



## Scientific Review

# Sexual function in spinal cord lesioned men

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**Study design:** Review of literature.

**Objective:** To review the physical aspects related to penile erection, ejaculatory dysfunction, semen characteristics, and techniques for enhancement of fertility in spinal cord lesioned (SCL) men.

**Setting:** Worldwide: individuals with traumatic as well as non-traumatic SCL.

**Results: Recommendations for management of erectile dysfunction in SCL men:** If it is possible to obtain a satisfactory erection but of insufficient duration, then try to use a venous constrictor band to find out if this is sufficient to maintain the erection. Otherwise we recommend Sildenafil. If Sildenafil is not satisfactory then use intracavernous injection with prostaglandin E<sub>1</sub> (some SCL men may prefer cutaneous or intraurethral application). We discourage the implantation of penile prosthesis for the sole purpose of erection.

**Recommendations for management of ejaculatory dysfunction in SCL men:** Penile vibratory stimulation (PVS) to induce ejaculation is recommended as first treatment choice. If PVS fails, SCL men should be referred for electroejaculation (EEJ).

**Semen characteristics:** Impaired semen profiles with low motility rates are seen in the majority of SCL men. Recently reported data gives evidence of a decline in spermatogenesis and motility of ejaculated spermatozoa shortly after (few weeks) an acute SCL. It is suggested that some factors in the seminal plasma and/or disordered storage of spermatozoa in the seminal vesicles are mainly responsible for the impaired semen profiles in men with chronic SCL.

**Fertility:** Home insemination with semen obtained by PVS and introduced intravaginally in order to achieve successful pregnancies may be an option for some SCL men and their partners. The majority of SCL men will further enhance their fertility potential when using either PVS or EEJ combined with assisted reproduction techniques such as intrauterine insemination or *in vitro* fertilization with or without intracytoplasmic sperm injection.

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## Introduction

For several decades it was a general belief that individuals with a spinal cord lesion (SCL) and cauda equina lesion were permanently and completely impotent and sterile. Fortunately, over time many investigations have proved that this is wrong. It remains important to continue counselling and education in this area to prevent health professionals perpetuating the myth that disabled persons are asexual.<sup>1</sup> Likewise the general public should be made

aware that it is incorrect that a person with some degree of paralysis or deformity is unable to engage in sexual intercourse.<sup>2</sup>

It is important that the SCL person himself is aware of and uses his sexuality, as there has been shown to be a positive correlation between the SCL individual's avoidance of a conscious consideration of his sexuality and avoidance of a realistic acceptance of his physical disability.<sup>3</sup> Furthermore, sexually non-functioning paraplegics have shown decreased ability to engage in vocational training and may express their sexual disability symbolically through feelings of insecurity and helplessness.<sup>4</sup> Those who were sexually potent did

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not have the same difficulty in relating to others. It appeared that maximum rehabilitation and successful hospital discharge had a high positive correlation with sexual potency and was negatively correlated with sexual impotence. The study indicated that sexual functioning is a basic factor among the motivations and dynamics of paraplegia. Even though the investigations here cited are 25–50 years old, it seems that much of the knowledge that can be drawn from them is still true. In recent studies it has become evident that the provision of information regarding sexuality, for both men and women, should remain a high priority for health care providers.<sup>5–9</sup>

Preoccupation with future sexual performance occurs early and is quite prominent in the minds of persons with SCL.<sup>10</sup> Although the nature of the sexual response may be altered, sexual activity persists and is enjoyed by a large segment of the SCL population.<sup>11</sup> However, other factors may affect sexual function, including age, associated diseases, medication, partner relationships, and opportunity for sexual activity.<sup>12,13</sup> Furthermore, subjective sexual arousal was independent of penile tumescence levels and SCL men who did not have erections were subjectively no less aroused by film, spoken text, and fantasy than SCL men with erections or men who did not have SCL.<sup>14</sup> Therefore, any claim that SCL men who gain erections are more 'sexual' than SCL men who do not is untenable. Men who are unable to engage in intercourse must therefore be encouraged to achieve sexual arousal and satisfaction through other activities, none of which is labelled inferior to intercourse.

This review will primarily consider the present knowledge regarding the physical aspects related to penile erection, ejaculatory dysfunction, semen characteristics, and techniques for enhancement of fertility in SCL men, and we will not deal with the many other, equally important, aspects of sexual behaviour and partnership.<sup>5,9,15–18</sup> In this article we do not distinguish between individuals with traumatic or non-traumatic SCL, including congenital spina bifida, sequelae of transverse myelitis, spinal cord tumours, prolapsed discs, spinal infections etc., since they generally have the same erection and fertility problems.

## Neurology

The neurological background for erection and ejaculation in SCL men has been reviewed and discussed in several reports<sup>8,11,19–39</sup> and is here only presented briefly.

### Erection

A parasympathetic centre (reflex-activated centre), located in the spinal cord segments S<sub>2–4</sub>, is the main mediator of erection; it affects vasodilation and opening of the arteriovenous shunts in the corpora cavernosa whereby erection is obtained. The efferents

run in the *nervi erigentes*, but the final path is believed to be short adrenergic nerves that release norepinephrine and act on  $\beta$ -receptors. The afferents transmitting penile sensation run in the pudendal nerve to the sacral centre.

A sympathetic centre (psychologically activated centre), located in T<sub>11–L2</sub>, likewise mediates erection through fibres in the hypogastric nerves to the corpora cavernosa.

Erection is sustained by compression of the veins between the expanded corpora and the tunica albuginea.

It is the smooth muscle relaxation of the penile arteries and in the corpus cavernosum, which leads to the penile erection. This is a result of parasympathetic/nonadrenergic noncholinergic neural pathway activation and simultaneous inhibition of sympathetic outflow.<sup>40</sup>

The smooth muscle tone has been found to be an important factor in erection and detumescence, and a variety of factors may modulate the corporal smooth muscle tone. Neurotransmitters may function via gap junction, potassium and calcium channels. A nitric oxide (NO)/cyclic guanosine monophosphate (cGMP) mechanism as well as cyclic aminomonophosphate (cAMP) have been shown to participate in the induction of corporal smooth muscle relaxation.<sup>40</sup>

### Ejaculation

The sympathetic nervous system (T<sub>11–L2</sub>) sends efferent fibres in the hypogastric nerve to vasa deferentia, seminal vesicles and prostatic smooth muscle fibres, and gives rise to the peristalsis necessary for seminal emission: the first phase of ejaculation. Closure of the bladder neck also is enforced through sympathetic stimulation.

The parasympathetic centre (S<sub>2–4</sub>) supplies *nervi erigentes* with efferents to the prostate glands, in part leading to the formation of seminal fluid.

A somatic centre, located in S<sub>2–4</sub>, with fibres in the pudendal nerve, supplies the bulbospongiosus and ischiocavernosus muscles and the muscles of the pelvic floor to bring about the clonic contractions causing the projectile ejaculation with release of semen from the urethra: the second phase of ejaculation, or ejaculation proper. Therefore, if a person has a lesion of this centre, the ejaculation is not projectile, but dribbling in nature.

### Consequence of the spinal cord lesion

A sudden and complete spinal cord transection results in:<sup>41–43</sup> (1) all voluntary movement below the level of the cord lesion is immediately and permanently lost; (2) all sensations are abolished; and (3) reflex function in all segments of the isolated spinal cord is completely lost (spinal shock). Less complete lesions of the spinal cord may result in little or no spinal shock, and the same is true for lesions that develop slowly.

Guttman<sup>28</sup> distinguished three phases in the pathophysiology of the sexual organs: spinal shock, reflex return, and readjustment.

The phase of spinal shock lasts from a few hours to several weeks, during which time there is a complete or almost complete suppression of reflex activity below the level of the cord lesion. The male genital reflexes (reflex penile erection, bulbocavernosus and scrotal reflexes) are abolished or profoundly depressed. The erectile and ejaculatory functions are abolished. In complete lesions, the penis may become enlarged and partially erect as a result of a passive engorgement of the corpora cavernosa from paralytic vasodilation following the interruption of the vasoconstrictor fibres in the anterolateral tracts of the spinal cord.<sup>28</sup> The stage of spinal shock is believed to be due to the sudden interruption of the suprasegmental descending fibre systems that keep the spinal motor neurons in a continuous state of subliminal depolarisation (ready to respond).<sup>41</sup> The period of spinal shock is the main reason why it is usually impossible to predict sexual function, including erection and ejaculation, in SCL men within the first weeks after the injury.

When the spinal shock subsides, reflex activity and spasticity may appear in the lower extremities, and bladder and bowel function may become reflexogenic. In suprasacral lesions the erection reflex becomes one of the components of the autonomic functions of the isolated cord, taking part in the 'mass response'. In fact, it may appear independent of cerebral participation, before the reflex responses of the skeletal muscles are fully developed. Tactile stimuli of varying type and intensity, including stimulation of the glans and around the penis, result in erection.<sup>28</sup>

Sexual readjustment after a SCL depends greatly on the particular person's wishes, experience, and sexual habits in the pre-SCL life, whether this applies to love play or actual methods of intercourse. It may also to a great extent depend on the cooperation and helpfulness of a partner.<sup>28</sup> This is in line with the finding by Siösteen *et al*,<sup>44</sup> that sexual readjustment after injury was closely and positively correlated with willingness to experiment with alternative sexual expressions and young age at injury. Physical and social independence and a high mood level were further positive determinants of sexual adaptation after injury.

#### *Autonomic dysreflexia*

Men with SCL at or above T<sub>6</sub> may experience excessive activation of the autonomic nervous system during sexual arousal. This condition, known as autonomic dysreflexia or hyperreflexia, is usually marked by a sudden pounding headache due to increase in the blood pressure.<sup>45</sup> Flushing, sweating, and cardiac arrhythmias also may accompany autonomic dysreflexia.

Likewise, procedures involving triggering of ejaculation in SCL men may precipitate an acute episode of autonomic dysreflexia in individuals who are suscep-

tible to this syndrome.<sup>46,47</sup> Therefore, if couples are performing these techniques themselves, they must be instructed to stop as soon as the symptoms develop and should be familiar with the appropriate procedures to follow. Prophylactic use of nifedipine sublingually may be the solution in certain situations.<sup>48</sup>

#### **Erection**

Three types of erections after SCL<sup>20,23</sup> have been described. 'Reflexogenic erection' is induced by cutaneous or mucous membrane stimulation from areas below the level of the lesion, thus requiring an intact reflex arc, including S<sub>2-4</sub>. Rigidity of the penis can be obtained when the lesion is above T<sub>11</sub>, whereas the erection will involve only the corpora cavernosa and not the corpus spongiosum when the level is caudal to T<sub>11</sub>.

'Psychogenic erection' is induced by psychic stimulation: visual, auditory, olfactory, as well as from dreams, memories, and fantasies. In SCL men with lesions below L<sub>2</sub> it is believed to be via the thoracolumbar sympathetic outflow. This erection results only in swelling and lengthening of the penis without rigidity and therefore without the possibility of intromission.

'Mixed erection' may occur when the level of the lesion is below L<sub>2</sub> and above S<sub>2</sub>. The erectile response may differ individually regarding the duration and quality of the erection.

So-called spontaneous erection is probably caused by covert intrinsic reflex stimulation in individuals with upper motor neuron lesions.<sup>24</sup>

In a previous literature review<sup>21</sup> the frequency of erection was found to be between 54 and 95%, and successful coitus was obtained in 5% to 75%. Previous studies have pointed out the difficulties in interpreting these variable results due to methodological differences and incompleteness in data collection etc.<sup>11,14,19,27,29,39,49,50</sup> It has been found that incomplete SCL individuals are better in assessing their erectile function than persons with complete lesions.<sup>51</sup> In addition, Courtois *et al*<sup>52</sup> observed using penile strain gauge and reflexogenic stimulation (masturbation) and psychogenic stimulation (film) that erectile potential was a function of the lesion type and stimulation source.

Erection is more likely to be obtained in incomplete than complete lesions. Individuals with suprasacral lesions with an intact parasympathetic centre, have a higher frequency of erection than individuals with lower lesions.<sup>27</sup> In spite of this, one should be aware that this may not apply to the future sexual function of the particular individual.<sup>24</sup> Likewise it has been shown that the neurological level and the completeness of the SCL have no significant correlation with the sexuality.<sup>44</sup> Tsuji *et al*<sup>50</sup> found in a group, including complete and incomplete SCL, recovery of erectile function in about 25% within 1 month after injury, in 60% within 6 months, and in 80% within 1 year. In

5%, the recovery occurred after 2 years. In those with cervical or thoracic vertebral injury, 30% to 40% regained erectile function within 1 month, and 70% to 80% within 6 months. Only 10% of those with a lumbar vertebral injury recovered erectile function within 1 month and 40% within 6 months.

#### *Physical management*

Kuhn<sup>53</sup> found that slight movements of the prepuce over a sharply circumscribed reflexogenous area, including the corona of the glans and the penile frenulum, was the most effective stimulus for the elicitation of penile erection, and almost invariably evoked complete penile erection within 30 s. Once elicited, it was possible to prolong erection indefinitely. Some patients claimed to have an increase in the number of erections with an indwelling urethral catheter. In general, there was a fairly close correlation between the vigor and frequency of skeletal muscle activity and the frequency of penile erection. A striking finding was the penile detumescence that occurred during digital (or other) stretch of the internal anal sphincter. Comari<sup>24</sup> likewise described how catheter manipulation, use of lower limb spasticity, precoital bladder emptying, and application of hot towels to the penile shaft may enhance and maintain erection. The effect of masturbation may be enhanced by the use of lubricants.<sup>54</sup> 'Penile vibratory stimulation' may improve the erection in 30% of paraplegics.<sup>55</sup>

Erection can be prolonged by use of a 'venous constrictive band' (pubic ring, elastic band, retention band, rubber ring) carefully placed at the root of the penis to trap blood, and thereby maintain penile rigidity for a longer period.<sup>55</sup> It is important to instruct SCL men not to use the band for more than 30 min at a time, to avoid ischemic damage.

'Artificial penile appliances' of plastic material can be of help to some individuals with no or insufficient erection.<sup>38</sup>

*Vacuum erection devices* Vacuum erection devices in the form of vacuum pumps, either manual or electric, have been used for many years. The device consists of a plastic cylinder into which the flaccid penis is placed and subsequently engorged with blood by producing a vacuum within the cylinder. When adequate erection has been obtained, a venous constrictor band is slid from the base of the device onto the base of the penile shaft to maintain the erection. The cylinder is then removed from the penis and sexual intercourse may be initiated. The venous constrictor band should be removed after 30 min, and the skin closely monitored. SCL individuals on anticoagulation therapy or those with a bleeding disorder should not use this system, as common, but normally insignificant, adverse effects including bruises, petechiae and abrasions as well as skin oedema may occur.<sup>56</sup> Although uncommon, penile skin necrosis has been reported.<sup>57</sup>

Lloyd *et al*<sup>58</sup> reported from their follow-up study of a vacuum device in 13 SCL men, that 92% were able to achieve an erection sufficient for intercourse and indicated overall satisfaction with the device. With the use of the device, the frequency of intercourse increased. They emphasised the importance of instruction and adequate demonstration for the male user and his partner. Denil *et al*<sup>56</sup> found in SCL men using a vacuum device adequate erection for vaginal penetration in 93% (15/16) and 72% (10/14) after three respective 6 months of use. The most frequent complaint was the lack of erection duration. After 6 months of application, 27% of the men with SCL and 40% of their partners reported more frequent sexual activities than before.

Zasler and Katz<sup>59</sup> presented an alternative vacuum device, which consists of a soft, transparent silicone sheath with a thin pliable collar at its base. The unit is worn during intercourse. Proper sizing of the device is necessary. Twenty respondents reported successful vaginal intercourse after having used the device on at least 20 separate occasions. The device differs from the other vacuum devices in that theoretically it can be used for prolonged periods of time because of the absence of a constricting band.

#### *Pharmacological management*

*Sildenafil* Sildenafil citrate (Viagra<sup>TM</sup>) promotes erection by inducing smooth muscle relaxation in the corpus cavernosum through selective inhibition of phosphodiesterase type 5, and thereby reducing the inactivation of cGMP, which potentiates the corporal smooth muscle relaxation. There is further indication that sildenafil augments NO mediated activity in the corpus cavernosum.<sup>60</sup> Initially it was used only in SCL individuals with intact reflexogenic erectile response, but subsequently it was also found effective in SCL men with no residual erectile function.<sup>31</sup> In a study where the neurological conditions permitting therapeutic success for sildenafil was evaluated, it was concluded that the efficacy depends on sparing of either sacral (S<sub>2-4</sub>) or thoracolumbar (T<sub>10-L2</sub>) spinal segments.<sup>61</sup> This suggests that the absence of both psychogenic (non-somesthetic supraspinally elicited) and reflexogenic (somesthetic spinally elicited) erections seemed to exclude a successful treatment. On the other hand SCL men with preserved function of at least one component of the erection phenomenon (psychogenic/reflexogenic) responded well to sildenafil.<sup>61</sup> Sildenafil should be taken about 20 to 60 min prior to intercourse.<sup>31</sup>

The first published double-blind, placebo-controlled, randomised study on the use of sildenafil in a SCL population came in 1998.<sup>62,63</sup> This study included individuals able to achieve at least a partial reflexogenic erectile response to penile vibratory stimulation. After 28 days of treatment 75% (9/12) on sildenafil (50 mg) and 7% (1/14) on placebo reported improved

erections. In addition, significant improved satisfaction with sex life was reported by SCL individuals taking sildenafil.<sup>62</sup>

A larger double-blind, placebo-controlled, flexible-dose, two-way crossover study with 6 weeks sildenafil/placebo and a 2 weeks washout period included both SCL men with and without reported residual erectile function at baseline.<sup>64</sup> For all men 76% (127/168) reported improved erections and preferred sildenafil to placebo. Further, 80% (132/166) reported that sildenafil improved sexual intercourse compared with 10% (17/166) reporting improvement with placebo.<sup>64</sup>

This group also used quality of life and psychometric measurements, and found significant improvements for overall satisfaction with sex life, sexual relationship with partner, and concerns about erectile problems.<sup>65</sup> Significant improvements for sildenafil *versus* placebo were also reported in scores for the quality of life parameters of mental health, well-being, depression, and anxiety.<sup>65</sup>

Adverse effects seem, in SCL men, most often to include headache and flushing,<sup>61,63,64</sup> but dyspepsia was also found in all three studies.<sup>61,63,64</sup> Among other symptoms reported were dizziness, abnormal vision, rhinitis/respiratory tract infections/disorders, diarrhoea and rash.<sup>61,63,64</sup> These adverse events were the same as found in other studies, and generally they are transient and mild to moderate. Similar proportions of men receiving sildenafil ( $n=2722$ ) and placebo ( $n=1552$ ) in 18 clinical trials discontinued therapy because of adverse events (2.8% *versus* 2.6%).<sup>60</sup> None of the SCL men experienced priapism.<sup>61,64</sup> No dysreflexia symptoms were reported.<sup>61</sup>

Cardiovascular disease is not a contraindication to the use of sildenafil. Monga *et al*<sup>31</sup> suggest that individuals with a significant cardiac history and sedentary lifestyle should institute a behavioural modification program before receiving sildenafil. This should include a graduated exercise program, dietary modification, tobacco cessation, and weight loss. Persons with angina should be evaluated by a cardiologist before using sildenafil.

Sildenafil alone can cause mean peak reduction in systolic/diastolic blood pressure of 10/7 mmHg whereas the heart rate is unchanged.<sup>66</sup> Sildenafil and nitrates both increase cGMP levels in systemic circulation but at different points along the NO-cGMP pathway. Therefore coadministration of sildenafil and nitrate-containing medications (nitroglycerin, isosorbide dinitrate, amyl nitrate, etc.) is contraindicated and potentially lethal, because they synergistically potentiate vasodilation and may cause excessive reductions in blood pressure.<sup>60,66</sup> Therefore, men on nitrate-containing medications should not be prescribed sildenafil under any circumstances.<sup>31</sup> This is of particular importance since some SCL individuals may use nitrate-containing medications to treat autonomic dysreflexia. They must be warned about this danger and advised to use nifedipine instead.

**Intracavernous injection** Intracavernous injection of vasoactive drugs to produce erection was first reported in 1982 by Virag,<sup>67</sup> who used papaverine, a smooth muscle relaxant that produces both vasodilation and relaxation of the sinusoidal spaces in the corpora cavernosa. Brindley<sup>68</sup> obtained full erection in two of three SCL men when using an intracavernosal injection of phentolamine. Since that time, several reports have been published on the use of papaverine<sup>20,69–76</sup> or a combination of papaverine and phentolamine, a potent short-acting  $\alpha$ -blocking agent that causes vasodilation.<sup>69,70,72–74,77,78</sup> and more recently prostaglandin E<sub>1</sub><sup>70,79,80</sup> a vasodilator and smooth muscle relaxant in men with SCL. Prostaglandin E<sub>1</sub> seems to produce cavernosal vasodilation via an increase in cyclic adenosine monophosphate. Further a tri-mixture combination of all three substances may be used.<sup>81</sup>

In SCL men it is the general experience that the denervated tissues are supersensitive to the drugs used for intracavernous injection.<sup>20,69–73,77,78</sup> Monga *et al*<sup>31</sup> write that the neurologic condition may enhance the release of erection-inducing neurotransmitters from the parasympathetic nervous system. Another reason for the good response in SCL men is because it generally is a younger population with a low prevalence of significant vascular disease and other comorbidities. Therefore the time of erection is longer and the quality of erection is better in men with neurogenic impotence compared with men with vascular impotence.<sup>77</sup> A success rate up to 95% is not uncommon in SCL men, when defined as an erection adequate for penetration.<sup>69,71</sup> The erection will usually be obtained around 10 min after the injection and last for 30 min to 6 h; on average, 2 h depending on the dose.

To avoid sustained erection (priapism), the SCL men should begin with low doses (papaverine 2–5 mg or prostaglandin E<sub>1</sub> 1–2  $\mu$ g<sup>70,82</sup>) and gradually increase the dose if necessary. The SCL men must be instructed to seek medical advice if erection lasts for more than 4–6 h, to have the erection reversed. Sustained erection may require aspiration of blood from the corpora cavernosa and intracavernosal injection of a  $\alpha$ -adrenergic agent.<sup>82</sup> In this circumstance 5 mg oral terbutaline, if necessary repeated 1–2 times with an interval of 15 min, may cause penile detumescence.<sup>83</sup> It has been recommended in the case of reflex penile erection to wait with the intracavernosal injection until complete detumescence is achieved, or, if the circumstances do not permit any procrastination, to proceed with the administration of a reduced dose, preferably the dose being halved. In the presence of reflex penile erection, the SCL man may run the risk of developing drug-induced priapism.<sup>82</sup>

If the male partner is unable to perform the injection himself because of motor problems, the female partner may be taught the intracavernous injection technique. The dose required may vary considerably from person to person, even among SCL men with similar neurological lesions. Lloyd and Richards<sup>77</sup> instructed their impotent men to

alternate sides for the injection and vary the injection site along the lateral aspects of the penis to decrease the risk of fibrosis. In addition, we recommend a maximum of one injection per week.<sup>74</sup> For training in self-injection, two to five consultations are usually required.

Virag *et al*<sup>84</sup> presented an 8-year experience with intracavernous self-injection of vasoactive drugs in 615 impotent men, including 12 with SCL. In all, 87% were available for follow-up: 114 episodes of prolonged erections among 51 men represented less than three per 1000 of the 38 475 recorded injections. All these patients were treated successfully. The percentage of patients with nodules or permanent deformations was 2.8. No cases of intracavernous fibrosis were diagnosed. In 40 SCL men complications occurred frequently in 52%, prolonged erection, ecchymosis, and fibrosis, although fibrosis appeared less often in those with SCL than in those with vascular impotence.<sup>77</sup> The difference may be related to the less frequent use by SCL men or the much lower doses required. It is not known if the duration of therapy correlates with the development of fibrosis. Papaverine is associated with a higher rate of fibrosis than prostaglandine E<sub>1</sub>. If fibrosis develops, it is recommended to discontinue the use of intracavernous injections for 3 to 4 months.<sup>31</sup>

Disadvantages with injection therapy are the risk of prolonged erection and fibrosis in the corporal tissue;<sup>85</sup> concern regarding unknown long-term side effects;<sup>86</sup> and stress induced by injection therapy, a method too 'technical' and therefore unacceptable to some men.

*Cutaneous application* Claes and Baert<sup>87</sup> obtained positive results in impotent men using nitroglycerin plasters placed on the skin of the penile shaft, while we tested this procedure on SCL men.<sup>88</sup> In 17 SCL men who had responded to intracavernous papaverine injections with sufficient erections, five reported an erection sufficient for vaginal penetration and seven had a partial erection. The complications with this method are primarily related to allergic dermatitis (which we did not observe) and headache, which requires only mild analgesics, like paracetamol. Even better results for transdermal nitroglycerin were obtained in a randomised, cross over trial with intracavernous injection of papaverine.<sup>89</sup> Papaverine was, as expected, significantly more effective, but had a higher rate of complications. Therefore, treatment with transdermal nitroglycerin may be an option for some SCL men, but then the use of Viagra<sup>TM</sup> at the same time must be avoided.

Topical application of papaverine and prostaglandin E<sub>1</sub> gel to the penis, scrotum and perineum has shown some effect.<sup>90,91</sup> The papaverine gel could, in selected cases, strengthen reflex erection,<sup>90</sup> and topical prostaglandine E<sub>1</sub> gave, in two of 10 cases, clinical erections, while placebo gave no reaction.<sup>91</sup>

Minoxidil, an  $\alpha$ -adrenergic antagonist with a direct relaxant effect on arterial smooth muscle, has also

been tested in SCL men when applied as an aerosol spray to the glans penis. The topical application of minoxidil caused minimal, if any, response subjectively and objectively.<sup>92</sup>

*Intraurethral application* Recently, intraurethral prostaglandin E<sub>1</sub> (alprostadil, MUSE) has been tried for treatment of erectile dysfunction in men with SCL.<sup>93</sup> An intraurethral delivery system has been developed to administer an intraurethral MUSE suppository. Usually the effect should come with 5–10 min and last for 30–60 min. In the mentioned study it was found that all men required the maximum dose of 1000  $\mu$ g, and still the grade of erection was less in all 15 SCL men compared with erections obtained with intracavernous injection, and none were completely satisfied with the quality of erection when using MUSE. In addition, transient hypotensive episodes (decrease in systolic blood pressure of 20 mmHg and/or decrease in diastolic blood pressure of 10 mmHg) were observed if no venous constrictor band was used before introduction of the medication. But if the band was used no hypotensive episodes were experienced.<sup>93</sup> Other adverse reactions may be pain in the penis, with burning sensation in the urethra and occasionally bleeding from the urethra.

The dissatisfying result seems to be because absorption through the ventral side of the tunica albuginea lining the corpora cavernosa is required and the majority of the medication is absorbed systemically through the well-vascularised corpus spongiosum.<sup>31</sup>

### *Surgical management*

*Penile prosthesis* The surgical insertion of penile prostheses (rigid, semirigid, inflatable) has been performed in SCL men for a number years in the past to obtain erection for intercourse, and also to facilitate application of an external condom-type urinary collection device as well as intermittent self-catheterisation.<sup>94–102</sup> However, complications such as infection, tissue breakdown, and extrusion of the prosthesis occur more frequently in men with SCL than in other populations for whom penile prostheses have been used. Late erosion, extrusion or removal of the prosthesis has been the result in 10% to 25% of SCL men.<sup>94,95,99,100</sup> Dietzen and Lloyd<sup>95</sup> and Fallon *et al*<sup>103</sup> reported that half of the prosthesis in their series had to be revised or removed or had failed during follow-up. The complication rate increased with the duration of follow-up.<sup>103</sup> Because of loss of sensation and vasomotor control, and pressure produced by the penile prosthesis, SCL men represent a higher operative risk than other men, and this may delay recognition, treatment, and salvage of an infected prosthesis due to inability to perceive and complain of pain.<sup>104</sup> Urinary tract infection can be another major risk factor for infection to develop around the prosthesis. The increased infection rate is related to

the presence of chronic foci of infections that may be unrecognised and therefore untreated before implantation.<sup>104</sup>

Because of the high risk of complications and the many other possibilities available to obtain erection in SCL men we do not recommend this kind of surgery today for the sole purpose of erection.

*Sacral anterior root stimulation* Brindley *et al*<sup>105–109</sup> have demonstrated that the sacral anterior root stimulator (SARS) for bladder control can also be used to obtain erection. In 38 SCL men, 26 were able to produce penile erection by means of the implant; the erection lasted without decrement for as long as stimulation continued, even as long as 1 h.<sup>109</sup> In their long-term follow-up they found that 10 of 37 SCL men used the implant-driven erection for sexual intercourse.<sup>107</sup> The best root is usually S<sub>2</sub>, but S<sub>3</sub> might in a few men be more effective. The frequency for stimulation is usually about 9 Hz.<sup>106</sup> The influence of anterior root stimulation (S<sub>2</sub>) in deafferented SCL men on cavernous electrical activity suggests a possible role for single potential analysis of cavernous electrical activity in the fine tuning of erection induced by the SARS.<sup>110</sup> Induction of erection may not be an indication for this implant in SCL men, but when it is in place it is possible to use it for erection.

#### *Recommendations for management of erectile dysfunction in SCL men*

If it is possible to obtain a satisfactory erection but of insufficient duration, we would suggest the use of a venous constrictor band to find out if this is sufficient for maintenance of the erection. Otherwise we recommend sildenafil (**but avoid nitrates**). If sildenafil is not satisfactory then the use of intracavernous injection with prostaglandine E1 may be the solution. Some SCL men may prefer cutaneous or intraurethral application.

### **Ejaculation**

Contrary to SCL females, the ability to procreate naturally is lost in the majority of SCL males due to ejaculatory dysfunction and abnormal semen characteristics.<sup>30,35,111</sup> In a literature survey,<sup>35</sup> including 2527 SCL men, the reported ability to ejaculate during sexual stimulation or masturbation ranged from 0 to 55% (median 15%). The characteristics of semen obtained by several different methods of assisted ejaculation in men with chronic SCL have been consistently reported below normal levels,<sup>112</sup> in particular, the sperm motility rates when compared to WHO Standards.<sup>113</sup>

In order to solve the problems of ejaculatory dysfunction in men with SCL several methods of assisted ejaculation have been used including intrathecal and subcutaneous administration of cholinesterase inhibitors as well as rectal electroejaculation (EEJ) and penile vibratory stimulation (PVS).<sup>35</sup>

#### *Cholinesterase inhibitors*

In 1946, Guttmann<sup>28</sup> was the first to use an intrathecal injection of an cholinesterase inhibitor resulting in several spontaneous ejaculations over several hours. Unfortunately, many unwanted autonomic adverse effects also occurred, such as paroxysmal changes in the blood pressure, sweating and flushing (see autonomic dysreflexia). In the spinal cord injured, one death has been reported from malignant hypertension and cerebral hemorrhage with the use of this technique.<sup>114</sup> Because of this substantial risk to the patient, intrathecal injection of cholinesterase inhibitors has been abandoned in the management of ejaculatory dysfunction.

In order to facilitate ejaculation and to decrease the autonomic side effects of intrathecal administration of cholinesterase inhibitors, subcutaneous administration has been suggested by Chapelle *et al*.<sup>115</sup> This requires additional penile stimulation by masturbation or vibration to induce ejaculation. Subcutaneous administration of cholinesterase inhibitors may cause parasympathetic side effects such as nausea, vomiting, abdominal cramps and diarrhoea.<sup>115</sup> Therefore, with alternative procedures available like PVS and EEJ, subcutaneous administration of cholinesterase inhibitors is not recommended as a first choice of treatment.<sup>116</sup>

#### *Electroejaculation (EEJ)*

Rectal EEJ has been the cornerstone in the treatment of ejaculatory dysfunction in SCL men for many years. Electroejaculation was first described in 1931 in man by Learmonth.<sup>117</sup> In 1948, Horne *et al*<sup>118</sup> reported the first use of EEJ in SCL men with successful ejaculation in nine out of 15 SCL men. In the 1980s the EEJ method was refined and new equipment developed by Seager.<sup>119</sup>

EEJ is carried out with an electrical probe, which is inserted rectally and placed in contact with the rectal wall in the area of the prostate gland and the seminal vesicles. The electrical stimulation is given in a wave-like pattern with progressively increasing voltage with 1–2 V increments until ejaculation occurs.<sup>116,119,120</sup> A low level of electrical baseline (100 mA) is usually recommended to be maintained between voltage peaks and during ejaculation. However, in a recent study<sup>121</sup> concerning sphincteric events during EEJ and PVS in SCL men, the data suggest that it would be optimal in EEJ procedures to discontinue electrical stimulation completely during ejaculation in order to allow more relaxation of the external urethral sphincter, as this practice may increase the percentage of semen ejaculated in the antegrade direction.<sup>122</sup>

The fraction of antegrade ejaculate is not produced as a projectile ejaculation, but rather as an intermittent release of semen during the course of the procedure.<sup>119,123</sup> Between 15–35 stimulations are usually needed to assure emptying of the semen.<sup>119</sup> The voltages and currents used to obtain ejaculation

range from 5–25 V and 100–600 mA, respectively.<sup>120,124</sup>

Prior to the EEJ procedure, the patient is catheterised to completely empty all the urine, since many individuals have a substantial portion of retrograde ejaculation.<sup>124</sup> Because urine may adversely affect this retrograde ejaculate<sup>125</sup> a sperm friendly medium (eg Ham's F 10 medium) can be instilled into the bladder before the EEJ.<sup>126</sup> After the procedure the bladder is catheterised again to empty the retrograde fraction. Rectoscopy is performed prior to and following the procedure to confirm that there are no pre-existing rectal lesions and to exclude injury to the rectum from EEJ, respectively.

It should be noted that in men with partly preserved sensation, EEJ can cause significant discomfort<sup>123,126–128</sup> and the procedure will require either a spinal or general anaesthesia.<sup>126</sup>

EEJ may be successful in obtaining ejaculate from men with all types of SCL including those missing major components of the ejaculatory reflex arch.<sup>126</sup> In a prospective study by Ohl *et al*<sup>124</sup> information has been given about predictors of success in relation to the EEJ response of 48 SCL men. They found in relation to successful EEJ no significant difference between SCL men with high *versus* low or complete *versus* incomplete spinal cord lesion. Ejaculation was produced in 60% of cervical patients compared to 50% of lumbar patients. Ejaculation was seen in 71% of men with complete lesions and in 61% with incomplete lesions. However, more recent studies show that it is possible to induce ejaculation with EEJ in 80% to 100% of all SCL men.<sup>126,129–132</sup>

#### *Penile vibratory stimulation (PVS)*

PVS to induce ejaculation was first described in 1965 by Sobrero *et al*<sup>133</sup> in a group of non-SCL men. The first reported use of PVS in a SCL man was with a hand massager.<sup>24</sup> Brindley<sup>134</sup> has been largely responsible for popularising the use of PVS in men with SCL by reporting successful ejaculation in 48 of 81 SCL men.

The PVS procedure is performed with the patient placed in the supine position or in a sitting position in the wheelchair.<sup>135</sup> The goal of PVS is to activate the ejaculatory reflex and the afferent penile dorsal nerve stimulation is initiated by application of a vibrating disc primary against the frenulum for periods of 3 min or until antegrade ejaculation occurs. If no ejaculation has occurred the stimulation period is followed by a rest period of 1–2 min and stimulation begins again. An antegrade ejaculation occurs as a pulsatile projectile ejaculation similar to normal ejaculation. In contrast to EEJ, nearly all spermatozoa in PVS trials are ejaculated in the antegrade direction.<sup>136</sup> The required time to induce ejaculation by PVS ranges from 10 s to 45 min.<sup>137–139</sup> During PVS, somatic reactions such as erections, abdominal muscle contractions and leg spasms may be seen.<sup>138</sup>

In contrast to EEJ, PVS seems to require an intact spinal cord at the level of T<sub>11</sub>–S<sub>4</sub> in order to induce antegrade ejaculation.<sup>134,137,138</sup> However, the data from Brindley's retrospective study<sup>134</sup> concerning the exact level and completeness of spinal cord lesion in relation to the ejaculatory response is unclear. Szasz and Carpenter<sup>138</sup> reported from their retrospectively performed study that the level and completeness of the spinal cord lesion could not predict with certainty successful ejaculation by PVS in a group of 35 SCL men.

Brindley<sup>134</sup> noted that the most important factor indicating whether or not an ejaculate could be obtained by PVS was the clinical presence or absence of the hip flexion reflex (L<sub>2</sub>–S<sub>1</sub>) which is elicited by scratching the soles of the feet. Ejaculation was obtained in 75% of SCL men who had an intact hip flexion reflex, but in none who did not have the hip flexion reflex. It should be noted that 25% of the SCL men who had a hip flexion reflex failed to ejaculate by PVS. Szasz and Carpenter<sup>138</sup> stated that absence of the bulbocavernous reflex (S<sub>2</sub>–S<sub>4</sub>) predicts in most SCL men no ejaculatory response by PVS.

Brindley<sup>134</sup> and Szasz and Carpenter<sup>138</sup> also noted that the output of the vibrators and, in particular, the amplitude might have some effect on the ejaculatory response. No information about the optimum vibratory amplitude was given. In the literature concerning PVS results, it becomes apparent that a wide range of ejaculation rates (19–91%) has been reported.<sup>32,36,55,128,134,137–142</sup> This may be due to the fact that several non-medical vibrators have been used and the vibratory output has been poorly standardised.

PVS with different amplitudes in relation to ejaculatory response has been examined in a prospective study of 25 SCL men.<sup>143</sup> Detailed measurements of the vibratory output demonstrated that the manufacturers' specifications regarding the vibratory amplitudes were inaccurate whereas the frequencies were in accordance with the specifications indicated by the manufacturers. When the vibratory output was determined it turned out that the different amplitudes correlated very well with ejaculation rates obtained. The highest rates of ejaculation (antegrade plus retrograde) were seen with a vibrator amplitude level of 2.5 mm and a frequency of 100 Hz (96%), and low rates were seen when the amplitude was only 1 mm (32%). The effectiveness of the high amplitude vibration was verified in the same study by obtaining an ejaculation rate of 83% in another comparable group of 41 SCL men with ejaculatory dysfunction. The ejaculatory responses were similar irrespective of whether the investigator or the patient or his partner performed the procedure. The total number of patients responding to PVS with antegrade or retrograde ejaculation was 41 (62%) and 17 (26%), respectively. Eight (12%) patients did not obtain ejaculation.

In the same study,<sup>143</sup> antegrade ejaculation was seen only in men with cord lesions above T<sub>10</sub> and no other

absolute predictors of the ejaculatory response were identified related to reflexes, completeness of lesions, somatic reactions, age and time since SCL. However, when the reflexes and/or somatic reactions such as erections, abdominal muscle contractions and leg spasms were present during PVS there was a significantly higher percentage of men with antegrade ejaculation compared to those men where none of the reflexes and/or somatic reactions were seen.

#### *Side-effects*

All procedures of assisted ejaculation in SCL men with lesions above T<sub>6</sub> may provoke an acute episode of autonomic dysreflexia, if they are prone to this syndrome.<sup>46,47</sup> To prevent an episode of autonomic dysreflexia nifedipine is given sublingually 10 to 15 min prior to PVS or EEJ in men with SCL above T<sub>6</sub>.<sup>48</sup> During the first procedures the blood pressure should be monitored until the right dose of nifedipine has been established.

Significant complications from PVS and EEJ are rare.<sup>35,120,127,130,131,134,139–141,144–147</sup> In PVS, local skin abrasion is a common finding but no treatment has been necessary other than a short rest period. In EEJ, there is a potential risk of rectal injury, which may require operative repair and diverting colostomy.<sup>148</sup> Forceful abdominal and leg contractions, which may be more uncomfortable than those seen in PVS, are common.

#### *Surgical sperm retrieval*

If assisted ejaculation procedures fail or yield insufficient motile and/or viable spermatozoa for assisted reproductive techniques, surgical procedures of sperm retrieval are indicated. The SCL man should be evaluated (as if he had no neurologic lesion) for obstructive as well as non-obstructive causes of the problem before any invasive procedure is performed.<sup>112</sup>

Successful sperm retrieval from the vas deferens and from implanted sperm reservoirs have been reported in SCL men.<sup>149–152</sup> Brindley<sup>153</sup> reported an additional method to induce an ejaculate through direct stimulation of the hypogastric nerve using an implanted nerve stimulator. One pregnancy achieved using spermatozoa aspirated directly from the testicle or epididymis combined with intracytoplasmic sperm injection in an in-vitro fertilisation cycle has also been reported.<sup>154</sup>

Although the surgical techniques are relatively easy to perform, an effective non-surgical method must be preferable.<sup>30</sup>

#### **Fertility**

Despite the fact that nearly all SCL men are able to produce an ejaculate with PVS or EEJ the ability to procreate is still impaired due to abnormal semen characteristics.<sup>35</sup> However, successful pregnancies in partners of SCL men have been reported using either

vaginal home insemination or various methods of assisted reproduction techniques.<sup>155</sup>

#### *Semen characteristics*

Semen analyses data from ejaculates obtained without therapeutical assistance in SCL men is virtually non-existent,<sup>35</sup> but one early publication in 1948 by Horne *et al*<sup>118</sup> reported the analysis of semen obtained by masturbation in three SCL men. They found total motile sperm counts between 30 and 110 millions (total sperm count >40 millions according to WHO standard criteria 1992<sup>113</sup>). In the man with the highest count an additional specimen demonstrated a motility rate of 26% (Motility rate >50% according to WHO standard criteria 1992<sup>113</sup>). However, nearly all data concerning semen analyses in SCL men are from ejaculates induced by PVS or EEJ and the semen is, in general, characterised by normal to high sperm count and low sperm motility rates compared to WHO standards.<sup>113,124,128,131,134,136,139,140,156–158</sup>

Several theories have been suggested to explain the impaired sperm motility in SCL men including urinary tract infections, type of urinary bladder management, abnormal testicular histology, testicular hyperthermia, changes in the sex hormonal profiles, antisperm antibodies and sperm stagnation in the seminal ducts due to anejaculation.<sup>30</sup>

There is a high incidence of urinary tract infections in persons with SCL.<sup>159</sup> Recurrent infections may lead to epididymitis and epididymo-orchitis, which can impair semen profiles by leading to obstruction of the epididymal ducts or atrophy of the testicles.<sup>116</sup> Effects of urinary tract infections on EEJ semen characteristics have been investigated in chronic SCL individuals, and no significant effect on semen characteristics was seen in ejaculates from SCL men with infected urine compared to subjects without infections.<sup>160</sup> It was reported that the sperm motility rates were better in SCL men performing intermittent catheterisation or who had undergone sphincterotomy as methods for bladder emptying compared to those men who achieved bladder drainage with an indwelling catheter or high pressure reflex voiding (27% and 25% versus 5% and 15%, respectively).<sup>124</sup> It has also been demonstrated on video-urodynamics that SCL men using reflex voiding and who generally have a higher voiding pressure may have reflux of urine to the ejaculatory ducts which may lead to chronic inflammation in the reproductive organs and reduced sperm motility.<sup>124</sup> Rutkowski *et al*<sup>157</sup> reported that intermittent catheterisation was superior to other methods of bladder management when looking at the number of SCL men with the presence of motile sperm obtained from both PVS and EEJ ejaculates.

Changes in testicular histology have been noted in SCL men. Hirsch *et al*<sup>161</sup> demonstrated a significantly lower mean spermatid count and higher Sertoli cell count per seminiferous tubule, together with a higher Sertoli cell/spermatid ratio when compared to normal,

fertile controls. In other studies, abnormal as well as normal testicular histology has been found.<sup>127,162–164</sup>

Elevated scrotal temperatures have been reported to decrease spermatogenesis<sup>165</sup> and this is a concern in men who are sitting in a wheelchair for much of the day. In SCL men both elevated and unchanged scrotal temperatures compared to non-injured controls have been described.<sup>166–168</sup>

Reports on the sex hormonal profiles in SCL men have been conflicting.<sup>127,163,169–176</sup> Serum levels of testosterone, follicle-stimulating hormone and luteinising hormone have been found normal, above normal as well as below normal after SCL when compared to laboratory standards and controls, respectively. Although changes in sex hormone levels may accompany SCL, a significant correlation between these hormone levels and abnormal semen characteristics has not been found.

Antisperm antibodies are believed to adversely influence male fertility<sup>177,178</sup> and men with SCL might be predisposed to conditions associated with the development of antisperm antibodies such as recurrent urinary tract infections leading to epididymitis and epididymal obstruction.<sup>127,179,180</sup> Presence as well as absence of antisperm antibodies in serum, seminal fluid and on the surface of spermatozoa, respectively, has been demonstrated in SCL men.<sup>181–185</sup> No significant correlation between semen characteristics and antisperm antibodies has been documented, but it was suggested that sperm antibodies in the seminal fluid may play a negative role in relation to sperm function in SCL men.<sup>184</sup>

Another theory that has been commonly discussed is stagnation of spermatozoa in the genital ducts from a period of anejaculation, leading to the presence of large numbers of senescent spermatozoa in the ejaculate and, consequently, poor sperm motility.<sup>30</sup> The obvious solution to this problem would be to produce ejaculation in patients more frequently. Previously, some improvement of semen parameters in SCL men has been reported after frequent PVS ejaculation for variable periods of 3 to 6 months.<sup>139,140</sup> In a recent study,<sup>186</sup> 19 SCL men were followed for an entire year of frequent ejaculation, which represents the longest follow-up in such a study. Because none of the semen parameters improved in this study it was suggested that stagnation in the seminal ducts due to infrequent ejaculation is not the etiology of the impaired sperm motility rates seen in SCL men. Although some of the above mentioned factors may play a role for abnormal semen characteristics in chronic SCL men, none are the sole cause of the problem.

Differences in semen profiles from the use of EEJ and PVS in SCL men and, in particular, the potential damaging effects of EEJ on semen profiles have been discussed in the literature.<sup>30,134</sup> In a prospective study<sup>187</sup> of 11 SCL men it was shown that the motility rate of PVS induced antegrade sperm was significantly better than that of EEJ induced antegrade sperm, even

though such motility rates are subnormal with both methods. This difference in sperm motility rates may be due to the effect of chronic denervation caused by SCL rather than to the method of assisted ejaculation. A similar significant difference between PVS and EEJ has been shown in the antegrade sperm motility rates in a non-human spinal cord intact primate model.<sup>188</sup> This indicates that the EEJ method itself may compromise the sperm motility rate in antegrade ejaculates and should be taken into consideration when fertility and semen characteristics are studied in SCL men.

In another study including 51 SCL men<sup>158</sup> it was demonstrated that the completeness and level of lesion also influence the sperm motility with significantly higher motility rates in men with cervical *versus* thoracic lesions, lesions at or above T<sub>6</sub> *versus* below T<sub>6</sub> and incomplete *versus* complete lesions, respectively. This is in contrast to the EEJ study by Ohl *et al*<sup>124</sup> where the sperm motility was highest in the thoracic lesions and the presence of motile sperm was more frequent with complete lesions.

Recent investigations indicate that factors in the seminal plasma contribute to the impaired sperm motility in SCL men. For example, seminal plasma from ejaculates of SCL men inhibited motility of sperm from normal men, and seminal plasma from normal men improved motility of sperm from SCL men.<sup>189</sup> The viability and motility rate of ejaculated spermatozoa induced by PVS or EEJ was significantly lower than the viability and motility rate of spermatozoa aspirated from the vas deferens in a group of 12 SCL men compared to non-SCL controls.<sup>190</sup> This indicates that an accessory gland factor is responsible for the low sperm motility.

Another recent study<sup>191</sup> found that large numbers of senescent spermatozoa with poor motility and viability are present within the seminal vesicles of SCL men and these spermatozoa comprise a large portion of the ejaculates obtained by PVS and EEJ. This indicates that SCL men have disordered storage of spermatozoa in the seminal vesicles leading to impaired quality of ejaculated semen.

The acute effects of SCL on semen characteristics in humans have only been addressed in one study,<sup>192</sup> probably because men with acute SCL are not physiologically or emotionally prepared to participate in assisted ejaculation studies and their recovery may demand attention in so many other areas of acute treatment and rehabilitation as well as social reintegration. In the study by Mallidis *et al*,<sup>192</sup> EEJ was used to obtain frequent ejaculates in seven men from day 2 after an acute SCL. No decline in semen profiles was seen until day 16. Thereafter sperm motility and viability decreased towards the pattern seen in chronic SCL men.

Few other studies have examined the direct changes in spermatogenesis and semen characteristics during the acute phase of SCL. Billups *et al*<sup>193</sup> demonstrated in a sympathectomised rat model decreased epididy-

mal sperm motility as well as disordered epididymal spermatozoa storage.<sup>194</sup> Huang *et al*<sup>195</sup> performed SCL in a rat model to examine acute changes in spermatogenesis. Different groups of rats were sacrificed at various times after SCL. They found that a significant decrease in spermatogenesis a few days after SCL with some recovery noted after 6 months. While useful information was gained by these studies,<sup>193–195</sup> what was still lacking was the ability to examine serial changes in spermatogenesis in the same animals, and the ability to examine ejaculated semen characteristics, rather than epididymal spermatozoa. To investigate these questions, a dog model of SCL has been developed allowing serial examination of both semen profiles and spermatogenesis in the same animals and the data gives strong evidence for a decline in spermatogenesis and sperm motility at 3 weeks following SCL compared to non-SCL control dogs.<sup>196</sup>

The mechanisms responsible for the impaired semen characteristics in SCL men is still largely unknown but to gain more insight into the impact of the autonomic nervous system on the production, transport and storage of spermatozoa as well as the composition of biochemical substances in the seminal fluid further studies are required. Also, studies of changes in spermatogenesis and semen characteristics from the acute SCL, through spinal shock, and into the chronic phase of SCL remain to be performed.

## Pregnancies

### *Home insemination*

PVS and vaginal self-insemination performed by the couple at home is a viable option for those SCL men with adequate semen parameters.<sup>131,134,146,155,197</sup> The SCL man and the partner should be carefully instructed in the use of PVS through supervised procedures at the hospital. Men with spinal cord lesion at or above T<sub>6</sub> are instructed to self-administer nifedipine prophylactically to prevent autonomic dysreflexia. Those men whose autonomic dysreflexia is not well controlled by nifedipine are not candidates for home PVS. A non-spermicidal container is used for collection of the ejaculate and a 10 ml syringe is used for vaginal self-insemination.

In 1984 Brindley<sup>134</sup> reported seven pregnancies following PVS and vaginal self-insemination with delivery of five healthy babies (one ongoing/one spontaneous abortion). Recently, several pregnancies have been reported from PVS procedures combined with self-insemination at home.<sup>131,146,155,197</sup> Most studies reported that multiple ovulation cycles were used to achieve the home pregnancies and the overall pregnancy rate per couple is ranging from 25% to 61%. The ovulation timing is important and the use of luteinising hormone detection kits should be further evaluated to determine whether they may improve home pregnancy rates.

The unique advantage of PVS is the possibility of home use. Furthermore, it will allow the majority of SCL couples to perform the PVS procedure themselves at the hospital when a specimen is required in connection with assisted reproduction techniques.

### *Assisted reproduction techniques*

Several successful pregnancies have been reported<sup>131,146,155,156,197–200</sup> using spermatozoa obtained by PVS or EEJ combined with assisted reproduction techniques such as intrauterine insemination or in-vitro fertilisation with or without intracytoplasmic sperm injection. The overall pregnancy rate per cycle from those studies<sup>131,135,146,156,197–200</sup> is about 25%, and this rate is similar to the pregnancy rate per cycle during natural procreation in healthy couples wanting to become pregnant (25–30%).<sup>201</sup>

Several fertility treatment options are available to enhance the reproduction prospects in SCL men and their partners. The proper choice of treatment should be made through coordinated efforts of different specialities, which may involve urology, gynaecology, andrology and rehabilitation. The most effective reproduction technique may not be the best treatment for all couples. Therefore, when proceeding onto higher levels of reproduction techniques, it is of importance to inform the couples about possible side-effects from hormonal ovulation induction as well as problems related to multiple births.

### *Recommendations for management of ejaculatory dysfunction and fertility problems*

PVS and EEJ will almost ensure a 100% ejaculation rate in SCL men. PVS is recommended as the first choice of treatment, with EEJ reserved for PVS failures. Surgical retrieval of spermatozoa is only indicated if PVS or EEJ fails or yields insufficient motile and/or viable spermatozoa. Motivated couples with adequate semen parameters may be offered PVS combined with ovulation timed self-insemination at home. In order to further enhance the fertility potential in SCL men and their partners' intrauterine insemination and, in particular, in-vitro fertilisation with or without intracytoplasmic sperm injection may be recommended.

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