Conservative and surgical semen retrieval in patients with spinal cord injury

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Assisted semen retrieval was applied in 219 men with spinal cord injury (212 supranuclear, seven infranuclear lesions). Vibrostimulation in supranuclear lesions was successful in 133, and in five more after physostigmine injection. Electroejaculation was successful in all seven infranuclear lesions and in four supranuclear patients failing with vibrostimulation. Eight more supranuclear patients responded to electroejaculation and physostigmine. Surgical retrieval was applied in 27 patients. Nine *Wagenknecht* spermatoceles showed only one success, from all 18 implanted *Brindley* reservoirs semen could be collected. Three patients, in whom no pregnancy could be induced after *Brindley* reservoir implantation, had testicular sperm aspirated. In 109 patients who wanted to have offspring, 73 pregnancies could be induced in 46 couples, leading to 54 births (four twins), 16 abortions and three pregnancies. Conservative semen retrieval was possible in 82 of these men (63 pregnancies in 37 couples) and surgical methods were used in 27 (10 pregnancies in nine couples).

Keywords: ejaculation; vibrostimulation; electroejaculation; fertility; sperm collection devices; semen retrieval; spinal cord injury

Introduction

After spinal cord injury, sexual dysfunction is a frequent condition. The patient becomes aware of his situation after recovery from the acute phase and, for many, loss of sexual function is a heavier burden than the loss of mobility.

Therefore, rehabilitation of spinal cord injured men has to include resolution of their problems in the sexual field.¹ Spinal cord injured males are not reluctant to discuss their problems in this field with their physician. We noticed the interesting fact that unmarried men are interested principally in fertility, for married men erectile dysfunction comes in the first place.

For fertility, availability of semen is a *conditio sine qua non*. Ejaculation by masturbation is possible in only about 10% of spinal cord injured males.² Methods for artificial ejaculation are available; their application depends on location and extension of the spinal injury.

Two phases are distinguished in the expulsion of semen. During the emission phase, contraction of seminal vesicles, spermatic ducts and bladder neck with relaxation of the external urethral sphincter expresses semen into the proximal urethra. This phase is under sympathetic control, through sacral segments Th11–L3. The proper ejaculation phase is partly

parasympathetic (prostate), partly somatic via the pudendal nerve (S2–S4). The somatic part controls the contraction of ischio- and bulbocavernosus muscles and of the pelvic floor. Treatments to restore fertility are dependent on the condition of the sacral cord. Non-surgical methods presuppose intact sacral segments Th11–L3.

Methods and patients

Non-surgical methods

Vibrostimulation, introduced in 1970,³ is at present the method of choice among conservative methods for semen collection in spinal cord injured males,^{4–6} also because supranuclear lesions are more frequent than infranuclear lesions. An ejaculation can be provoked independent of the presence of erection. First reports on pregnancies after using this technique were published about 10 years later.^{7,8} Its therapeutic use is limited, however. A positive result may be expected only in spastic paralysis above Th11. Various vibrators with more or less complicated control systems are available in a wide price range. Technological finesses are of minor significance for the semen collection, but vibration frequency,⁹ amplitude and power appear to be the important factors. In this study, a constant frequency of 50 Hz and an amplitude of about 3 mm proved sufficient.

Ejaculation can often be evoked only by forceful pressure of the vibrator olive on the penile glans. Two of our patients stimulate themselves with the swinging head of an electric razor. In the department, we use a simple skin massage vibrator.

Electroejaculation is the oldest method for semen collection. Developed in veterinary medicine, the first application on a spinal cord patient was reported in 1948.¹⁰ Electrodes are introduced rectally and stimulation of sympathetic fibres in the hypogastric plexus leads to emission. The first pregnancy was reported in 1975.¹¹ Contrary to vibrostimulation, this method is available not only for patients with lesion above Th11, but also for those with lesion below L3.^{5,6,12}

Pharmacoejaculation or medical stimulation of semen production in spinal cord injured males by intrathecal injection of neostigmine was introduced in 1971.¹³ Four pregnancies were reported, the last one in 1985.¹⁴ Because of serious adverse effects (critical blood pressure increase with danger of haemorrhagic insults) this drug now is obsolete. The related drug physostigmine has less side effects, mainly a possible blood pressure decrease and seldom nausea. The antidote is atropine. Physostigmine is fat-soluble, passes the blood-brain barrier and can be injected subcutaneously. As a precaution, combination with butylhyoscine is recommended. The first pregnancy report dates from 1983.¹⁵ Both compounds are competitive cholinesterase blockers and act as indirect parasympathomimetics. A massive excitation of reflexes below the spinal lesion results.

We combine vibrostimulation or electroejaculation with physostigmine, if these techniques by itself do not enable semen collection. Except for two cases of blood pressure decrease which were easily controlled, no serious side effects have been noted. Therefore, the combination with butylhyoscine was omitted.

Retrograde ejaculation occurs frequently on electroejaculation or after bladder neck surgery. Treatment of this condition is by drugs (imipramine or desipramine 24 h before, midodrine, transurethral xylometazine) or by the use of a thin balloon catheter to close the bladder neck^{16,17} is not always successful. Emptying the bladder and flushing with a buffer solution (Ham's-F10), of which about 30 ml is left, before stimulation is a better way. After the stimulation, the ejaculate is retrieved from the bladder. Alkalisation of urine appears not to be necessary.¹⁴

Surgical methods

When all conservative methods fail, surgical intervention can be used and is becoming increasingly successful. In an early phase, we implanted an *alloplastic spermatocele ad modum Wagenknecht*¹⁸ on the epididymis. Because of lack of success, we now apply Brindley's *sperm reservoir*.¹⁹ The reservoir is a flat container with non-pierceable bottom; implanted directly in the lumen of the vas deferens by a small tube. After subcutaneous implantation, it can be

punctured percutaneously and semen can be withdrawn. The advantage of this reservoir is that the epididymis is not compromised and further semen retrieval options remain available. The implantation technique is relatively simple; an operating microscope is not needed. Multiple punctations are possible and allow collection of punctates for freeze conservation and pooling. Concern exists about a reduction of sperm quality in the punctate after 5–6 months of implantation.

Recently, *testicular sperm aspiration* (TESE), combined with intracytoplasmic sperm injection (ICSI) proved to be a successful option.

Patients

A total of 219 unselected patients with spinal cord injury wanted to have semen collected. The average duration of the spinal cord lesion was 11.9 years (maximum 24 years). Seven patients had an infranuclear, 212 a supranuclear lesion (51 tetraplegics; 161 paraplegics). Supranuclear patients were treated by vibrostimulation. When this failed, staged further treatment was applied: physostigmine medication and vibrostimulation; electroejaculation; physostigmine with electroejaculation, surgical approaches. Infranuclear patients were treated immediately by electroejaculation. From these men, 109 sought treatment because they wanted to father children.

Results

Semen retrieval

Semen collection by conservative methods was possible in 157 patients (72%) (Figure 1). Vibrostimulation was successful in 138 of 212 supranuclear patients (65%), of whom five after physostigmine and electroejaculation in all seven infranuclear lesions and in 12 supranuclear patients failing on vibrostimulation. Eight patients had physostigmine with electroejacula-

Figure 1 Distribution of supra- and infranuclear lesions and success rates of conservative semen retrieval in 219 spinal cord injured males

tion. Retrograde ejaculation occurred more frequently after electroejaculation (11/19; 58%) than after vibrostimulation (3/138; 2%). Semen quality was reduced in all patients, after electroejaculation more than after vibrostimulation. The total number of spermatozoa was varying, relative motility at 10–20%. Hormonal status and testicular histology were uneventful. No correlation between duration of lesion and reduced semen quality was detected.

Fertility

For 109 couples who sought treatment because they wanted to have children (Table 1), semen collection was possible by conservative methods in 82 men. Sixty-

three pregnancies could be initiated in 37 couples, in 18 more than once. Fifty-one healthy children were born (three twins), 13 abortions occurred, two pregnant at the preparation of the paper. Sixty pregnancies resulted with semen retrieved from vibrostimulation (35/73 couples, 48% success rate), three after electroejaculation (2/9 couples, 22%). Thirty-seven pregnancies were achieved in 22 couples who practised semen collection and insemination at home. In 15 couples 26 pregnancies were induced after conservative semen retrieval in the department (one vibration with physostigmine, one electroejaculation, one electroejaculation with physostigmine). *In vitro* fertilisation (IVF) was applied in two cases (three pregnancies) and ICSI in one, all after vibrostimulation retrieval.

Table 1 Semen retrieval and pregnancies in 109 spinal cord injured males wishing to father

Conservative retrieval (82 men): Vibrostimulation: 72; + physostigmine: 1 Electroejaculation: 8; + physostigmine: 1							
Location	Semen retrieval	Fertilisation	Couples	Pregnancies	Births	Abortions	Pregnant during preparation of paper
Home	Vibrostimulation	Insemination	22	37	32 11	4	1
Clinic	Vibrostimulation	Insemination	9	18	Twins: 2 1	6	1
Clinic	Vibrostimulation	IVF	2	3	Twins	2	
Clinic	Vibrostimulation	ICSI	1	1	1		
Clinic	Vibrostimulation + physostigmine	Insemination	1	1	1		
Clinic	Electroejaculation	Insemination	1	1		1	
Clinic	Electroejaculation + physostigmine	Insemination	1	2	2		
	Subtotal	Success after conservative retrieval	37	63	48 Twins: 3	13	2
		No pregnancy inducible	45				
Surgical retrieval (27 men):							
Semen retrieval	Fertilisation	Couples	Pregnancies	Births	Abortions	Pregnancy actual	
Wagenknecht spermatocele	Insemination	1	1	1			
Brindley reservoir	IVF	4	4	3 Twins: 1	1		
Brindley reservoir	ICSI	2	2		2		
TESE	ICSI	2(+ 1*)	3	2		1	
Subtotal	Success after surgical retrieval	9	10	6 Twins: 1	3	1	
	No pregnancy inducible	18		8 Wagenknecht – no semen available 11 Brindley – insemination (1 TESE-ICSI later); 1 Brindley – IVF (TESE-ICSI later)			
*This couple had one pregnancy after Brindley implantation with IVF earlier							
Totals		Couples	Pregnancies	Births	Abortions	Pregnancy actual	
	Pregnancy inducible	46	73	54 Twins: 4	16	3	
	No pregnancy inducible	63					

Surgical methods allowed semen retrieval in 19 patients. In nine patients a Wagenknecht spermatocele was created and in 18 a Brindley reservoir implanted. One pregnancy was induced by insemination after sperm retrieval from a Wagenknecht spermatocele (carried out). Viable semen could not be collected from these spermatoceles shortly after surgery. All Brindley reservoirs allowed retrieval of viable semen, but conservative insemination was unsuccessful in the first 11 couples. Six pregnancies could be induced in six couples; four IVF treatments led to three births (one twin) and one abortion; two ICSI treatments ended both with abortion.

Three couples have been successfully treated by TESE and ICSI. Two pregnancies were carried out, the other one is actual. All three had Brindley reservoir implantation before, one couple had a child born after IVF already, in one IVF and in one conservative insemination was unsuccessful.

Discussion

The present results on semen collection in spinal cord injured men (Figure 1) compare well with literature data²⁰ (Table 2). In 88% of the patients in whom semen collection was possible by conservative methods, this was achieved by vibrostimulation (138/157). Of 19 patients in whom electroejaculation was necessary, 12 had a supranuclear lesion but did not respond to vibrostimulation. Physostigmine injection was necessary in five patients with vibrostimulation and eight with electroejaculation (all supranuclear lesions). Pregnancies were induced mostly and more effectively with semen retrieved from vibrostimulation.

Electroejaculation has the drawbacks of increased incidence of retrograde ejaculation (58% vs 2% in this study; cf.^{21,22}), even more reduced sperm quality^{5,21–25} maybe by a direct deleterious effect of the electrical current,^{25–27} a rare risk of rectal wall damage^{12,28} and its application is feasible only in a clinical setting. Vibrostimulation often enables semen collection and insemination in the home intimacy^{5,6,9} (Table 1, 22 couples). Those research groups that use electroejaculation for semen retrieval only, irrespective of the lesion location, do not report higher overall retrieval rates^{29–32} (Table 2), and could have better treatment for their patients with high lesions by vibrostimulation.

The results of the Wagenknecht spermatocele are generally disappointing, because of early fibrosis of the channel between epididymis and spermatocele. This prevents transfer of sperm cells to the spermatocele. Brindley's sperm reservoir allows multiple punctation and retrieval of semen that can be pooled until the amount of spermatozoa allows IVF or ICSI. However, the quality of the punctated semen might deteriorate after about 6 months of implantation.

TESE followed by ICSI was used successfully in three patients in this study. This technique is probably the easiest way for surgical collection of semen by the urologist, but the further preparation of semen cells

from the biopsy and ICSI are complex procedures. Nevertheless, congenital anomalies after this procedure are comparable to those in children that were conceived in a physiological way. Human genetic consultation to prevent hereditary pathology is, however, advisable before ICSI. Foetal karyotyping (chorionic villi biopsy, amniocentesis) and specific sonography (DEGUM II/DEGUM II) are also advised.

Microsurgical epididymal sperm aspiration (MESA) followed by *in vitro* fertilisation^{5,33} had disappointing results as compared to the Brindley sperm reservoir and *in vitro* fertilisation³³ and is thus not advocated. Sperm pooling is more effective with the sperm reservoir and less adverse effects on the condition of the vas are to be expected.

Fertility in spinal cord injured men is generally reduced, probably because of reduced semen quality.^{20,22,31} In this study, a relative motility of 10–20% could not be explained by hormonal status or testicular histology. The cause may be cofactorial: long-lasting lack of semen transport, chronically increased scrotal temperature,³⁴ level of the lesion, and – interestingly – method of bladder evacuation. Controversy exists on the significance of the lesion level. A trophic effect of low lesions on testicular function, with disturbance of maturation and improved spermatogenesis is reported.³⁵ Contrary, a decrease in sperm motility related to a lower level of the lesion is found by other researchers.³⁶ The last group also reports a better sperm motility in patients who evacuate by self catheterisation, as compared to patients who perform triggered voiding. They suppose that high pressure in the prostatic urethra during the triggered voiding causes urine influx into the adnexae. The duration of the lesion does not impair the quality of semen. No relation was found in this study, which corroborates standing literature. Medical improvement of sperm quality is not possible. Contrary to other

Table 2 Conservative semen retrieval in spinal cord injured males

Authors	Patients	Success
Dahlberg <i>et al</i> ⁵	35	29 (83%)
Nehra <i>et al</i> ⁶	78	61 (78%)
François <i>et al</i> ⁷	140	96 (68%)
Brindley ⁸	195	100 (51%)
Siösteen <i>et al</i> ²¹	32	29 (91%)
Amelar and Dubin ²⁹	134*	80 (60%)
Halstead <i>et al</i> ³⁰	12*	10 (83%)
Hargreave ³¹	92*	56 (61%)
Sarkarati <i>et al</i> ⁴¹	34	29 (85%)
Bennett <i>et al</i> ⁴²	37*	22 (59%)
Madersbacher and Ebner ⁴³	53	40 (75%)
Total	842	552 (66%)
Review:		
Beckerman <i>et al</i> ²⁰	428	257 (60%)
Present study	219	157 (72%)

*: Only electroejaculation

Table 3 Pregnancy rates after semen retrieval in spinal cord injured males

Authors	Couples	Success
Dahlberg <i>et al</i> ⁵	35	22 (63%)
Nehra <i>et al</i> ⁶	27	17 (63%)
François <i>et al</i> ⁷	83	33 (38%)
Brindley ⁸	24	11 (45%)
Amelar and Dubin ²⁹	14	2 (14%)
Hargreave ³¹	14	6 (43%)
Bennett <i>et al</i> ⁴²	10	4 (40%)
Total	207	95 (46%)
Present study	109	46 (42%)

researchers^{21,37–39} no improvement of semen quality after repeated stimulations was found^(40,41).

In this study, semen could be retrieved by conventional methods in 82 men from 109 couples (75%), the majority by vibrostimulation (73/82, 89%), and pregnancies induced in 37 of 82 couples (45%). After semen collection by vibrostimulation, conventional insemination was successful in the vast majority of these cases (56 of 60 pregnancies, 93%). The overall pregnancy rate (46 of 109 couples, 42%) compares with literature data^{7,8,29,31,42} (Table 3). Assisted fertilisation techniques (IVF, ICSI) might increase the overall pregnancy rate after collection of semen from spinal cord injured men, particularly when surgical techniques for semen collection are used.

Conclusions

The results of this study reconfirm that collection of semen by vibrostimulation is possible in most spinal cord injured men, particularly because the incidence of supranuclear lesions (97% in the present data) is much higher than that of infranuclear lesions. Apart from these patients with infranuclear lesions, electroejaculation will be necessary only in selected cases. In about two thirds of the patients sperm is indeed retrieved after vibrostimulation. Physostigmine injections can enhance semen emission when the stimulation techniques fail. In all patients the semen quality is considerably reduced, even more so after electroejaculation. Fertilisation was often successful with sperm retrieved from vibrostimulation, but failed after electroejaculation in many patients in this study. Also, vibrostimulation can be performed in a non-clinical setting. Thus, vibrostimulation is advocated as the method of choice for semen retrieval in spinal cord injured males with lesion higher than Th11, enhanced by physostigmine when necessary, with conservative insemination for couples who want offspring.

When surgical intervention is necessary, Brindley sperm reservoir implantation with *in vitro* fertilisation is the first option. Compared to microsurgical epididymal sperm aspiration the implantation is much easier. Compared to both MESA and direct vas aspiration, the harvest of sperm cells for pooling is

greater, and the pregnancy rate considerably better. Thus, MESA is not advocated. When no pregnancy can be induced with semen from the reservoir, testicular aspiration of semen with preparation of the sperm cells and intracytoplasmic sperm injection appears to have the best chances.

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