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Physical Neuro-Urological Examinationin Patients with Spinal Cord Injury Revisited

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Results: 121 individuals were included, 80 males and 41 females, age 46 ± 16 years old, with different levels and completeness of SCI, determined with ASIA/ISCoS International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI). The examination was done 6.6 ± 12 years post lesion. The findings did not differ between gender or age, except that ASR was more frequently absent in women and ASC diminished with increasing age.

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Conclusions: The different components of the physical neuro-urological examination give complementary information on parts of the peripheral innervation and ascending and descending nervous pathways sfrom and towards the lower part of the spinal cord, and on the pelvic floor muscular status. Their combination permits togain detailed information on the nervous structures involved in SCI.

Keywords: SCI, neuro-urological, physical examination, sensation, reflexes, contraction.

Data Archiving and Data Availability: The data are in the patient files. Data from the database are available on request to the corresponding author, blinded for patient name and file number and other information that might consist a breach of confidentiality.

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I. Introduction

Besides inspection and palpation of the genitalia, a physical neurological examination is part of the neuro-urological diagnosis in patients with a suspected or known neuropathy such as a spinal cord injury (SCI). The examination comprises different techniques: sensation of touch of the dermatomes in the perineal area (SENSPER), scoring of the tone of the anal sphincter (AST), voluntary contraction of the anal sphincter/pelvic floor muscles (ASC), anal (ASR)and bulbocavernosus (BCR)reflexes, and the cremaster reflex. The tests are notinvasive, and inform about parts of the afferent and efferent peripheral innervation, the related pathways in the spinal cord, and the pelvic floor muscular status (Table 1)[1].When the reasons for the tests are explained, consent is easily obtained. The assessment of SENSPER includes a test of the patient's compliance and reliability by asking for sensation without touching[2].

We looked at data from such examinations (except cremaster reflex) in a cohort of patients with SCI. Our aim was to show that combining neuro-urological examinations in the lumbosacral area permits to refine the neurological diagnosis by evaluating ascending and descending spinal cord pathways, sacral reflex arcs and the status of the related muscles.

II. Materials and Methods

This is a retrospective study on a consecutive cohort of SCI patients, investigated in a standardised way, when they presented for urodynamic evaluation during a period of 2 years. Patient age and sex, cause of SCI, and their neurological status determined following the ASIA/ISCoS International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI) were gathered, with the American Spinal Injury Association Impairment Scale score (AIS)(2).No data were included from patients who did not have a urodynamic investigation. The tests were performed 8 ±12 years after SCI as part of regular follow up (n=77) or as part of an extra evaluation (n=44), e.g. for changed spasticity, increase in AD.

The evaluation of the somatosensory afferent innervation was done in the dermatomes S3-S5 with light touch, blinded for the patient and with fake touching introduced to check for reliability. The findings were scored as 0= absent, 1= presentin all dermatomes and 2= present in part of the dermatomes or only on one side, for which the details are given. in the results. Then followed four tests with an intrarectal fingertip: the AST was graded by gentle lateral stretching ((0= absent with flaccid muscle and sometimes open anus, 1= weak with little resistance, 2= strong resistance); the ASC was scored as 0= no contraction possible, 1= contraction possible, 2 =strong contraction. Distinction was made with a reflex contraction provoked by the introduction of the finger. The ASR was elicited by making a brisk lateral movement of the fingertip in the anus and was considered positive if the sphincter grabbed the finger (0= absent, 1= present but not strong, 2= strong).Finally, the BCR was elicited with a brisk squeezing of the glans penis/clitoris and the same scoring system was used as for ASR [1].The differentiation between scores 1 and 2was subjective but made by experienced physicians.

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Statistical analysis was done with SPSS28, using Chi-Square (value, df, p value) for categorical, ANOVA for age, and Kappa (k, p value) for comparison of the outcome of two different tests. Statistical significance was set at $p<0.05$.

III. Results

The cohort consists of 121patients,80 males and 41 females, age 47 ± 16 years old. The examination was done 6.6 ± 12 years post SCI.AIS was determined 8 ± 17 days before the test .

There was no significant difference between gender (Chi-Square) for SENSPER (5.55, df 2, p=0.062), AST(1.33, df 2, p=0.514), ASC (3.21, df 2, p= 0.200), BCR (5,05, df 2, p=0.80). The ASR reflex was statistically more absent in women: in 54% (22/41) vs in 41% (33/80) of men (12.18, df 2, p=0.002). No influence of age was found on the neuro-urological physical examinations ANOVA for all (but one) test (SENSPER p=0.218; AST p=0.0.751; ASR p= 0.192; BCR p= 0,485; ASC became weaker with raising age (p=0.002).

The findings of the physical examination in the groups with different spinal cord level and lesion type are presented in table 1, together with the innervation used for the sensation, tone, contraction and reflexes tested.

The outcome of the SENSPER was unreliable in 7 patients not included in the study cohort. When the neuro-urological findings were compared in complete and incomplete lesions, a positive statistical significance(chi-square) was found for SENSPER (65.51,df 2, $p<0.001$). In complete lesions 20/67, 30% had touch sensation; in incomplete lesions SENSPER in all dermatomes or in part of them was present in 49/54 (91%) and absent in 5 (9%). Absence of S4-S5 sensation was found in 5 patients with incomplete lesion (1 cervical, 2 thoracic, 1 thoracolumbar and 1 cauda). Twenty patients had sensation but only in parts of the dermatomes (Table 1 score= 2): S3 present both sides and S4-S5 absent in 12 patients, S3 present at one side with S4-S5 absent in 5 patients, S4-S5 present only one side 2 patients, S5present only one side 1patient.Interpretation of ASC was uncertain because of interfering spasticity in 2 patients examined in the same period, who were not included in the cohort.ASC was possible in 3/67 (4.5%) of the complete lesions and in 40/54 (74 %) of the incomplete lesions.

A comparison between complete and incomplete lesions is given for each test in table 1. To evaluate if the different tests gave similar results Kappa was done . Between ASR and BCR an almost perfect relation was found in complete (k 0.810 $p<0.001$) and a good relation in incomplete (k 0.734 $p<0.001$). Significant similarity ($p<0,05$)was in complete lesions found between SENSPER-ASC and AST- ASR but both with a low k (0.118 and 0.202 respectively). In incomplete, significance in similarity of outcome in AST-ASR and AST-BCR had medium k of 0.294 and 0.261 respectively.

The tests were repeated in 31patients who had not shown changes in their neurological status (determination of AIS was done mean 5 days before the second urodynamics and compared with the one done at the time of the first urodynamics, with an interval of 32 ± 31 weeks). All tests were highly reproducible (Table 3).

IV. Discussion

A neuro-urological physical examination includes testing of motor, sensory, muscular and reflex function in the lower sacral segments(table 1).

In our cohort the relation between AIS and SENSPER was highly positive, as would be expected as sacral sensation is used to help determine AIS. But in a number of complete lesions SENSPER was positive, and in a number with incomplete lesion SENSPER was absent. The reasons may be: unsuspected change in the neurological situation since the last determination of AIS, sensation present in part of the perineal area not examined in the original scoring (especially S3 versus S4-S5), insufficient attention to pitfalls and not introducing fake tests, insufficient cooperation of the patient, and presence of multiple lesions [1-3]. A SCI patient may strongly want to feel without being able to do so. Doubtful outcome of SENSPER was found in some patients examined during the same period who reported sensation while not being touched, but they were not included in this study. Finnerup et al evaluated

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sensation evoked by painful or repetitive stimulation below injury level in patients with a clinically complete (AIS A) lesion. Their findings suggest retained sensory communication across the injury in complete SCI, and they suggested the term 'sensory discomplete' (4).

Muscle tone is the continuous and passive-partial contraction of the muscle or the muscle's resistance to passive stretch during the resting phase [5].If the AST is slack (our score 0), it mostly indicates peripheral motor denervation while a normal or strong tone(our score1 and 2) points at decentralization. Previous interventions on the anus or lower bowel must be considered, and an overfilled rectal canal at the time of the examination must be avoided. We found the AST globally not related to the AIS score. We also did not find a relation between AST and ASC, while AST was positively related to ASR(minor significance in complete/mediocre in incomplete) and BCR (mediocre in incomplete lesions), suggesting some role of the lowest spinal reflex activity for the tone of the anal sphincter. A negative relation between AST and ASC has been found in non-neurogenic women with provoked vestibulodynia who combined greater PFM resting stiffness with a decrease in the strength of the pelvic floor muscle contraction[6]. Malouf and Kamm presented the case of a women who had suffered a SCI T12-L1 24 years previously [7]. On rectal examination her anus was closed at rest but gaped after digital examination for several minutes. Palpable voluntary ASC was absent. This sign should be distinguished from the "gaping anus" seen in some patients with faecal incontinence or rectal prolapse, where the AST is permanently diminished, and the sphincter remains always open. In patients with a lesion below L1 (n=17) we found in 4 patients an atonic sphincter which on palpation remained open for a short time. A closed but slack sphincter was present in 1, and AST was normal in 12. The perianal skin sensation to light touch was reduced in the Malouf and Kamm's patient. In our group we did not find a statistical relation between SENSPER and AST, which may suggest that pudendal afferent pathways are only playing a reflex related role in AST.

Voluntary contraction of the anal sphincter and the pelvic floor muscles is normally present if the corticospinal tract is preserved and is a sign that the SCI is motor incomplete. The anal sphincter contraction and anorectal motility was studied by Sun et al in a small sample [8]. They found in patients with incomplete spinal lesions (6 high, 11 low and 3 mixed) a low squeeze pressure of the anal sphincter. In those with T10-L1 lesion in our study tone was present in the anal sphincter in the majority, while ASC was mostly absent. This again indicates the importance of the integrity of the lower spinal cord in the preservation of the anal sphincter tone and the independence of descending spinal cord pathways.

It has been described that healthy men have a stronger anal sphincter pressure compared with women, and findings were similar in cases with chronic constipation[9].It is generally accepted that the condition of muscles diminishes with age, and also in our data such influence was seen. Nielsen and Pedersen found no significant correlation between external sphincter thickness and age on endosonography [10]. When the SCI is motor incomplete, Vasquez et al showed in selected cases that a 6-weekprogram of pelvic floor muscle training (PFMT) may have a beneficial effect on promoting voluntary control of neurogenic detrusor overactivity and may reduce incontinence [11]. This indicates that PFMT can interact more broadlythan only through an increase of the muscle strength.

We have no explanation why in our sample ASR was more absent in women, while no gender differences were found for any of the other tests.

The ASR reflex has afferents in the pudendal nerve, which take synapse in the spinal cord and travel back via the inferior hemorrhoidal nerve to the external anal sphincter [12-14].

The BCR is multisynaptic, mediated mostly by the roots S2–4 , occasionally with synapses as high as L5 [15-16]. The efferent innervation can include S5 [16].Impulses from the glans penis and the frenulum run via the dorsal nerve of the penis/clitoris or perineal nerve, mostly through the dorsal roots andback from the motor neurons and pudendal nerves to the external anal sphincter and bulbocavernosus muscles [17-18].Wang et all showed in suprasacral SCI patients with detrusor overactivity, that 63.0% (58 of 92) had a normal bulbocavernosus reflex (BCR) response (19).

ASR and BCR were in our study statistically significantly related ($p > 0.001$), likely due to the similar innervation involved in both reflexes. But some differences between ASR and BCR were seen and may be caused by a difficulty to elicit, especially the BCR, as seen in healthy individuals [20-21].

The presence of sacral reflexes below the level of injury is key to determining an UMN lesion, absence of sacral reflexes defines a lower motor neuron (LMN) lesion [22].

Extrapolation from the neurological examination to the nature of the neurogenic LUTD is only possible to a certain extent. Wyndaele found a correlation between different levels of SCI, the function of the bladder neck and sphincter, and the ACR and BCR. Higher lesions corresponded more with a reflex lower urinary tract and somatic motor activity, lower lesions more with areflexia. With a lesion between thoracic 10 and lumbar 2 as many reflective as a-reflective dysfunctions were found. Detrusor and striated sphincter reflexia/areflexia corresponded significantly with the presence/absence of bulbocavernosus and anal reflexes. The presence or absence of perineal sensation of light touch has been shown to correspond significantly with the presence or absence of sensation in the lower urinary tract [23]. In SCI patients with thoracolumbar fractures pinprick sensation in the perineal area was shown to have negative predictive value: absence of pinprick sensation predicted poor bladder recovery [24]. Alexander et al found that subjects with greater preservation of sensation in S3-S5 reported greater ability to initiate and control voiding [25].

For a detailed diagnosis of the LUT function after SCI clinical examination alone is not sufficient [23], as also concluded by Moslavac et al [26].Dartos-cremaster reflex is predictive of some aspects of sexual and bladder neck function in men[27]. It has in our study be done in a few patients only and was thus not included in the results.

Pavese et al could predict urinary continence and complete bladder emptying 1 year after traumatic SCI with the full prediction model relying on lower extremity motor score (LEMS), light-touch sensation in the S3 dermatome of ISNCSI, and SCIM subscale respiration and sphincter management.[28] In patients with ischemic SCI the same model was also useful to predict functional bladder outcome [29].

We conclude that different techniques of lumbosacral physical examination give each a complementary information in the neurological diagnosis after SCI. Our results show that in most tests a different outcome is seen. Only BCR and ASR gave good to perfect similarity in the results. But their outcome can be different as seen in some of our cohort. Combining the tests permit to evaluate ascending and descending spinal cord pathways, sacral reflex arcs and the status of the related muscles.

Limitations of our study are that it is retrospective., the interpretation of the tests is done manually by clinicians and is subjective based on experience. Electrodiagnostic tests and cerebral imaging permit semiobjective and objective measurements which are today not often done outside research.

Statement of Ethics: We certify that all applicable institutional and governmental regulations concerning the ethical use of the data were followed during this research.

Conflicts of Interest: the authors have no conflicts of interest.

Author Contributions:

- Wyndaele Jean Jacques collected the file data, put them in a database, made evaluations and wrote the text.
- Wyndaele Michel contributed to data interpretation and read and corrected the text.

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Table 1: Results of the Examination in Patients with a Different AIS Score and Lesion Level

Nervous system related to the tests / Spinal cord levels and lesion type	SENSPER Afferent: pudendal S3-S5 through fasciculi gracilis towards brain (ref 1)			AST Afferent: pudendal Efferent: pudendal nerve and suprasegmental nuclei (ref 3)			ASC Efferent: corticospinal tract and pudendal nerve (ref 1)			ASR Afferent pudendal S2-S4 Efferent Inferior hemorrhoidal nerve (ref 10-12)			BCR Afferent L5-S4 pudendal Efferent: deep perineal, inferior hemorrhoidal nerve (ref 14-16)			
	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2	
Complete																Total
C1-C8	13	2	4	2	10	7	18	1	-	6	8	5	8	7	4	19
T1-T9	25	4	1	3	19	8	30	-	-	8	13	9	9	13	8	30
T10-L1	8	-	4	4	5	3	11	1	-	9	3	-	9	3	-	12
L2-S3	-	1	1	-	2	-	1	1	-	-	2	-	-	2	-	2
Conus/cauda	1	1	2	1	2	1	4	0	-	4	-	-	4	-	-	4
total	47	8	12	10	38	19	64	3	-	27	26	14	30	25	12	67
Incomplete																Total
C1-C8	1	21	3	2	15	8	17	7	1	8	13	4	10	10	5	25
T1-T9	2	6	1	2	5	2	9	-	-	5	3	1	5	2	2	9
T10-L1	1	6	2	4	4	1	7	1	1	5	3	1	6	3	-	9
L2-S3	-	6	2	1	7	-	4	4	-	2	4	2	2	5	1	8
Cauda	1	2	-	2	1	-	3	-	-	2	1	-	2	1	-	3
total	5	41	8	11	32	11	40	12	2	22	24	8	25	21	8	54
Global total	52	49	20	21	70	30	104	15	2	49	50	22	55	46	20	121
Chi Square between complete and incomplete	65.51, df 2, p<0.001 More absent in complete			1.42, df 2, p= 0.491 No difference			14.470, df 2, p<0.01 More absent in complete			1.156, df 2, p = 0.561 No difference			0.344, df 2, p= 0.842 No difference			

SENSPER= touch sensation perineal dermatomes S3-S5=0 absent, 1= present,2= present in only parts of area; AST= tone anal sphincter; ASC= voluntary contraction anal sphincter; ASR= anal sphincter reflex; BCR= bulbocavernosus reflex. ASC, ASR and BCR are graded as 0= absent, 1=not strong, 2=strong.For AST :0= absent with flaccid muscle and sometimes open anus, 1= weak with little resistance, 2= strong resistance. Complete = AIS A, incomplete= AIS B-D. - = no patient with this finding.

Table 2: Outcome of the Tests in Groups of at Least 7 Patients with the Same Level of Lesion and Complete or Incomplete Lesion

Level injury	Number patients	SENSPER			AST			ASC			ASR			BCR		
		0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
C5 Complete	3	3	-	-	-	1	2	3	-		1	1	1	1	1	1
C5 Incomplete	4	1	3	-	-	4	-	3	1		2	2	-	2	2	-
D8 Complete	5	5	-	-	-	3	2	5	-		1	2	2	2	2	1
D8 Incomplete	2	-	2	-	-	2	-	2	-		1	1	-	1	1	-
L1 Complete	2	2	-	-	-	2	-	2	-		1	1	-	1	1	-
L1 Incomplete	5	1	2	2	3	2	-	5	-		4	1	-	4	1	-
Cauda Complete	4	1	1	2	1	2	1	4	-		4	-	-	4	-	-
Cauda Incomplete	3	1	2	-	2	1	-	3	-		2	1	-	2	1	-

Table 3: Results of Repeated Testing with an Interval of Mean 32 Weeks in 31 Patients who had Unchanged AIS Scores (%).

Test	No change	Appearance while originally absent	Disappearance while originally present	Total	Missing values
SENSPER	26 (84%)	4	1	31	0
AST	24 (83%)	1	4	29	2
ASC	27 (90%)	3	-	30	1
ASR	16 (59%)	7	4	27	4
BCR	16 (67%)	6	2	24	7