Description of Urological Surveillance and Urologic Ultrasonography Outcomes in a Cohort of Individuals with Long-Term Spinal Cord Injury

Jacinthe J.E. Adriaansen, MD, PhD,[1] Floris W.A. van Asbeck, MD, PhD,[1] Helma M.H. Bongers-Janssen, MD,[2] Dorien Spijkerman, MD,[3] ALLRISC, Johanna M.A. Visser-Meily, MD, PhD,[1] Laetitia M.O. de Kort, MD, PhD,[4] and Marcel W.M. Post, PhD[1,5]*

[1]*Center of Excellence in Rehabilitation Medicine, Brain Center Rudolf Magnus, University Medical Center Utrecht and De Hoogstraat Rehabilitation, Utrecht, the Netherlands;* [2]*Spinal Cord Injury Department, Rehabilitation Center Sint Maartenskliniek, Nijmegen, the Netherlands;* [3]*Spinal Cord Injury Department, Rehabilitation Center Rijndam, Rotterdam, the Netherlands;* [4]*Department of Urology, University Medical Center Utrecht, Utrecht, the Netherlands;* [5]*Center for Rehabilitation, University of Groningen, University Medical Center Groningen, Department of Rehabilitation Medicine, Groningen, the Netherlands*

Background: Individuals with spinal cord injury (SCI) have an increased risk of developing urological complications. Therefore, long-term routine urological surveillance is recommended. **Objective:** To describe urological surveillance in individuals with long-term SCI and to determine factors associated with urologic ultrasonography (UU) outcome. **Methods:** Wheelchair-dependent individuals with an SCI for 10 years or more were included. A medical assessment was done in 8 participating rehabilitation centers. The International Lower Urinary Tract Function Basic SCI Data Set was used to assess bladder-emptying methods and previous surgical procedures on the urinary tract. We studied urological surveillance: whether participants had routine urological checkups (including UU) and when latest urodynamic study was performed. Latest UU (performed <1 year ago) was retrieved or, when lacking, UU was performed as part of our study. **Results:** Median time since injury (TSI) was 22.0 years. Overall, 39% of the 282 participants did not have routine urological checkups and 33% never had a urodynamic study performed. UU data ($N = 243$) revealed dilatation of the upper urinary tract (UUT) in 4.5% of the participants and urinary stones in 5.7%. Abnormal UU outcome was associated with increasing TSI, nontraumatic SCI, and previous surgical bladder or UUT stone removal. UU outcome was not associated with routine urological checkups or type of bladder-emptying method. **Conclusions:** Over one-third of Dutch individuals with long-term SCI did not receive routine urological surveillance. UU outcome was not associated with routine urological checkups or type of bladder-emptying method. Further research on the indication and frequency of urological surveillance is recommended. **Key words**: *long-term care, neurogenic, spinal cord injuries, ultrasonography, urinary bladder, urinary tract*

Introduction

Urological surveillance and improved medical management have contributed to greatly reduced rates of mortality due to urological complications in spinal cord injury (SCI).[1] However, individuals with SCI remain at risk of developing urological complications, which are the leading cause of rehospitalization after traumatic SCI.[2] The increased risk of developing urological complications, such as renal stones and upper tract dilatation, is coupled with an often atypical clinical presentation.[3] Therefore, long-term routine urological surveillance is recommended.

The European Association of Urology (EAU) published an extensive guideline on Neurogenic Lower Urinary Tract Dysfunction (NLUTD) in 2008.[4] Based on expert opinion, a follow-up scheme is recommended in which urologic ultrasonography (UU) should be performed every 6 months. Urodynamic study is recommended every 2 years and yearly in patients with detrusor overactivity and/or low bladder compliance.

*See list of ALLRISC members in the Acknowledgments.

Corresponding author: Marcel W.M. Post, PhD, Center of Excellence in Rehabilitation Medicine, University Medical Center Utrecht and De Hoogstraat Rehabilitation Utrecht, Rembrandtkade 10, 3583TM Utrecht, the Netherlands; e-mail: m.post@dehoogstraat.nl

Top Spinal Cord Inj Rehabil 2017;21(1):78–87

www.scijournal.com

doi: 10.1310/sci2301-78

Less rigorous recommendations concerning urological surveillance have been published by the Paralyzed Veterans of America,[5] the Spinal Cord Injury Think Tank from the United Kingdom,[6] and the Dutch Urological Association.[7] This last guideline states that the urological surveillance interval can vary depending on the neurological pathology and the type of neurogenic bladder dysfunction.[7] For patients with high bladder pressures, urological surveillance, including UU and urodynamic studies, should be performed every 1 to 2 years. In case of low bladder pressures and little postvoid residual volume, no routine urodynamic studies are necessary.

The only component of urological surveillance that is recommended in all guidelines is routine UU to detect upper urinary tract (UUT) abnormalities. UU is noninvasive, cost-effective, and easy to perform, making it an established component of urological surveillance to date.[8]

Few studies explored the outcomes of UU and the influencing factors in individuals with long-term SCI. One study found renal stones to be present in 9.7% of the participants and dilatation of the UUT in 17.3%.[9] Increasing age and TSI were associated with renal scarring, but not with renal stones and UUT dilatation. Another study retrospectively reviewing renal ultrasonography outcomes in individuals with long-term SCI found moderate or severe dilatation of the UUT, renal scarring, or a renal size less than 8 cm in 26.3% of the participants.[10] A higher incidence of UUT abnormalities was associated with the use of a suprapubic indwelling catheter in this study[10] and with transurethral catheter use in another long-term follow-up study.[11]

Previous studies in other countries have reported a variable adherence to the available urological surveillance guidelines[12-15] and just few studies have explored UU outcomes in individuals with long-term SCI, therefore we conducted this study with the following aims:

1) To describe current urological surveillance in a cohort of Dutch individuals with long-term SCI.
2) To explore whether demographic and injury-related factors, type of bladder-emptying method, and routine urological checkups are associated with the outcome of UU.

Methods

Design

The current study is part of the Dutch multicenter research program Active LifestyLe Rehabilitation Interventions in aging Spinal Cord injury (ALLRISC).[16] This is a TSI-stratified cross-sectional study among individuals with long-term SCI living in the Netherlands. TSI strata were 10 to 19, 20 to 29, and 30 or more years after SCI.

Participants

Inclusion criteria were (a) traumatic or nontraumatic SCI with a TSI of 10 or more years, (b) age at injury of 18 to 35 years, (c) current age of 28 to 65 years, and (d) wheelchair-dependency (hand-rim propelled or electric wheelchair) at least for longer distances (>500 m). Exclusion criterion was insufficient mastery of the Dutch language.

Basis for the power analysis was the aim to detect differences in the prevalence of secondary health conditions between TSI strata. With alpha = 0.05 and power = 0.80, a prevalence of 0.2 can be estimated with a margin of error of ±4.6%. A prevalence difference of 0.2 (0.3 vs 0.5) between 2 TSI strata with 100 participants each would be statistically significant with the same alpha and power. For regression analysis, this number of 300 participants would allow inclusion of 19 independent variables in the analysis using the rule of thumb of 15 participants per variable. Therefore, it was aimed to include 100 participants per stratum.

Procedure

Eligible individuals were identified through databases from all 8 Dutch rehabilitation centers with a specialty in SCI rehabilitation. The study consisted of a 1-day visit to the rehabilitation center for a checkup including an extensive medical assessment and physical examination performed by a SCI rehabilitation physician and an oral interview and several physical tests performed by a research assistant.[16] Two weeks before the visit to the rehabilitation center, participants were asked to complete a self-report questionnaire.[16] The

research protocol was approved by the Medical Ethics Committee of the University Medical Center Utrecht. All participants gave written informed consent.

Instruments

Personal characteristics: Questions concerning age, nationality, relationship status, educational level, and employment were addressed in the self-report questionnaire.

Urological surveillance: Routine urological checkups were defined as routine checkups with a urologist and/or by routine UU in a hospital or specialized rehabilitation center. Participants were asked and the medical files were checked as to whether the participants had had a UU of the bladder and the UUT within the 12 months prior to the visit and in which year the latest urodynamic study was performed.

Urologic ultrasonography: When UU was performed more than 1 year ago, a new UU of the bladder and UUT were requested. The results of UUs performed more than 1 year prior to the visit were reclaimed with approval of the participants. All UUs were evaluated by a radiologist and classified as abnormal in case of dilatation of the UUT or renal and/or bladder stone(s).

Bladder management: The International Lower Urinary Tract Function Basic Spinal Cord Injury Data Set was used to assess bladder-emptying methods and previous surgical procedures on the urinary tract.[17] If participants used more than one type of bladder-emptying method, only the main (most frequently used) bladder-emptying method was reported.

Urinary tract infections: One question about UTIs within the last 3 months was asked. UTI was defined as a symptomatic infection of the urinary tract, which was treated with antibiotics. Symptoms had to include one or more of the following: onset of urinary incontinence, increased spasticity, malaise, autonomic dysreflexia, discomfort or pain during urination, gritty particles or mucus in the urine, or cloudy or smelly urine.

Injury-related characteristics: The International Standards for Neurological Classification of Spinal Cord Injury were used to assess the level and completeness of the injury.[18] Tetraplegia was defined as a lesion at or above the first thoracic segment and paraplegia as a lesion below the first thoracic segment. A complete lesion was diagnosed in the absence of motor and sensory function in the sacral segments, that is, American Spinal Injury Association Impairment Scale (AIS) grade A. AIS grades B, C, and D were considered incomplete. The self-report questionnaire included the date of the origin of the SCI, age at injury, and cause of the injury.

Statistics

Descriptive analyses were performed. Data was partly missing because some participants did not complete the self-report questionnaire ($N = 266$). Furthermore, UU outcomes were lacking in 39 participants due unwillingness ($n = 8$), no appointment for UU ($n = 5$), no referral for UU ($n = 5$), health issues ($n = 3$), UU performed too late ($n = 2$), deceased ($n = 2$), and unknown ($n = 14$). The actual number of each analysis is reported in the Results section.

The chi-square test and Fisher's exact test were used to explore associations between the categorical variables. Since age was normally distributed, the independent samples t test was used to compare 2 independent groups on this continuous measure. TSI was not normally distributed so the Mann-Whitney U test was used to test for differences between 2 independent groups on this continuous measure. The level of significance was set at $p < .05$. All analyses were performed by using the SPSS statistical software program (SPSS 21.0 for windows; IBM Corp; Armonk, NY).

Results

Participant characteristics

Between November 2011 and February 2014, a total of 566 individuals were invited to participate in the study; ultimately 292 participated. Main reasons for nonparticipation were a large travel distance, unwillingness, being too busy, and having health issues. Afterwards, 10 participants who did not meet all eligibility criteria were excluded from the analyses. The characteristics

of the 282 participants are described in **Table 1**. A nonresponse analysis was not possible, because not all participating rehabilitation centers could provide the required information concerning the nonrespondents.

Table 1. Participant characteristics ($N = 282$)

Characteristics	
Age, years, mean (*SD*)	48.3 (8.9)
Age at SCI, years, median (IQR)	23.4 (20.6-27.7)
Time since injury, years, median (IQR)	22.0 (17.0-30.5)
Time since injury strata, %:	
10-19 years	38
20-29 years	34
≥30 years	28
Gender, % male	74
Nationality, % Dutch[a]	96
Relationship, % married/stable relationship[a]	61
Level of education, % college/university[a]	44
Employment, % having paid work ≥1 hour/week[a]	39
Cause, % traumatic	91
Level, %	
Paraplegia	59
Tetraplegia	41
AIS, %	
A	69
B	14
C	10
D	8
Previous surgical procedures of the urinary tract, %	
Bladder stone removal	9
UUT stone removal	6
Cystectomy	1
Nefrectomy	1

Note: AIS = American Spinal Injury Association Impairment Scale; SCI = spinal cord injury; UUT = upper urinary tract.
[a] Data extracted from the self-report questionnaire: $N = 268$.

Urological surveillance

Overall, 39% of the participants had no routine urological checkups (**Table 2**). This percentage was not significantly different among the 3 TSI groups. In about half of the participants, no UU was performed in the past year. Urodynamic study was done 0 to 5 years prior to the checkup in 29% of the participants, 6 to 10 years prior in 9%, and more than 10 years prior in 20%. For 10% of the participants, this was not known and one-third of the participants had never had a urodynamic assessment after the onset of their injury. More participants in the TSI 30 or more years group never had a urodynamic study performed compared to those in the TSI 10 to 19 years and 20 to 29 years groups.

A comparison between participants with and without routine urological checkups is given in **Table 3**. Significant differences in the severity of the lesion and the type of main bladder-emptying methods were observed.

Urological surveillance and bladder-emptying methods

The proportion of participants without routine urological checkups for the different main bladder-emptying methods was as follows: normal voiding, 86%; voluntary bladder reflex triggering, 42%; condom catheter drainage, 41%; bladder expression, 67%; clean intermittent catheterization (CIC), 32%; sacral anterior root stimulation (SARS), 27%; indwelling catheter (transurethral or suprapubic catheter), 44%; and urinary diversion, 25%.

Table 2. Distribution of routine urological checkups and urinary tract evaluation by ultrasonography and urodynamic study for the 3 TSI groups and for the total group of participants

	TSI: 10-19 years (*n*=107)	**TSI: 20-29 years (*n*=96)**	**TSI: ≥30 years (*n*=79)**	**Sig.**	**Total (*N*=282)**
No routine urological checkups	38 (35.5%)	40 (41.7%)	33 (41.8%)	.586	111 (39.4%)
No urologic ultrasonography in the past year	54 (50.5%)	44 (45.8%)	35 (44.3%)	.672	133 (47.2%)
No urodynamic study after injury	29 (27.1%)	28 (29.2%)	35 (44.3%)	**.032**	92 (32.6%)

Note: Sig = significance; TSI = time since injury.

Table 3. Comparison of demographic and injury-related characteristics and type of main bladder-emptying methods for participants with and without routine urological checkups

	Routine urological checkups		
	Yes	**No**	**Sig.**
Age, years, mean (*SD*)	47.9 (8.9)	49.1 (8.8)	.268
Time since injury, years, median (IQR)	21.0 (16.0-30.0)	24.0 (17.0-31.0)	.291 .586
Time since injury strata, %			
10-19 years	40.4	34.2	
20-29 years	32.7	36.0	
≥30 years	26.9	29.7	
Cause, %			.619
Traumatic	91.8	90.1	
Nontraumatic	8.2	9.9	
Level, %			.693
Tetraplegia	40.4	42.7	
Paraplegia	59.6	57.3	
AIS, %			**.002**
A	73.1	61.8	
B	12.3	15.5	
C	11.1	7.3	
D	3.5	15.5	
Gender, %			.363
Men	76.0	71.2	
Women	24.0	28.8	
Relationship, %			.868
Married/stable relationship	61.2	60.2	
Single	38.8	39.8	
Education: college/university, %			.281
Yes	41.8	48.5	
No	58.2	51.5	
Employment, %			.868
Having paid work, ≥1 hour/week	38.8	39.8	
Not having paid work	61.2	60.2	
Main bladder-emptying method, %			.000
CIC	48.5	33.3	
Indwelling catheter	13.5	16.2	
Condom catheter drainage	11.1	11.7	
Bladder reflex triggering (voluntary)	10.5	11.7	
Urinary diversion	7.0	3.6	
SARS	6.4	3.6	
Normal voiding	1.8	16.2	
Bladder expression	1.2	3.6	

Note: AIS = American Spinal Injury Association Impairment Scale; CIC = clean intermittent catheterization; IQR = inter-quartile rang; SARS = sacral anterior root stimulation; *SD* = standard deviation; Sig. = significance; TSI = time since injury.

Urologic ultrasonography

A total of 243 UU studies were analyzed. Fewer participants without UU data had routine urological checkups (33%) compared to participants with UU data (63%) (p = .003). No other differences between these groups were observed.

Urologic ultrasonography outcomes

Ninety percent of the 243 UUs were classified as normal (**Table 4**). Dilatation of the UUT was observed in 4.5% of the participants and renal and bladder stones in 4.5% and 1.2%, respectively. A significant decrease in the proportion of normal UU outcomes with increasing TSI was observed.

Increasing TSI, having nontraumatic SCI, and previous surgical bladder or UUT stone(s) removal were the only variables associated with an abnormal UU outcome (**Table 5**). Previous surgical bladder or UUT stone(s) removal was, however, only associated with bladder and/or renal stones and not with dilatation of the UUT (data not shown). There were no significant differences in UU outcome for the different bladder-emptying methods nor for the participants with and without routine urological checkups.

Discussion

This study is one of the few addressing urological surveillance and UU outcomes in individuals with long-term SCI. The results show that over one-third of our participants did not receive routine urological checkups and that one-third of the participants never had any urodynamic study performed. Meanwhile, the frequency of abnormal UU outcomes was relatively low and not associated with receiving routine urological checkups.

Urological surveillance

A total of 39% of the participants did not receive routine urological checkups, including no routine lower and UUT imaging studies. This observation is in contrast with the recommendations of all guidelines on NLUTD. Studies on urological surveillance in individuals with SCI in other countries also demonstrated inadequate adherence to the respective guidelines.[12,14,15] For instance, a

Table 4. Results of the urologic ultrasonography outcomes for the total group (*N*=243) and for the 3 TSI groups.

	TSI: 10-19 years (*n*=90)	**TSI: 20-29 years (*n*=83)**	**TSI: ≥30 years (*n*=70)**	**Sig.**	**Total (*N*=243)**
Normal (no dilatation or renal / bladder stones)	86 (95.6%)	74 (89.2%)	58 (82.9%)	**.031**	218 (89.7%)
Dilatation in UUT	3 (3.3%)	3 (3.6%)	5 (7.1%)	.457	11 (4.5%)
Renal stone(s)	2 (2.2%)	5 (6.0%)	4 (5.7%)	.414	11 (4.5%)
Bladder stone(s)	0 (0.0%)	1 (1.2%)	2 (2.9%)	.262	3 (1.2%)

Note: Values given as *n* (%). Sig = significance; TSI = time since injury; UUT = upper urinary tract.

Table 5. Bivariate analyses for the association between potential predictors and an abnormal urologic ultrasonography outcome

	Normal urologic ultrasonography outcome (%) (*n*=218)	**Abnormal urologic ultrasonography outcome (%) (*n*=25)**	**Sig.**
Age, years, mean (*SD*)	48.1 (8.9)	50.7 (8.5)	.179
TSI, years, median (IQR)	21.0 (17.0-30.0)	29.0 (21.0-37.0)	**.017**
Gender			.097
Male (*n*=179)	72.0	88.0	
Female (*n*=64)	28.0	12.0	
Education			.313
Low (*n*=149)	54.5	43.5	
High (college/university) (*n*=119)	45.5	56.5	
Completeness of SCI			.822
Complete: AIS A (*n*=167)	68.3	72.0	
Incomplete: AIS B, C, or D (*n*=76)	31.7	28.0	
Level of SCI			.672
Paraplegia (*n*=144)	58.7	64.0	
Tetraplegia (*n*=99)	41.3	36.0	
Cause of SCI			**.019**
Traumatic (*n*=220)	92.2	76.0	
Nontraumatic (*n*=23)	7.8	24.0	
Main bladder-emptying method			.745
CIC (*n*=109)	44.0	52.0	
Indwelling catheter (*n*=32)	13.3	12.0	
Bladder reflex triggering (voluntary) (*n*=27)	11.5	8.0	
Condom catheter drainage (*n*=26)	11.0	8.0	
Normal voiding (*n*=17)	6.9	8.0	
SARS (*n*=12)	5.5	0.0	
Urinary diversion (*n*=15)	5.5	12.0	
Bladder expression (*n*=5)	2.3	0.0	
Urologic ultrasonography in the past year			.794
Yes (*n*=142)	58.7	56.0	
No (*n*=101)	41.3	44.0	

(*Continued*)

Table 5. Bivariate analyses for the association between potential predictors and an abnormal urologic ultrasonography outcome (CONT.)

	Normal urologic ultrasonography outcome (%) (*n*=218)	Abnormal urologic ultrasonography outcome (%) (*n*=25)	Sig.
Routine urological checkups			.092
Yes (*n*=154)	65.1	48.0	
No (*n*=89)	34.9	52.0	
UTI(s) in the past 3 months			.275
Yes (*n*=84)	35.8	24.0	
No (*n*=159)	64.2	76.0	
Surgical bladder stone(s) or UUT stone(s) removal in the past			**.008**
Yes (*n*=32)	11.0	32.0	
No (*n*=211)	89.0	68.0	

Note: AIS = American Spinal Injury Association Impairment Scale; CIC = clean intermittent catheterization; SARS = sacral anterior root stimulation; TSI = time since injury; UTI = urinary tract infection; UUT = upper urinary tract.

recent study from the United States reported that only 35.7% of a large cohort of individuals with SCI visited a urologist in a 2-year period.[12]

A higher proportion of participants receiving routine urological checkups was expected based on a survey among Dutch urologists.[19] In this survey, 84% of the urologists claimed to perform routine follow-up in patients with NLUTD every 6 or 12 months.[19] Possible explanations for this apparent discrepancy are that some participants might not have been referred to a urologist at all or that some participants may have been noncompliant with scheduled follow-up contacts. Factors identified as being associated with noncompliance are costs, distance, transportation, time, and the belief that follow-up was not necessary.[20]

In 53% of the participants, UU was performed within 1 year prior to participation in this study. This does not correspond with the recommended 6 or 12 monthly assessment of the UUT with UU according to the available guidelines on NLUTD. Unfortunately, however, there is no evidence regarding the optimal follow-up intervals of UU with respect to long-term UUT outcomes.

Disappointingly, many participants never had had a urodynamic study after their injury (33%), especially since all published guidelines on NLUTD recommend performance of urodynamics at least once after SCI to determine lower urinary tract function and risk of UUT impairment.[4-7] However, recall bias, as well as the loss of information in medical records of a period of up to 47 years, may have played a role. The fact that participants with a shorter TSI had urodynamic studies performed more often may also be explained by the increasing recognition of the value of urodynamic studies in more recent decades.

Urologic ultrasonography outcomes

UU showed no dilatation of the UUT nor signs of renal and/or bladder stones in a high proportion of participants (90%). Few studies exploring UU outcomes in individuals with long-term SCI are available.[9,21] In one study evaluating urinary tract complications over a 6-year period (mean TSI, 33 years), renal stones were present in 9.7% and UUT dilatation in 17.3%.[9] These numbers are higher compared to our findings, but that study used a longer observation period with 3 assessments instead of 1.

Vaidyanathan et al performed UU in 87 individuals with SCI without urinary symptoms (eg, recurrent UTIs, passing blood in urine, or purulent urine) and in 21 individuals with urinary symptoms.[21] Some abnormalities were detected in 24 of the 87 individuals without urinary symptoms (eg, mild hydronephrosis in 1 and renal stones in 5 individuals); according to the authors, no specific surgical or medical intervention was needed.

Increasing TSI, having a nontraumatic SCI, and previous surgical bladder or UUT stone(s) removal were the only characteristics that were associated with an abnormal UU outcome in

our study. To our knowledge, only 2 previous studies have investigated potential risk factors for abnormal UU outcomes in individuals with long-term SCI.[9,11] The first study observed no significant associations between both renal stones and upper tract deterioration with age, TSI, completeness of the lesion, level of injury, and type of bladder-emptying method.[11] The second study also found no associations between age and TSI with the presence of renal stones or dilatation of UUT.[9]

It has been demonstrated that the prevalence of recurrent renal stone disease is high in individuals with SCI with reported frequencies of 34% to 64%.[22,23] Bladder stone recurrence appears to be 23%.[24] These data support our observation of an increased risk of finding urological stones with UU in individuals with a history of surgically removed bladder and/or renal stone(s).

Despite the number of individuals with (in) voluntary reflex voiding not receiving routine urological surveillance (41%), the frequency of abnormal UUs in these groups of participants was relatively low (7.4%-8.0%) and did not significantly differ from the frequency of abnormal UUs in the CIC group (11.9%). However, the subgroups in our study were too small to draw conclusions from this observation.

Limitations

There were some limitations concerning this study. First, its cross-sectional design limits the ability to interpret associations with TSI due to a possible (onset) cohort effect. Second, as high bladder pressure is supposed to increase the risk of UUT dilatation, stratification based on urodynamic outcome would be recommended. Unfortunately, in our study population, too few urodynamic parameters were available to calculate risk for UUT dilatation based on bladder pressure. Third, we lacked information on the reason why participants had not received routine urological surveillance. Fourth, we were not able to perform logistic regression analysis due to the small number of participants with abnormal UU outcomes. Hence, these study results should be regarded as descriptive and exploratory. Fifth, individuals with UUT deterioration may have died prematurely and were thus not evaluated, causing selection bias. Finally, due to the inclusion criteria, our study sample predominantly consisted of participants with a traumatic and complete SCI who obtained their SCI at a relatively young age, not corresponding with the general Dutch SCI population.[25]

Implications for future research

The fact that guidelines on the management of NLUTD in SCI are available does not necessarily mean that all individuals with SCI receive care accordingly. Individuals with long-term SCI may not be aware of the importance of urological surveillance because of a lack of education about this issue. More research on factors that may cause individuals with SCI not to receive urological surveillance is needed. Furthermore, the fact that all available guidelines on urological surveillance are mainly based on expert opinion supports the need for further research concerning the content, indication, and frequency of urological surveillance.

Taking into account the low percentage of abnormal UU outcomes, the recommended frequency of UU needs to be critically evaluated. Identification of risk factors for UUT deterioration or stones, including the risks associated with the use of different type of bladder-emptying methods, is of utmost importance.

Conclusion

In contrast to existing guidelines, 39% of our participants with long-term SCI did not receive routine urological checkups and 33% had never had a urodynamic study. However, UU outcome was not associated with routine urological checkups or with type of bladder-emptying method. The low frequency of abnormal UU outcomes that was found in this study supports the need for the identification of risk factors and for further research on the indication for and frequency of urological surveillance.

Acknowledgments

Dr. Spijkerman reports partial compensation of ISCOS conference attendance by Coloplast. The other authors declare no conflict of interest.

ALLRISC is sponsored by Fonds NutsOHRA under the responsibility of the Netherlands Organisation for Helath Research and Development (www.ZonMw.nl), project number 89000006. No commercial party having a direct financial interest in the results of the research supporting this article has or will confer a benefit on the authors or any organisation with which the authors are associated.

We thank all ALLRISC research assistants and SCI rehabilitation physicians for collecting all the data and the following participating Dutch rehabilitation centres: Rehabilitation Centre De Hoogstraat (Utrecht), Reade Centre for Rehabilitation (Amsterdam); Rehabilitation Centre Het Roessingh (Enschede); Adelante Rehabilitation Centre (Hoensbroek); Sint Maartenskliniek (Nijmegen); University Medical Centre Groningen, Centre for Rehabilitation-Beatrixoord (Haren); Rehabilitation Centre Heliomare (Wijk aan Zee) and Rijndam Rehabilitation Centre (Rotterdam).

ALLRISC members: Lucas H.V. **van der Woude**, University of Groningen, University Medical Center Groningen, Center for Human Movement Sciences, Center for Rehabilitation, Department of Rehabilitation Medicine, Groningen, the Netherlands; Jan **van der Scheer**, University of Groningen, University Medical Center Groningen, Center for Human Movement Sciences, Groningen, the Netherlands; Thomas W.J. **Janssen**, MOVE Research Institute Amsterdam, Faculty of Human Movement Sciences, VU University, Amsterdam, the Netherlands; Amsterdam Rehabilitation Research Center/Reade, Amsterdam, the Netherlands; Sonja **de Groot**, Amsterdam Rehabilitation Research Center/Reade, Amsterdam, the Netherlands; University of Groningen, University Medical Center Groningen, Center for Human Movement Sciences, Groningen, the Netherlands; Arjan **Bakum**, Faculty of Human Movement Sciences, VU University, Amsterdam, the Netherlands; Hans **Bussmann**, Department of Rehabilitation Medicine and Physical Therapy, Erasmus MC University Medical Center, Rotterdam, the Netherlands; Hedwig **Kooijmans**, Department of Rehabilitation Medicine and Physical Therapy, Erasmus MC University Medical Center, Rotterdam, the Netherlands; Janneke **Stolwijk**, Department of Spinal Cord Injury, De Hoogstraat Rehabilitation, Utrecht, the Netherlands; Maurits **Sloots**, Amsterdam Rehabilitation Research Center/Reade, Amsterdam, the Netherlands; Dirk **van Kuppevelt**, Sint Maartenskliniek, Nijmegen, the Netherlands; Hennie **Rijken**, Sint Maartenskliniek, Nijmegen, the Netherlands; Willemijn **Faber**, Rehabilitation Center Heliomare, the Netherland; Linda **Valent**, Rehabilitation Center Heliomare, the Netherlands; Govert **Snoek**, Rehabilitation Center Het Roessingh, Enschede, the Netherlands; Marijke **Schuitemaker**, Rehabilitation Center Het Roessingh, Enschede, the Netherlands; Marga **Tepper**, University Medical Center Groningen, Center for Rehabilitation, Department of Rehabilitation Medicine, Groningen, the Netherlands; Ferry **Woldring**, University Medical Center Groningen, Center for Rehabiliation, Department of Rehabilitation Medicine, Groningen, the Netherlands; Sandra **Slangen**, Adelante Rehabilitation Center, Hoensbroek, the Netherlands; Mia **Wynants**, Adelante Rehabilitation Center, Hoensbroek, the Netherlands; Rogier **Broeksteeg**, Rijndam Rehabilitation Center, Rotterdam, the Netherlands; Peter **Luthart**, De Hoogstraat Rehabilitation, Utrecht, the Netherlands

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