Paraplegia

Quality of Semen After Repeated Ejaculation Treatment in Spinal Cord Injury Men

A. Siösteen, BA,¹ L. Forssman, MD, PhD,² Y. Steen, MLT,² L. Sullivan, MD, PhD,¹ I. Wickström, MD, PhD³

¹ Spinal Injuries Unit, Department of Neurosurgery, Sahlgren's Hospital, Gothenburg, S-413 45 Göteborg, Sweden, ² Department of Obstetrics and Gynecology, Östra Hospital, Gothenburg, S-416 85 Göteborg, Sweden, ³ Department of Anaesthesiology, Sahlgren's Hospital, Gothenburg, S-413 45 Göteborg, Sweden.

Summary

The study was designed to document the effects of regular drainage after penile vibrator stimulation on the quality of semen in SCI men. Twenty three tetraplegics and 9 paraplegics, 18 to 40 years of age and with neurological levels ranging from C4 to L1, were examined between 1 and 23 years after injury (median 2 years). None had ejaculated after the injury. Penile vibrator stimulation was tried in patients with cervical or thoracic lesions who showed reflex hip flexion on scratching the soles of the feet, 29 out of 32, and rectal electrostimulation in the remaining 3 low lesions with no reflex function in lumbar and sacral segments. The stimulation yielded semen in 29 (91%) of the men; 22 had antegrade and 7 retrograde ejaculation. Sixteen of the 22 patients with antegrade ejaculation entered a home programme of vibrator stimulation prescribed once weekly.

Four to 6 months of stimulation resulted in a rise of semen volume and of fructose and acid phosphatase levels in the seminal plasma, suggesting improved function of the seminal vesicles and the prostate. The percentage of motile sperms was low both before and after the treatment period. Despite this, the total count of motile sperms per ejaculate was already high in the patient's first ejaculates compared to the laboratory normal standard, and further clearly increased after the stimulation period. A standardised functional test measuring sperm penetration capacity showed strong evidence of long term stimulation effect. It is suggested that the test is used in the assessment of fertility potential in SCI men.

Key words: Spinal cord injury; Vibratory stimulation; Ejaculation; Quality of semen; Penetration test.

There are two main causes for the impaired reproductive potential in SCI men, ejaculatory dysfunction and poor quality semen. However, current treatment techniques allow a large number of SCI males to achieve ejaculation. Essentially

three techniques are used to day in SCI centres: rectal electrostimulation working over efferent sympathetic fibres of the hypogastric plexus (Brindley, 1981a; Francois *et al.*, 1983; Martin *et al.*, 1983); penile vibrator stimulation causing a reflex ejaculation (Francois *et al.*, 1980; Brindley, 1981b); and subcutaneous injections of physostigmine which facilitates reflex ejaculation (Chapelle *et al.*, 1983). The latter method can also be used in combination with the other two.

The semen of men with spinal cord injuries has commonly been characterised by small volume, low count and low motility (Brindley, 1984; Francois *et al.*, 1980; Halstead *et al.*, 1987). Insufficient drainage, genitourinary infections and raised scrotal temperature are thought to cause the impairment (Brindley, 1984). Other studies have shown that testicular dysfunction is common in SCI men. Testicular biopsies disclose varying degrees of tubule degeneration and decreased spermatogenic activity (Leriche *et al.*, 1977; Perkash *et al.*, 1985).

A few authors have observed an improvement in the quality of semen with repeated ejaculations but, as yet, there is no systematic documentation to provide a basis for treating infertility by repeated stimulation (Brindley, 1984; Halstead *et al.*, 1987).

The primary aim of this study was to define the effects of regular drainage after vibrator or rectal electrostimulation on the quality of semen. In order to allow a physiologically more accurate assessment of semen function we supplemented the usual laboratory tests with a sperm penetration test.

Materials and methods

Patient population

Thirty two men with SCI were included in the study. They had all wished to have their fertility potential investigated and none of them had been able to achieve ejaculation after injury. Patients who had been injured less than 6 months were excluded. The men were between 18 and 40 years of age (median 25 years). The neurological level of the injury varied between C4 and L1, and the time elapsed after injury between 1 and 23 years (median 2 years). Twenty three men were tetraplegics and 9 were paraplegics. Five of the subjects had incomplete lesions.

Techniques used to obtain semen

Penile vibrator stimulation was our first choice in patients with cervical or thoracic lesions (29 out of 32 patients) in whom reflex hip flexion was present on scratching the soles of the feet (Brindley 1984). Over the past 10 years, the vibrator technique has been widely used and it is fully described elsewhere (Brindley 1984).

In most cases, we used a vibrator (Relax)* suitable for domestic use, with a frequency of 100 Hz and an amplitude of about 1.5 mm when loaded with a

* Arab Belysning AB, Skellefteå, Sweden.

penis. When the Relax failed, we used a more powerful vibrator (Ling 201)* set to 80 Hz frequency and an amplitude of about 2.5 mm.

With the patient supine the knob of the vibrator was applied to the lower surface of the glans penis. The prepuce was not retracted. The knob of the vibrator was held in the same position until ejaculation occurred or for 3½ minutes. A pause of 1½ minutes was then allowed. The stimulation-pause cycle was repeated 4 times before the attempt was regarded as a failure.

We used rectal electrostimulation in men with low lesions (3 out of 32 patients) in whom the sole scratch reflex did not occur, indicating loss of reflex function in lumbar and sacral segments. We adopted the equipment and technique developed by Brindley and described in detail elsewhere (Brindley, 1981a).

The battery-driven stimulator allowed stepwise regulation of the voltage up to 80 V and a frequency of 15 or 30 Hz. The electrodes were placed in a finger-shaped silicon rubber mount fitting the right index finger of the examiner. The single cathode was placed on the palmar surface and the two anodes on its dorsal side. Stimulation was performed with the patient supine with the knees bent. The electrode mount was placed over the examiner's right index finger and gently inserted into the anal canal. Using 36 or 54 V pulses, the posterior pelvic floor was explored to obtain a somatic motor effect and ensure that there were anterior horn cells alive from the L5 to the S2 segment. The palmar surface of the finger then explored the right lateral wall of the pelvis for the obturator point, where stimulation at 80 V was applied to obtain semen. After 40 seconds without emission we considered the attempt a failure. The opposite side was then tried.

Electrostimulation was not prevented by local pain in any of the 3 subjects.

Using either technique, the semen was collected in specific non-toxic plastic condoms (Pro-ception seminal pouch)†, pulled over the penis.

If stimulation did not result in antegrade ejaculation, the next portion of urine was analysed for retrograde seminal emission.

Prevention of side-effects

In both techniques used, there is a risk of autonomic dysreflexia during treatment in patients with lesions at or above T5 (Brindley, 1981a; Brindley, 1981b). In our group of patients all men with lesions above this level were treated with vibrator stimulation. In these patients, continuous monitoring of the blood pressure was achieved using an automatic sphygmomanometer. If the blood pressure exceeded 200 mm Hg systolic or if the patient reported headache, stimulation was discontinued and the threefold couch was tilted vertically to raise the patient into the sitting position. If this was not sufficient, 6.5 mg dihydralazine was given intravenously, which was necessary in 1 case. Five patients with severe rises of blood pressure were further controlled at the clinic. All then showed lower blood pressure and it was considered safe for the patients to continue the stimulations at home.

* Ling Dynamic Systems Ltd, Royston, UK.

† MILEX, Products INC. Chicago, USA.

Figure Schematic illustration of the penetration test.

Liquified semen was placed in a reservoir and one end of the capillary tube was immersed in the semen. The other end was sealed by modelling clay. The capillary tube was filled with Sperm Select purchased from Pharmacia, 751 82 Uppsala, Sweden.

Evaluation of semen characteristics and penetration capacity

With few exceptions the semen analyses were performed by the same laboratory technician. Antegrade semen evaluation included volume, sperm concentration, motility (% motile sperms), motility degree (0 = immotile, 1 = non-progressive, 2 = slow or non-linear, 3 = rapid and linear), and total count of motile sperms (% motile sperms $\times$ total count of sperms per ejaculate). Morphologic evaluation, based on the principles described by Eliasson (1971), was made by 2 independent laboratory assistants counting the number of normal forms per 100 sperms with 5% discrepancy allowance.

Sperm penetration capacity was determined with a light microscope, using a modification of Kremer's *in vitro* test (Kremer, 1965). Briefly, sperms in a liquefied ejaculate are allowed to penetrate a capillary tube containing a medium with properties similar to the human cervical mucus (Sperm Select)* (Figure). The base value, determined after 1 hour, represents the differential line in the capillary tube where the mass of sperms are separated from a fast moving category of sperms. The normal value of our modification is $> 3.8 \mu\text{m}$ per second or $> 14 \text{ mm}$. The top value indicates the maximum distance that the fastest spermatozoa penetrate within 1 hour. The normal value is $> 9.6 \mu\text{m}$ per second or $> 40 \text{ mm}$.

Concentrations of fructose and acid phosphatase in the seminal plasma were used as markers for vesicular and prostatic secretion respectively. Fructose was determined by a method described by Roe (in Mann, 1964) and acid phosphatase according to the Sigma Method No. 104†.

Stimulation programme

Semen analysis and sperm penetration tests were made at the first ejaculation and at the follow-up after 4 to 6 months' regular treatment. Stimulations were

* Pharmacia AB, Uppsala, Sweden.

† Lab Kemi, V. Frölunda, Sweden.

performed once a week, mostly by the patients themselves. In 2 cases treatments were completed at the clinic.

Statistical methods

The variability of measured parameters was defined with standard statistical techniques and comparisons between values before and after stimulation were made using Wilcoxon's sign rank test for matched pairs.

Results

Means of obtaining semen

Penile vibrator stimulation was used in 29 men and rectal electrical stimulation in 3.

The stimulation treatment resulted in antegrade ejaculation in 22 men, retrograde in 7 and no ejaculation in 3 men. All the antegrade ejaculations were induced by vibrator application.

Evaluation of semen characteristics and analyses of the seminal plasma

The results of the antegrade semen analyses are shown in Table 1. The semen volume was significantly improved after the period of stimulation and reached the normal range.

The sperm concentration showed great individual variations but was often very high, both before and after treatment. Specimens from 12 men, 75% of all, had more than 100×10^6 sperm per ml after the stimulation period.

The percentage of motile sperm was low and did not increase substantially with treatment although the motility degree was estimated to improve. Despite the low motility counted in percent, there was a several-fold elevation of the total count of motile sperm per ejaculate before the treatment period (compared to laboratory normal standard) and a further clear increase after.

Baseline sperm morphology ranged from 40 to 68% normal forms, with both a mean and a median of 54%, and it did not change with repeated stimulations.

It is obvious from Table II that the levels of fructose and acid phosphatase increased with stimulation, the latter from a subnormal pretreatment value.

Evaluation of sperm penetration capacity

Before regular stimulation, penetration base values showed strongly lowered migration capacity. After treatment, there was a marked rise of the penetration base values, while the top penetration capacity was maintained at a level just under the normal range (Table III).

Four men (25%) had normal sperm penetration tests at the first ejaculation. In all, 11 men (69%) showed normal or nearly normal penetration tests after the period of regular stimulation.

In retrograde ejaculates, only total sperm counts were assessed. Three pati-

Table I Antegrade semen analysis values ($\bar{X} \pm SE$) in paraplegic men before and after 4 to 6 months' stimulation treatment (n = 16)

Semen characteristics	Laboratory normal standard	Before	After
Volume (ml)	≥ 2.0	1.6 ± 0.2	$2.2 \pm 0.3^*$
Concentration ($\times 10^6$)	≥ 20	285 ± 84.1	271 ± 65.5
Motility ($^{\circ}_o$)	≥ 50	23 ± 3.1	29 ± 3.0
Motility degree (grade 0-3)	≥ 3	2.2 ± 0.6	$2.7 \pm 0.1^*$
Total count of motile sperms/ejaculate ($\times 10^6$)	≥ 20	115 ± 40.3	$192 \pm 75.9^*$
Morphology ($^{\circ}_o$ normal forms)	≥ 50	54 ± 1.8	55 ± 2.8

* $p < 0.05$

(Wilcoxon's sign rank test for matched pairs)

Table II Concentration of fructose ($\mu\text{ml/l}$) and acid phosphatase ($\mu\text{cat/l}$) in the seminal plasma ($\bar{X} \pm SE$) in paraplegic men before and after 4 to 6 months' stimulation treatment (n = 11)

Semen characteristics	Laboratory normal standard	Before	After
Fructose	≥ 5.5	5.0 ± 1.8	$6.7 \pm 1.7^*$
Acid phosphatase	≥ 5.5	2.6 ± 0.8	$6.4 \pm 2.0^*$

* $p < 0.05$

(Wilcoxon's sign rank test for matched pairs)

Table III Sperm penetration ($\bar{X} \pm SE$) ($\mu\text{m/sec}$) in paraplegic men before and after 4 to 6 months' stimulation treatment (n = 16)

Laboratory normal standard	Penetration base		Laboratory normal standard	Penetration top	
	Before	After		Before	After
≥ 3.8	1.1 ± 0.5	$4.0 \pm 0.7^{***}$	≥ 9.6	8.2 ± 0.7	9.1 ± 0.4

*** $p < 0.001$

(Wilcoxon's sign rank test for matched pairs)

ents of the 7 with retrograde ejaculation had sperm counts in excess of normal, 2 had less than normal and 2 much less (Table IV).

Discussion

Six drop-outs had to be accepted; 2 men could not continue the treatment at home because of impaired hand function, 2 discontinued after being informed about their low baseline semen quality, 1 was advised not to take part because of repeated urinary infections and in 1 case vibratory treatment no longer resulted in ejaculations. Of 2 other patients who completed the study and with equally poor semen values to those causing the drop-out mentioned above, 1 showed improved values without reaching normal levels and the other 1 maintained the low baseline quality.

Table IV Total sperm count after retrograde ejaculation

	N
$> 50 \times 10^6$	3
$20-30 \times 10^6$	2
$< 1 \times 10^6$	2
Total	7

The use of penile vibrator stimulation or rectal electrical stimulation thus yielded semen in as many as 29 out of 32 men (91%). Compared to studies by others (Brindley, 1984; Perikash *et al.*, 1985), this appears to be a high figure. The majority of the men had cervical or high thoracic lesions and thus preserved lower parts of the spinal cord, necessary for seminal emission. This may explain the high rate of ejaculation in the total material. Furthermore, in a few patients, attempts were made on several occasions before ejaculation occurred.

When both techniques were likely to be successful, vibrator stimulation was preferred for several reasons. The vibrator less often gives retrograde or partly retrograde emission and the antegrade semen specimens often have a better volume and are not contaminated with urine. This technique should therefore give a better quality of semen. Moreover, the vibrator is easy to handle, even for persons with impaired hand function, which makes it suitable for domestic use, and it is relatively cheap.

Indications for domestic use had to be carefully considered because of the risk of autonomic dysreflexia. Notably, our 5 patients with dysreflexia reactions at the first vibrator stimulation showed decreased pressure and lesser symptoms at later stimulations, then not exceeding 170 mm Hg systolic. We have therefore taken this pressure as an upper limit for using vibrators at home. Also, the patients are urged to discontinue the domestic stimulation if any headache occurs.

The antegrade semen analyses showed that the volumes of the ejaculates increased with treatment and often reached normal levels after the stimulation period. This agrees with the finding of Brindley (1984) that vibrator stimulation yields better volumes than electrostimulation. Fructose and acid phosphatase were found in the seminal plasma of all the patients and levels increased after treatment. Although the presence of these markers has not been shown to be correlated with fertility, the results may indicate an improved function of the seminal vesicles and the prostate, and may also raise the volume of the ejaculates.

Although regular drainage was achieved during the treatment period, the frequency of ejaculations was probably low in the SCI men compared to normal, and some patients reported that stimulation did not always result in ejaculation. The high sperm concentration found both before and after treatment is probably mainly explained by this infrequent drainage and possibly also by incomplete ejaculations during artificial stimulation in SCI men, causing sperm storage in the genital tract.

The importance of sperm morphology for fertility potential is well documented. In this group of SCI men, morphology was usually normal and did not change with repeated stimulations. Only 1 patient with long standing

Table V Summary of improved antegrade semen characteristics ($\bar{X} \pm SE$) after 4 to 6 months' stimulation treatment in paraplegic men ($n = 16$)

Semen characteristic	Laboratory normal standard	Before	After
Volume (ml)	≥ 2.0	1.6 ± 0.2	$2.2 \pm 0.3^*$
Concentration of fructose ($\mu\text{mol/l}$) ($n = 11$)	≥ 5.5	5.0 ± 1.8	$6.7 \pm 1.7^*$
Concentration of acid phosphatase (ucat/l) ($n = 11$)	≥ 5.5	2.6 ± 0.8	$6.4 \pm 2.0^*$
Motility degree	≥ 3.0	2.2 ± 0.6	$2.7 \pm 0.1^*$
Total count of motile sperms/ejaculate ($\times 10^6$)	≥ 20	115 ± 40.3	$192 \pm 75.9^*$
Penetration base (um/sec)	≥ 3.8	1.1 ± 0.5	$4.0 \pm 0.7^{***}$

* $p < 0.005$ *** $p < 0.001$

(Wilcoxon's sign rank test for matched pairs)

urinary problems and epididymitis had a very low proportion of normal cells (25%).

The percentage of motile sperms was low both before and after the treatment. Despite this, the total count of motile sperms was already high before treatment and rose further with repeated stimulation. We conclude that the increase of the semen volume was relatively smaller than the increase in motile sperms.

The penetration test was chosen to get a functional measure of sperm progressive motility. It has been reported that in normal subjects good sperm motility and good morphological characteristics can compensate for low sperm concentration (Macleod *et al.*, 1951; Freud, 1962). Similarly, impaired sperm motility may be compensated by high sperm concentration, increased volume, improved motility degree and good morphology in SCI men. It is probable that the significantly improved penetration base values reflect the summarised effects of the various quantitative and qualitative semen properties, improved *per se* as shown in Table V.

We therefore think it is appropriate in fertility evaluation to use a standardised functional test, measuring the sperm penetration capacity, when the biological validity of the test is secured (Wikland *et al.*, 1987).

We conclude that repeated ejaculation treatment, for at least 4 months, using the vibrator technique improves semen quality and fertility potential in SCI men who have not ejaculated earlier after injury. It should be noted that the patients were their own controls in a before-after design and that stimulation started at a median of 2 years after injury. There was no neurological evidence that the effects of treatment were caused by a spontaneous clinical improvement, as all but 1 patient had seemingly reached a status quo in the continuous follow-up.

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