joint pain can be difficult. Acromioclavicular degenerative changes may be seen on radiograph but plain radiographs are commonly of little value in the assessment of shoulder pain in these individuals. For more optimal diagnostic capabilities, arthrography, MRI, and ultrasound can commonly show impingement syndromes, tendinopathies, and rotator cuff tears in both symptomatic and asymptomatic individuals with SCI reporting shoulder pain.<sup>74–76</sup>

Overuse syndrome at the shoulders may present as a muscular imbalance across the glenohumeral joint with anterior musculature development significantly greater than posterior to the shoulder. Muscular balance across the joint to restore an optimal glenohumeral geometric relationship can be facilitated with exercises designed to

address the posterior shoulder girdle.<sup>71</sup> Surgery for impingement or rotator cuff tears may be an option when a conservative approach cannot resolve the problem; however, studies reporting on postsurgical outcomes for shoulder surgery in SCI are few and limited by small sample sizes.<sup>77-79</sup> The postoperative rehabilitation period can be prolonged and potentially difficult for the person with SCI, and temporary limitations in independence because of the postoperative shoulder activity restrictions may necessitate the use of personal assistance services.<sup>77,78</sup> A balance between the potential benefits of surgical intervention and the temporary postoperative functional limitations is a realistic consideration, and the long-term benefits of such intervention require more study.

Osteoporosis is common to the aging process, most typically associated with postmenopausal women but also occurring in aging men.<sup>80,81</sup> Osteoporosis related to paralysis and disuse is commonly believed to be the underlying risk factor for pathologic fractures following SCI. Lower extremity osteoporosis develops rapidly in the first year postinjury, with approximately one third of original bone mass being lost by 16 months postinjury before relative stability is achieved.<sup>82</sup> A lower extremity fracture rate and extremity fracture rate of over 30% for individuals followed for several decades has been reported.<sup>83</sup> Various interventions have been proposed to limit further bone loss and potentially enhance bone growth, including standing, functional electrical stimulation, and treatment with bisphosphonates. There is some evidence that high-volume functional electrical stimulation cycling induces bone formation at the distal femur, although other areas of the lower extremities do not show the same benefit.<sup>84</sup> Frotzler and colleagues<sup>85</sup> studied five individuals with motor and sensory complete SCI who had participated in high-volume functional electrical stimulation cycling and after detraining or reduced cycling, found that the bone mass gained was maintained longer term with reduced cycling. Furthermore, preliminary trials of pamidronate showed some promise in reducing bone loss in the acute-phase post-SCI,<sup>86</sup> but more recent evidence suggested limited efficacy in preventing long-term bone loss.<sup>87</sup>

Because of both the frequency of musculoskeletal complaints in this population and increased fracture risk, a reasonable monitoring approach is to incorporate a thorough symptom review and examination as a part of periodic reassessment. Equipment modifications, assessment of and changes to posture, and techniques used in performing functional activities may be necessary for individuals with SCI as they age. In addition, periodic bone density evaluations may be warranted, particularly for menopausal women with SCI.

### ***Nervous System***

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Histologic changes in the normal spinal cord demonstrate continual neuronal loss with aging.<sup>88</sup> Physiologic changes related to the nervous system in the aging general population have been reported to include loss of vibratory sensation, muscle mass, and strength; slower reaction time; decreased fine coordination and agility; decreased deep tendon reflexes; and deteriorating stability in station and gait.<sup>89-92</sup>

With the combination of age and SCI, it is reasonable to expect a progressive deterioration of neurologic function above and beyond that imposed by the original injury. A study of individuals aging with SCI of more than 20 years duration showed that 12% reported some sensory loss, and more than 20% reported increasing motor deficits over the years.<sup>93</sup> Similarly, a Canadian study found self-reported prevalence of neurologic deterioration in 11% of 633 individuals with traumatic SCI.<sup>18</sup> Although these data are compelling, it is not possible to state with certainty that an age-related loss of myelinated tracts and dropout of anterior horn cells may contribute to these reported

symptoms, and further research regarding age-related neurologic decline in SCI is needed.

A high incidence of upper extremity entrapment neuropathies has been reported in studies of people with long-term SCI, with up to 63% of those with paraplegia showing evidence of neuropathies, both on electrodiagnostic testing and on symptom surveys.<sup>94,95</sup> The most frequent site of involvement is the median nerve at the wrist, but ulnar nerve entrapments at the elbow and wrist are also common. Repeated hand contact with wheelchair rims, and positioning of the wrist during transfer activities and pressure relief, may predispose individuals with SCI to increased risk for nerve entrapments in the upper extremities. It is suspected that the incidence of significant entrapment increases with duration of injury, although this has not been conclusively proved. The functional implications for this type of upper extremity injury are profound and may pose significant limitations to mobility and independence.

Treatment includes assessing the mechanics of mobility and daily living activities to determine any underlying sources of repetitive trauma. Some individuals may need to modify activities to minimize further trauma to conserve and protect wrist function. Wrist splinting may be beneficial in reducing repetitive trauma at the extremes of wrist flexion and extension, which are known to contribute to carpal tunnel symptomatology. Individuals with SCI usually are successfully treated with activity and equipment modification and rarely require surgical intervention. When conservative measures fail to provide a relief of symptoms in people with significant entrapments, however, surgical release of the entrapped nerve may be necessary. Similar to those who undergo procedures for musculoskeletal problems, such as rotator cuff tears, individuals undergoing carpal tunnel surgery should anticipate a postoperative period of restricted activity, which may temporarily require increased assistance from others.

Individuals with chronic SCI may experience a new onset of more marked neurologic deterioration, most commonly the result of progressive posttraumatic cystic myelopathy.<sup>96-98</sup> This condition is also referred to as "posttraumatic syrinx," and is characterized by the progressive enlargement of a cystic cavity originating at the site of injury and extending in either a cephalad or caudal direction in the spinal cord. The concept of progressive cystic myelopathy recently has been broadened to include progressive noncystic or myelomalacic myelopathies. These conditions are thought to be a part of a pathophysiologic continuum. The onset of this neurologic complication may vary from several months to several decades after injury, but most commonly occurs within the first 5 to 10 years postinjury. Signs and symptoms of late progressive neurologic deterioration include losses of sensory or motor function; increasing spasticity; neuropathic pain; increasing autonomic dysreflexia; increasing sweating; and the development of a variable, positional Horner syndrome. Confirmation of this diagnosis includes a combination of the typical history and physical findings and MRI. Arachnoid scarring, which interferes with spinal fluid flow and spinal cord mobility, seems to be the underlying mechanism of progressive spinal cord pathology. When neurologic deterioration is progressive, surgical treatment, including untethering of the arachnoid scar and, in some cases, shunting of the cyst cavity fluid, is warranted.<sup>98,99</sup> All individuals with SCI have the potential for late neurologic change; the assessment of motor and sensory function, and a neurologic review of systems, should be included in periodic follow-up. Appropriate electrodiagnostic and imaging studies are indicated in the presence of signs or symptoms of neurologic deterioration.<sup>98,100</sup>

Unlike nociceptive mechanical or musculoskeletal pain, neuropathic pain can be initiated or caused by a primary lesion or dysfunction in the spinal cord, such as

that which occurs with SCI.<sup>101</sup> The clinical manifestation of this is an abnormal pain perception, characterized by burning, stabbing, and electric shock-like pain.<sup>102</sup> Neuropathic pain can occur above, at, or below the level of injury. That which occurs below the level of injury occurs in a diffuse distribution, compared with at-level, which typically occurs in a dermatomal or segmental distribution at the level of injury.<sup>103</sup> Neuropathic pain is typically constant; unrelated to position or movement; and may be exacerbated by other conditions, such as urinary tract infections or bowel function disturbances.<sup>104</sup> The prevalence of neuropathic pain following SCI has not been well-described, because most surveys combine all types of pain (including musculoskeletal) in their estimates.

There is no specific evidence to suggest that neuropathic pain in the person with SCI worsens with age; however, there may be age-related differences in the response to pharmacologic interventions for this type of pain, which commonly include gabapentin; pregabalin; tricyclic antidepressants; or weak opioids, such as tramadol. A study of 66 individuals without SCI, aged 5 to 84 years with a variety of conditions including neuropathic pain, found a significantly higher gabapentin blood pharmacodynamics in those aged 65 and older.<sup>105</sup> The authors posited that the higher concentrations of gabapentin in the elderly may be the result of slower bowel transit time leading to better absorption and a decline in renal function leading to decreased clearance. It is reasonable to suspect that as individuals with SCI using drugs, such as gabapentin, age, smaller doses may be indicated to provide the desired therapeutic response.

### **Cardiovascular System**

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Cardiovascular diseases (CVDs) are the most common causes of death in the United States among both men and women of all racial and ethnic groups.<sup>106</sup> Although age is the most important risk factor for manifest ischemic heart disease, the contribution of other risk factors is significant.<sup>107</sup> Notably, physical inactivity, common in older individuals, is associated with cardiovascular deconditioning.<sup>108</sup>

Heart disease is known to be one of the leading causes of mortality in long-term SCI, accounting for more than 20% of deaths.<sup>40,109,110</sup> A longitudinal study of long-term SCI survivors showed the risk of developing CVD was associated with both level and completeness of injury.<sup>111</sup> A number of studies have documented abnormalities of glucose and lipid metabolism and other risk factors for the development of CVD in people with SCI.<sup>112–115</sup> Individuals with SCI tend to have a lipid profile characterized by low high-density lipoprotein, compared with matched nondisabled controls.<sup>116</sup> Nonetheless, a report from the Agency for Healthcare Research and Quality concluded that there was insufficient evidence to suggest that adults with SCI are at greater risk of carbohydrate and lipid disorders, nor did it support the use of different thresholds to define or treat lipid abnormalities in this population.

It has been suggested that diabetes is an independent risk factor for mortality in people with SCI.<sup>40</sup> In a study of male veterans with SCI, 22% were found to be diabetic on oral glucose tolerance testing, compared with 6% in nondisabled control subjects, and 82% of the control subjects had normal glucose tolerance, compared with 50% of those with paraplegia and 38% of those with tetraplegia.<sup>114</sup> It has been suggested that changes in body composition, which are common in SCI, may contribute to impaired glucose metabolism.<sup>113</sup> Spinal-injured individuals typically have a reduction of lean muscle mass and a corresponding increase of fat mass. In addition, the diminished activity level of people with SCI may also contribute to insulin resistance.

These alterations in lipid and glucose metabolism indicate that people with SCI may have an elevated risk of coronary heart disease and other manifestations of CVD. Routine follow-up should include periodic assessment of blood lipids, glucose,

weight, blood pressure, dietary habits, smoking, activity level, and alcohol consumption to identify potentially modifiable risk factors. Recommendations to reduce cardiac risk do not differ from those for the general population and include diets that limit the intake of saturated fats and cholesterol, weight management, smoking cessation, and medications to manage lipid abnormalities. There has been some evidence to suggest that functional electrical stimulation may improve arterial function and metabolic profiles in people with SCI,<sup>117,118</sup> and promotion of exercise and a general increase in physical activity may prove beneficial.

### ***Respiratory System***

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In the general population, studies have shown a number of changes that result in a gradual loss of respiratory system function with advancing age.<sup>119,120</sup> Elderly men, in particular, are likely to experience sleep-disordered breathing associated with age-related increases in body weight, loss of upper airway muscle tone, and other factors.<sup>121–123</sup>

Individuals with SCI may experience respiratory complications both in the immediate postinjury period and during long-term follow-up.<sup>18,41</sup> The highest risk of respiratory complications is in those with neurologically complete tetraplegia, because of respiratory muscle paralysis and dysfunction. Older age at the time of injury is also associated with a higher risk of respiratory complications.<sup>18</sup> The combined effects of SCI and older age are likely to pose a significant risk for respiratory tract complications, such as pneumonia and atelectasis, and sleep-disordered breathing. This is particularly concerning because the leading causes of rehospitalization and death in people with both acute and chronic SCI are respiratory disorders.<sup>124</sup> Stolzmann and colleagues,<sup>125</sup> in a longitudinal study of 174 men with SCI, found no relationship between neurologic level and completeness in predicting a negative change in forced expiratory volume or forced vital capacity. They did, however, identify an age-related acceleration of decline in these two respiratory parameters. Other studies have investigated the incidence of respiratory tract morbidity in persons aging with SCI. A longitudinal study of 834 British individuals with SCI of at least 20 years' duration found the incidence of pneumonia and atelectasis to increase with age (going from 1.6% in those <30 years of age to 5.4% in those >60 years), but not with duration of injury.<sup>16</sup> US Model System data reveal similar findings, with pneumonia incidence increasing from 1.5% per year in the 16- to 30-year age group to 8.2% in the over 76-year-old group.<sup>126</sup> It seems from these studies that the risk of respiratory complications is associated with age rather than duration of injury.

Several investigators have identified a higher rate of sleep-disordered breathing in individuals with SCI, noted within weeks of injury and continuing in the follow-up years, with prevalence ranging from 25% to 53%.<sup>127–130</sup> Further study is needed to identify the factors contributing to this potentially life-threatening condition in SCI, because level of impairment, increased abdominal girth, neck circumference, and duration of injury have not consistently predicted those at greater risk of sleep apnea.

Based on data showing an increased risk of respiratory complications, clinical follow-up of individuals aging with SCI should include periodic assessment of vital capacity, especially in those with cervical levels of injury who are at the highest risk.<sup>131</sup> Annual immunizations against influenza and pneumococcus as appropriate are also recommended. Diagnosis and treatment of sleep-disordered breathing may also be indicated in symptomatic individuals.<sup>132</sup> In terms of personal behavioral modifications, maintenance of an appropriate weight to reduce the risk of further respiratory compromise is optimal, and smoking cessation programs should be encouraged. Aggressive management of community-acquired pneumonia, including



hospitalization, mobilizing pulmonary secretions by manually assisted coughing, and mechanical cough assistance, and prompt administration of antibiotics are recommended.<sup>124</sup>

### ***Immune System***

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The constellation of health conditions associated with aging in each of the body systems includes many factors related to immune system function. In the general population, function of the immune system declines with age and the risk of infection increases.<sup>133,134</sup> Aging of the immune system is likely influenced by multiple factors including the pathogen load that individuals are exposed to throughout their lives.<sup>135</sup> This relationship may be circular, in that although aging is a major risk factor for infection, it has been suggested that infection may also contribute to the aging process.<sup>136</sup>

There is evidence of diminished immune function in people with SCI above the T-10 neurologic level, which is demonstrated by impaired bacterial phagocytosis.<sup>137</sup> The previously cited British longitudinal study of aging with SCI showed a dramatic increase in urinary tract infections among those aged 60 and over and a slight increase in frequency of infection between the tenth and thirtieth postinjury year.<sup>16</sup> Other factors, such as the use of indwelling urinary catheters and pressure ulcers, may be associated with an ongoing systemic inflammatory response.<sup>138</sup>

The high incidence of urinary infection in SCI, and the likely increase of respiratory and other infectious processes with aging, calls for aggressive management and preventive strategies. Education regarding optimal health maintenance, appropriate immunizations, and early identification of infectious processes is critical. It is possible that advances in immunologic assessment and treatment will identify therapies that can improve immune defenses in individuals aging with SCI.

## **FUNCTIONAL AND PSYCHOSOCIAL AGING**

People aging with SCI clearly face the possibility of numerous physical issues. The physical decline, often anticipated because of the consideration that time does take its toll on the body, regardless of disability, however, does not negatively affect the person with SCI if the functional consequences of such declines are negligible. In addition, when physical problems do arise, much can be done to intervene and either delay, minimize, or eliminate potential negative consequences. Of great importance is how the individual perceives the changes and is able to adapt his or her lifestyle in response to such changes. Also experienced by the person growing older with SCI are economic factors, the impact of environmental barriers and facilitators, cultural issues, and changes in intimate and more remote social relationships. Consideration of these multiple factors in the evaluation of individuals aging with SCI is critical to understand the multiple issues that underlie this complex phenomenon.

### ***Independence***

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In the general population, advancing age is often accompanied by a loss of physical independence resulting from diminished muscle strength, decreased sensory acuity, slowed reflexes, decreased coordination, inadequate aerobic capacity, and lower energy levels.<sup>139–144</sup> Data from the National Center for Health Statistics showed that nearly 20% of the civilian community-dwelling population of the United States aged 55 to 64 and more than 34% of those aged 65 and older reported some degree of activity limitation.<sup>145</sup>

Aging may magnify issues of physical dependency for the person with SCI, because abilities change over time. The issues of concern to people aging with SCI include their

overall health, their ability to remain independent, and their ability to sustain a satisfying lifestyle,<sup>146</sup> and research suggests that some of these concerns are well-founded. In the study of British individuals aging with SCI, increasing age was a significant predictor of functional decline. The average age when additional functional assistance was first needed was 49 years for those with tetraplegia and 54 years for those with paraplegia.<sup>147</sup> This study also found that 22% of the participants reported a functional decline or decreasing physical independence over a 3-year time span.<sup>148</sup> Other studies identified similar significant cross-sectional and longitudinal increases in the need for assistance among older individuals with SCI.<sup>149</sup>

Preserving or maintaining functional ability and independence can be facilitated through modifications in how activities are performed or the use of adaptive equipment and other technology. When assistance from others is necessary, the individual with SCI can still make decisions and direct his or her own care, optimizing independence.

### ***Quality of Life***

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Quality of life may be related to how well a person copes with changes that occur as a result of aging. Stress and poor health have been linked with depression in older individuals.<sup>150</sup> For example, prospective cohort studies have demonstrated evidence that psychosocial factors, such as depression, are independent, etiologic, and prognostic factors for coronary heart disease.<sup>151,152</sup>

The relationship between increasing age and depression is often inconsistent, reflecting the complexities of affect management in older age. Older adults living in nursing homes, and those with dementia and other deteriorating health conditions, typically have higher rates of depression than do their younger or healthier counterparts.<sup>153,154</sup> Community-dwelling older adults in good health seem to be at no greater risk of depression than are younger adults, however, and apparent age-effects on depression in this population are often linked to health-related impairments in functioning<sup>155,156</sup> and to birth-cohort effects in terms of exposure to social risk factors (eg, economic deprivation).<sup>157</sup> Although findings on prevalence of geriatric depression are equivocal, there is evidence that perceived overall quality of life may not be negatively affected for older individuals.<sup>158</sup> For some individuals, quality of life may be determined by financial security; for others, maintaining health or having good relationships with others are determinants of life satisfaction. Rather than aging itself, maintaining good health, social support, and participation in activities have been found to more predictive of higher quality of life<sup>158</sup> and a person's sense of contentment has been suggested as an underlying factor of life satisfaction.<sup>159</sup>

Studies have shown that depression is common among individuals with SCI<sup>160–162</sup> and is greater for those who are older and who have been injured longer.<sup>163</sup> This suggests that life satisfaction may also be diminished for older individuals, a finding consistent with research by the authors and others, showing significant differences in self-perceived quality of life with younger individuals and those injured shorter periods of time rating their quality of life higher than older individuals.<sup>16,164,165</sup> Longitudinal and cross-sectional studies indicate that life satisfaction is not necessarily negatively impacted by aging, finding mixed patterns of change over time.<sup>149,166,167</sup> The variation in these findings may be a consequence of the differences in how older and younger individuals assess quality of life. The general message, nonetheless, is that individuals with SCI maintain relatively good and reportedly stable life satisfaction over time, even after many years of living with SCI.<sup>168</sup> Identifying the multitude of underlying factors that might contribute to declines in perceived quality of life or increased depressive symptoms is difficult; health care providers should assess

both the physical health of the individual aging with SCI, and the psychologic status, social situation, and environment, because all have an impact on successful aging.

### ***Family Issues***

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SCI can have a far-reaching impact on family members, friends, and others in the community close to the individual, particularly when that person requires physical assistance. Evidence suggests that SCI survivors' need for help increases as they age.<sup>147</sup> Complicating this issue, however, is the fact that many SCI caregivers are also aging, and facing their own age-related health issues. Potentially, poor health of the caregiver can negatively affect the care recipient, and with the advancing age of both, these consequences are likely to be magnified. On-going assessment of not only the person with SCI, but the physical and emotional health of family members, particularly if they provide personal assistance services to their loved one with SCI, is important. Detecting potential difficulties early and offering appropriate interventions, such as seeking occasional respite care or employing home health agency assistance, can help families maintain a positive focus on issues other than caregiving. Even with these efforts, all may not progress smoothly. There is evidence that assistance provided by a caregiving spouse is not always perceived positively by the recipient, and increasing age is a significant predictor of negative reactions to receiving assistance.<sup>169</sup> This may be of particular concern for those individuals with SCI who, having been independent when younger, need assistance as they age. Beneficial strategies to incorporating the need for more help include encouraging people with SCI to prioritize those activities that are most time consuming, difficult, or tedious as those that can be delegated to others, such as dressing, bathtub transfers, or bowel programs. Small steps can help individuals with SCI preserve their energy to use in more desirable personal and social activities. Ultimately, it is the shared responsibility of health care providers, people with SCI, and their families to work cooperatively in identifying the underlying issues that may negatively affect quality of life and community participation. This involves evaluating many issues, including the living situation, resources, and environment, because all play an important role in successful aging for the person with SCI.

### **SUMMARY**

New challenges facilitating success for people aging with SCI aging are being encountered by health care providers. There remain substantial gaps in the literature regarding the numerous issues related to organ system aging in this unique population. Although this article has identified some key findings through various longitudinal and cross-sectional observational studies and limited clinical trials, research with larger, diverse samples allowing greater generalizability of findings is needed. In addition, knowledge of aging in SCI is enhanced through contacts with and liaisons to gerontologists and other professionals with an expertise in general population aging.

Strategies to minimize conditions and complications that occur with aging should be identified and implemented as early as possible to more effectively manage and assist people aging with SCI. The first critical component involves systematic surveillance by an experienced SCI team to identify potential problems at their earliest onset. Second and no less important is ongoing education for health care providers, involving learning about the physical, psychologic, social, and environmental consequences of aging and their potential impact on people with SCI. Education for the person with SCI is widely enhanced by electronic access to information. Unfortunately, much of this information is inaccurate and potentially damaging. Encouraging an open atmosphere

of mutual dialog can help guide people with SCI through the maze of information is critical to ensure that the best practices are adopted. There may be indications for “re-rehabilitation” or equipment modifications as physical needs and independence change over time.

Aging is another step along the continuum of life with SCI, equal in importance to initial rehabilitation, returning to work, developing relationships, and engaging in other life activities. Through research, clinical experience, and self-reported outcomes from those living with SCI, a much greater insight has been gained into this phenomenon. When both clinicians and people with SCI are apprised of the natural likely trajectory of health and psychosocial issues and the research that supports best practices, successful aging can be greatly enhanced.

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