International Urogynecology Journal (2019) 30:293–300
https://doi.org/10.1007/s00192-018-3620-8

ORIGINAL ARTICLE

Bladder management during pregnancy in women with spinal-cord injury: an observational, multicenter study

Elena Andretta[1] · Lorenza Maria Landi[2] · Mirella Cianfrocca[3] · Alberto Manassero[4] · Oreste Risi[5] · Giorgio Artuso[1]

Received: 25 October 2017 / Accepted: 1 March 2018 / Published online: 29 March 2018

Abstract

Introduction and hypothesis Pregnancy in women with spinal-cord injury (SCI) poses a clinical challenge. We hypothesized that changes in the management of neurogenic bladder during pregnancy are commonly required and should receive more attention.

Methods Data were collected by retrospective analysis of medical records and via cross-sectional survey of 52 women with SCI, representing 67 pregnancies, at ten Italian neurourological clinics. All participants provided informed consent.

Results Between 1976 and 2013, 39 participants had one child, 11 had two children, and two had three children. Mean age at the time of SCI was 18 years and at the time of first pregnancy was 30 years. Delivery occurred from weeks 32 to 40 in 98% of first and second pregnancies, and 94% of neonates were healthy. Oxybutynin was used by four women during five pregnancies, which resulted in delivery of healthy babies. Intermittent catheterization was used before 54% of first pregnancies and 39% of second pregnancies. Bladder management was altered during 45% of these pregnancies, and the most common changes were increased use or frequency of intermittent catheterization or use of an indwelling catheter. Urinary tract infections occurred in 48% of pregnancies, and an irregular course was reported in 13% of pregnancies mainly related to tetraplegia and urological complications.

Conclusions Pregnancy in women with SCI generally has good outcomes and limited risks but frequently necessitates changes in the management of neurogenic bladder. High levels of awareness and focused monitoring of bladder issues are recommended.

Keywords Bladder management · Lower urinary tract symptoms · Pregnancy · Spinal cord injury · Urinary tract infection

Abbreviations

LUTS	lower urinary tract symptoms
SCI	spinal-cord injury
UTI	urinary tract infection

✉ Elena Andretta
elenaandretta@libero.it

[1] Urology Department, General Hospital, Riviera XXIX Aprile, 2, 30031, Dolo, Venice, Italy

[2] Montecatone Rehabilitation Institute, Imola, Bologna, Italy

[3] Spinal Unit, CTO Hospital, Rome, Italy

[4] Neuro-Urology Department, Torino, Italy

[5] Neuro-Urology Unit, Treviglio, Bergamo, Italy

Introduction

Spinal-cord injury (SCI) is survivable and mainly affects individuals in the prime of their lives, including women of reproductive age [1]. Worldwide, ~250,000–500,000 new cases of SCI occur annually [1, 2]. In the USA, an estimated 0.08% of the population [2], including ~20,000 women of childbearing age, presently have SCI, and the annual incidence of SCI among women of reproductive age is ~2000 [3]. Among other effects, SCI causes neurologic bladder dysfunction requiring lifetime management and follow-up; it also causes transient amenorrhea. However, sustaining an SCI is not a contraindication for pregnancy [4–7]. An annual pregnancy rate of 2% has been reported among women with SCI registered in the US National SCI database, with this figure varying according to the number of years since the injury [8]. The likelihood of

pregnancy in these women is associated with age, marital status, motor function, mobility, and occupation [8].

Current literature indicates primarily good pregnancy outcomes in women with SCI [4, 7, 9–12], but limited data are available. Nevertheless, pregnancies in women with SCI pose a clinical challenge, both for patients and their health-care professionals [9]. Reports in the literature describe barriers and unmet needs related to pregnancy in women with SCI [13–15], suggesting that standardization of treatment programs, guidelines, and policies is needed [13, 14], particularly those that involve a multidisciplinary approach [7, 12]. Recently, a one-page guidance form was established by McLain et al. [16], highlighting important information for pregnancy and delivery in women with SCI. Several initiatives are also available on the Internet.

In general, women with SCI are likely to experience the same medical problems as able-bodied women but may additionally experience specific problems related to their injuries, including autonomic dysreflexia, increased tendency of pressure sores [9], worsening of spasticity, lower urinary tract symptoms (LUTS), and constipation [5, 9]. Autonomic dysreflexia (resulting in acute hypertension) could be a significant medical complication for pregnant women with a high-level SCI [9, 17], but the most common complications are urinary [3, 12, 17]. Urinary tract infections (UTIs), in particular, have been reported as common complications in several studies [3–5, 7, 9, 12, 18, 19], and methods for their prevention have been investigated [20]. In 1992, Cross et al. published the results of a study on the relationship between bladder-management methods and UTI frequency in pregnant women with SCI in which the risk of UTI related to the use of an indwelling catheter was 100%; however, the risk was lower in patients who did not use (or who only intermittently used) a catheter [19]. Despite confirmation of this finding, definitive evidence of a correlation between catheterization and UTI in these patients is insufficient to enable general recommendations to be made [5]. Continued management of neurogenic bladder is necessary [9] in the context of reported changes in bladder and bowel function during pregnancy, including increased urinary frequency and new or worsening urinary incontinence (UI) [10]. However, it remains unclear how many women with SCI change bladder management strategies during pregnancy.

The aim of this study was to further describe changes to bladder management that occur during pregnancy in women with SCI. We hypothesized that changes in the management of neurogenic bladder during pregnancy are common in these women and should receive an appropriate level of attention. Our results will also contribute to the previously insufficient body of general outcome data related to pregnancy in women with SCI [4, 8, 9].

Materials and methods

This was a retrospective, cross-sectional, single-cohort, observational study involving ten Italian neurourological clinics. A retrospective analysis of medical records between 1976 and 2014 was performed to identify and collect data from women with SCI, including reported parity. Women with any type or severity of SCI who had undergone pregnancy and delivery and who agreed to participate in the study by signing an informed consent form were provided with a self-reporting questionnaire describing pregnancy-related outcomes. Data were extracted from completed questionnaires and medical records into a database for analysis and evaluation. Data from medical records (e.g., type and level of SCI, urodynamic findings, bladder management) were collected by urologists and SCI specialist physicians. Data from the cross-sectional survey (e.g., pregnancy course, delivery, birth) were derived from participants' recall at a specified time point, meaning that for some individuals, the survey was taken soon after pregnancy, and for others, there was a longer time span between pregnancy and survey. All applicable institutional and governmental regulations concerning ethical use of human volunteers were complied with during the course of this research.

Descriptive and inferential statistics were used to analyze data and present results, including number of study participants, means, medians, standard deviations (SD), minimum (min) and maximum (max) values for continuous data and frequencies, and percentages for categorical data. When appropriate, nonparametric statistical tests were used for descriptive and explorative purposes. P values <0.05 were considered statistically significant. To avoid confounding factors based on individual variations, data were presented and based on individual rather than event level (i.e., number of pregnancies). This—as were individual factors such as type and level of SCI—were considered to have high impact on observed pregnancy/bladder-related outcomes.

Results

Demography

A total of 52 women, with a median age of 43 years at the time of the study and a median age at injury of 20 years, were included in the study. Most (75%) women had a traumatic SCI, and the most common injury was paraplegia caused by thoracic lesion, with an American Spinal Injury Association (ASIA) Impairment Scale classification of A, indicative of a complete SCI. Details relating to SCIs are listed in Table 1.

During the study period, 39 women (75%) had one child, 11 (21%) had two children, and two (4%) had three

Table 1 Ages and details of spinal-cord injuries (SCIs) of study participants

Variables	Mean (SD)	Median (min–max)
Age, years ($N = 50$)	42 (10)	43 (19–69)
Age at injury, years ($N = 51$)	18 (9)	20 (0–36)
Lesion ($N = 52$)	*N* (%)	
Traumatic SCI	39 (75.0%)	
Nontraumatic SCI	5 (9.6%)	
Spina bifida	6 (11.5%)	
Transverse myelitis	2 (3.8%)	
Lesion type ($N = 51$)	*N* (%)	
Paraplegia	32 (62.7%)	
Paraplegia incomplete	4 (7.8%)	
Tetraplegia	5 (9.8%)	
Tetraplegia incomplete	6 (11.8%)	
Cauda equina syndrome	4 (7.8%)	
Level of lesion ($N = 48$)	*N* (%)	
Cervical C1–C7	11 (22.9%)	
Thoracic T1–T12	29 (60.4%)	
Lumbar L1–L5	6 (12.5%)	
Sacral S1–S5	2 (4.2%)	
ASIA Impairment Scale ($N = 43$)	*N* (%)	
A: complete	22 (51.2%)	
B: incomplete	12 (27.9%)	
C: incomplete	5 (11.6%)	
D: incomplete	4 (9.3%)	

ASIA American Spinal Injury Association, *SD* standard deviation

children, in each case after the occurrence of the SCI. Data from third pregnancies were omitted because they were too few to enable statistical comparison. Mean age at the time of first pregnancy was 30 years, and age of the child at data collection ranged between 4 months and 36 years. Delivery occurred between weeks 32 and 40 in 98% of pregnancies, and 94% of neonates were healthy. Table 2 shows patient-reported data related to pregnancy and delivery. Seven patients had pelvic organ prolapse (POP) after delivery, three had perineal lacerations during vaginal delivery, and one required subsequent surgical correction of a high-degree genital prolapse. Eight pregnancies (13%) had an irregular course (as defined by patients and verified by reported complications): four (50%) occurred in women with tetraplegia, three (38%) in women with paraplegia, and on irregular course (12%) occurred in a woman with cauda equina syndrome. Causes of irregular courses were recurrent UTI ($N = 2$), recurrent renal colic ($N = 1$), recurrent episodes of autonomic dysreflexia secondary to bladder overactivity ($N = 1$), placental abruption ($N = 1$), deep-vein thrombosis ($N = 1$), bleeding and risk of abortion ($N = 1$), and premature delivery ($N = 1$).

Table 2 Pregnancy and delivery data

Variables	First pregnancy	Second pregnancy	Third pregnancy
Pregnancy, *N* (%)	52 (100%)	13 (25.0%)	2 (3.8%)
Age at pregnancy, years			
Mean (SD)	30 (5)	33 (5)	
Median (min–max)	30 (17–42)	34 (21–42)	
Pregnancy course[a], *N* (%)			
Regular	46 (88.5%)	9 (81.8%)	
Irregular	6 (11.5%)	2 (18.2%)	
Week of delivery[b], *N* (%)			
<32	0	1 (8.3%)[c]	
32–<37	24 (48.0%)	5 (41.6%)	
37–40	26 (52.0%)	6 (50.0%)	
Birthweight, kg			
Mean (SD)	2.82 (0.49)	2.92 (0.43)	
Median (min–max)	2.84 (1.7–3.9)	2.70 (2.5–3.8)	
Delivery[e], *N* (%)			
Cesarean section	43 (89.6%)	10 (83.3%)	
Vaginal delivery	5 (10.4%)	2 (16.7%)	
Healthy child[f], *N* (%)	48 (96.0%)	13 (100%)	
Feeding[g], *N* (%)			
Breastfed	27 (64.2%)	4 (57.1%)	
Formula fed	13 (31.0%)	1 (14.3%)	
Combined	2 (4.8%)	2 (28.6%)	

SD standard deviation

[a] Data missing from two patients from second pregnancy ($N = 11$)

[b] Data missing from two patients from first pregnancy ($N = 50$).; data missing from one patient from second pregnancy ($N = 12$)

[c] Premature delivery occurred in week 25

[d] Data missing from one patient from first pregnancy ($N = 51$)

[e] Data missing from four patients from first pregnancy ($N = 48$).; data missing from one patient from second pregnancy ($N = 12$)

[f] Data missing from two patients from first pregnancy ($N = 50$); one reported case of clubfoot and one of lung immaturity

[g] Data missing from ten patients from first pregnancy ($N = 42$); data missing from six patients from second pregnancy ($N = 7$).

Urodynamics and bladder management before pregnancy

Forty-six of the 52 women had findings from urodynamic studies that indicated most had normal bladder compliance; only three individuals reported reduced compliance (data not shown). Detrusor–sphincter dyssynergia was present in 52% of patients, with mean bladder overactivity of 63 cmH_2O (SD 33 cmH_2O); overactive bladder (OAB) was present in 13%, with mean activity of 30 cmH_2O (SD 12 cmH_2O). Detrusor areflexia was seen in 23% of patients, and vesicoureteral reflux was reported in 6%.

Before the first pregnancy, 54% of women used intermittent catheterization, but reflex triggering (25%) and bladder expression (23%) were also reported. UI was common (38%). Pharmaceutical treatments were used for bladder overactivity by 42% of women, mainly oxybutynin immediate release (IR; 38%), which is the most commonly reimbursed anticholinergic agent in Italy. Table 3 describes details of bladder management methods before pregnancy.

Bladder management methods and complications during pregnancy

One or more methods were practiced for bladder voiding, and methods changed during 45% of first and 55% of second pregnancies. The most common changes were increased use of intermittent catheterization and use of an indwelling catheter. Most reported changes occurred early in the pregnancy, particularly the first trimester (data not shown). Of women who used antimuscarinics ($N = 22$), most ($N = 18$) discontinued therapy during pregnancy, whereas four continued on oxybutynin IR (two pregnancies in one case) and delivered healthy babies. Details related to change in bladder management are reported in Table 4.

Among the 65 pregnancies, 31 UTIs were reported (48% of pregnancies). Recurrent UTIs, defined as three or more episodes, were common, occurring in 21% of women during their first pregnancy and 15% during their second. Details related to complications are reported in Table 5. The number of UTIs was evaluated in relation to SCI severity. Recurrent cystitis and acute pyelonephritis were common in association with cervical and thoracic SCIs; during first pregnancies, acute pyelonephritis was reported in 36% of tetraplegic patients with cervical SCI but only 7% of paraplegic patients with thoracic SCI (two-tailed P value = 0.0385, Fisher's exact test) (Table 6).

In addition to UTI, new or worsening UI was reported during 46% of pregnancies (Table 5). Most problems relating to incontinence occurred in the second half of pregnancy. Participants also reported other injury-related complications, such as breathing difficulties, autonomic dysreflexia, worsening of bowel dysfunction, worsening of spasticity, and loss of independence (Table 5).

For some ($N = 16$) women in the study, a gynecologist worked in collaboration with the SCI unit. Only a few women

Table 3 Bladder management before pregnancy

Variables	First pregnancy $N = 52$	Second pregnancy $N = 13$
Bladder-management method, *N* (%)[a]		
Bladder reflex triggering	13 (25.0%)	3 (23.1%)
Bladder expression	12 (23.1%)	4 (30.8%)
Intermittent catheterization	28 (53.8%)[b]	5 (38.5%)
1–3 times per day	4 (14.3%)	1 (20.0%)
4–6 times per day	21 (75.0%)	4 (80.0%)
7–8 times per day	2 (7.1%)	–
Other	3 (5.8%)[c]	
Incontinence, *N* (%)	20 (38.5%)	7 (53.8%)
Urgency	10 (19.2%)	2 (28.6%)
Stress	6 (11.5%)	4 (57.1%)
Other	5 (9.6%)	
Pads per day		
1–3	5 (9.6%)	1 (7.7%)
≥4	7 (13.5%)	3 (23.1%)
Drug treatment, *N* (%)	22 (42.3%)	5 (38.5%)
Oxybutynin	20 (38.5%)	5 (38.5%)
Trospium chloride	1 (1.9%)	–
Botox injections	5 (9.6%)	1 (7.7%)
Sacral neuromodulation	1 (1.9%)	–

[a] Multiple-choice question enabled >1 response for women who voided in a mixed manner (e.g., bladder expression and intermittent catheterization)

[b] Clean intermittent self-catheterization was performed by 27 individuals; one had assisted clean intermittent catheterization

[c] Unspecified by two patients; specified as total incontinence by one patient before first pregnancy

Table 4 Bladder management during pregnancy

Variables	First pregnancy $N = 52$	Second pregnancy $N = 13$
Change in bladder management[a], *N* (%)	23 (45.1%)[a]	6 (54.5%)[a]
Intermittent catheterization	10[b] (43.5%)	4[c] (66.7%)
Indwelling catheter	5 (21.7%)	1 (16.7%)
Bladder reflex triggering	3 (13.0%)	–
Bladder expression	2 (8.7%)	1 (16.7%)
Other	4 (17.4%)	2[d] (33.3%)
Drug treatment, *N* (%)		
No drugs	30 (57.7%)	–
Stopped	18 (34.6%)	4 (30.8%)
Partially stopped	1 (1.9%)	–
Continued use	3 (5.8%)	1 (7.7%)

[a] Data missing from one patient from first pregnancy ($N = 51$), and two patients from second pregnancy ($N = 11$).; multiple-choice question enabled >1 response for women who voided in a mixed way (e.g., bladder expression and intermittent catheterization)

[b] Increased frequency was reported by eight patients, i.e., 6.25 (5–8) catheters per day

[c] Increased frequency was reported by two patients, with five and seven catheters per day

[d] Two patients reported stopping bladder expression

Table 5 Complications during pregnancy

Variables	First pregnancy $N = 52$	Second pregnancy $N = 13$
UTI, *N* (%)		
Events	25 (48.1%)	6 (46.2%)
Recurrent (≥3 events)	11 (21.2%)	2 (15.4%)
With fever >38 °C (i.e., pyelonephritis)	8 (15.4%)	2 (15.4%)
Antibiotic treatment	19 (36.5%)	2 (15.4%)
Incontinence, *N* (%)		
New or worsened	24 (46.2%)	6 (46.2%)
Urgency	11 (45.8%)	4 (66.7%)
Stress	5 (20.8%)	3 (50.0%)
Uncertain	8 (33.3%)	–
General, *N* (%)		
Autonomic dysreflexia	3 (7.9%)[a]	
Pressure ulcers	1 (2.6%)[b]	
Breathing difficulties	4 (10.3%)[b]	
Edema of lower limbs	12 (31.6%)[a]	
Pressure stockings	10 (26.3%)[a]	
Bowel management		
Worsening	16 (41.0%)[b]	
Spasticity		
Worsening	7 (18.4%)[a]	
Loss of autonomy	19 (50.0%)[a]	

UTI urinary tract infection

[a] Data missing from 14 patients ($N = 38$)

[b] Data missing from 13 patients ($N = 39$)

($N = 7$) reported follow-up by a gynecological expert in the SCI unit. Few patients reported having received information on the risks and complications associated with pregnancy—such as autonomic dysreflexia ($N = 4$), deep-vein thrombosis ($N = 10$), and breathing difficulties ($N = 5$)—or on delivery alternatives ($N = 30$).

Discussion

Summary of main findings

In this study, we analyzed real-life data from 67 pregnancies in 52 women with SCI, covering a period of almost 40 years (1976–2013). Most pregnancies were associated with a reasonable level of risk and the delivery of healthy neonates, confirming previous conclusions that sustaining an SCI is not a contraindication for pregnancy. However, complications do occur in these pregnancies. This study focused and data on specific complications related to bladder dysfunction. Results showed that bladder dysfunction complications are common and often warrant changes in the management of neurogenic bladder during pregnancy: half of the women participating had to change their bladder voiding method, and the most common solution was to initiate/increase use of intermittent catheterization or use an indwelling catheter.

Previously published literature

Our results confirm a number of findings reported in previous publications and also raise new questions. Pregnancy affects LUTS, as shown by van Brummen et al. that 74% of able-bodied women report pollakiuria during pregnancy and 63% report urinary urgency from week 12 onward, as well as an increase in UI with increasing gestational age [21]. LUTS in pregnancy are considered to have a multifactorial origin, and the underlying causes include pressure exerted by the uterus on the bladder, alteration of urine production, and changes in bladder capacity [22]. Pregnancy-related LUTS is expected to affect women with SCI to a wider extent than healthy women. This is especially true for those with overactive neurogenic bladder who discontinue use of antimuscarinics to avoid fetal exposure/toxicity. However, limited information is available relating to bladder management during pregnancy in women with SCI [5]. Our results seem to provide evidence that new or

Table 6 Subgroup analysis by level of injury

Level of injury	1st pregnancy *N* (%)		2nd pregnancy *N (%)*	
	UTI	UTI (pyelonephritis)	UTI	UTI (pyelonephritis)
Cervical C1–C7 ($N = 11$)	4 (36%)[a]	4 (36%)[b]	1	–
Thoracic T1–T12 ($N = 29$)	15 (52%)	2 (7%)	5	2
Lumbar L1–L5 ($N = 6$)	3 (50%)	1 (17%)	–	–
Sacral S1–S5 ($N = 2$)	1 (50%)	1 (50%)	–	–
Missing ($N = 4$)	2 (50%)	–	–	–

UTI urinary tract infection

[a] Comparison of cervical versus thoracic two-tailed *p* value 0.4882, Fisher's exact test

[b] Comparison of cervical versus thoracic two-tailed *p* value 0.0385, Fisher's exact test

worsening UI can be expected in 46% of pregnant women with SCI and that this worsening requires changes in bladder-management methods. Despite these complications, 25% of women in our study had more than one pregnancy, demonstrating acceptance of the associated symptoms and risks.

Approximately half of the women in our study experienced UTI during pregnancy, which is consistent with rates reported in the literature. Pregnancy in itself increases the risk of UTI; in women without SCI, UTI is generally the most common complication of pregnancy, and bacteriuria is associated with a 1–2% increase in the risk of developing acute pyelonephritis, which is associated with adverse maternal and fetal outcomes [23]. The risk of UTI in pregnancy is higher in women with SCI than without owing to neurogenic bladder [9]. Consistent with this, many patients in our study also had recurrent UTIs. Importantly, a high proportion of women who experienced UTIs developed pyelonephritis (~15% in first and second pregnancies), confirming that this common complication must be taken seriously with appropriate precautions and/or monitoring.

Continuation of antimuscarinic treatment during pregnancy in women with SCI needs to be further investigated. In our study sample, four women continued to use antimuscarinics during five pregnancies, and none of their babies experienced adverse effects. However, we recommend that clinicians continue to carefully consider all relevant pros and cons. For example, continued treatment of an OAB to avoid recurrent UTI needs to be weighed carefully against the potential harm that a drug might cause to the fetus [24].

Preterm delivery (before 37 completed weeks of gestation) can be expected in women with SCI. In keeping with previously reported results [3, 4, 10–12], preterm delivery occurred in 48% of pregnancies in our study, including a single, very preterm, delivery before week 32. Although this is higher than the normal rate of preterm delivery, these observations may question the general notion of high rates of preterm delivery in patients with SCI. Notably, neonates were generally healthy, and breastfeeding was possible for most mothers. Median birthweight (2.8 kg) was consistent with previous reports [4] and was lower than the average birthweight in the general population, as would be expected with this level of preterm birth.

Delivery mode in women with SCI is unpredictable. The number of Cesarean deliveries is known to be relevant in the SCI population [4, 10, 12], with estimates ranging from 20 to 69% [4]. Cultural differences between countries may affect this rate [10]. In our patient sample, the number of Cesarean deliveries was as high as 83–90%, even though relevant guidelines and published results support vaginal delivery as an option for women with SCI [9, 16, 17]. The number of Cesarean sections in our study may be related to the historical timeframe of data collection (1976–2013) and the lack of reports of specific care of pregnant women with SCI prior to the 1990s; notably, only 23 women in our study received follow-up from a gynecologist who had experience of patients with SCIs. Another contributing factor to the high number of Cesarean sections may have been the goal of controlled delivery for these potentially frail women to avoid autonomic dysreflexia and to lower the risk of prolapse and UI [25].

Significance and implications for clinical practice

Our results highlight the importance of increasing awareness of and focus on bladder management in pregnant women with SCI. Approximately half of the women in this study experienced UTI during pregnancy and had new or worsening UI. In general, we agree with previous proposals for a multidisciplinary approach to managing pregnancy in patients with SCI and to the use of standardized treatment programs [7, 12–14]. Findings with our cohort suggest considerable scope for improvement in areas such as providing information to patients regarding risks associated with pregnancy, as well as collaboration between gynecologist experts and SCI unit, when caring for pregnant women with SCI.

Because approximately half the patients in our study experienced UTI during pregnancy, and many had recurrent UTIs, measures for preventing infection need to be considered both before and during pregnancy. First, all pregnancies in patients with SCI should be monitored by referring physicians to ensure the patient receives personalized care adapted to specific neurological conditions and types of injury. Second, given the association between the use of indwelling catheters and UTI, both for neurogenic bladder in general [26] and for pregnant women with SCI in particular [5, 19], we recommend avoiding indwelling catheters in favor of intermittent catheterization whenever possible. Initiation or increased frequency of intermittent catheterization can be considered for treatment of pregnancy-related polyuria and storage LUTS. Revision of the catheterization technique or changing catheter type may be necessary. Owing to the increasing risk of infection by antibiotic-resistant bacteria, especially among the common pathogens that cause UTIs [27], a focus on prevention rather than antibiotic treatment is important. Proposals include weekly oral cycling of antibiotics [20], botulinum-toxin injections to reduce bladder overactivity before pregnancy [28], and the use of intravesical aminoglycosides can be considered in some cases [29]. Catheters with hydrophilic coatings have been identified as a cost-effective contribution toward the prevention of infection among intermittent-catheter users [30]. These procedures are part of standard care in the Italian clinics in our study and should also be considered in other settings.

Limitations

This study was limited by its observational design, so that any conclusions relating to causality should only be considered as

hypothetical, requiring further verification in prospective, controlled trials. The study design also limited the amount of available data, because retrospective collection prevented ascertainment of missing variables, which may potentially have affected the final interpretation of results. In spite of these limitations, we believe that our results provide valuable information given the limited availability of data in this field and the challenges of systematic research in the target population.

Conclusion

In conclusion, our results support previously published data indicating that pregnancies in patients with SCI generally have good outcomes with acceptable levels of risk. Our results suggest the importance of increased awareness of (and focus on) bladder issues, which are the most common complications seen these patients. Bladder-management changes during pregnancy occurred in approximately half of our cohort and mainly consisted of initiation or increased use of intermittent catheterization. In general, there is room for improvement in standardized care for pregnant women with SCI.

Acknowledgements M Åström (StatCons, Sweden) contributed to the statistical analyses and guidance, P Signani (Wellspect HealthCare, Italy) contributed to the study setup and database preparation, and M Åberg Håkansson (Wellspect HealthCare, Sweden) contributed to the manuscript preparation.

Funding The study was partially sponsored by Wellspect HealthCare, DENTSPLY IH AB, Sweden, but there was no specific compensation related to its publication.

Compliance with ethical standards

Conflicts of interest None.

Previous presentation Parts of this work were presented at the ISCoS and ASIA Joint Scientific Meeting held 14–16 May in Montreal, Canada.

References

1. World Health Organization: International perspectives on spinal cord injury www.who.int (2013).
2. Taweel WA, Seyam R. Neurogenic bladder in spinal cord injury patients. Res Rep Urol. 2015;7:85–99. https://doi.org/10.2147/RRU.S29644.
3. Ghidini A, Healey A, Andreani M, Simonson MR. Pregnancy and women with spinal cord injuries. Acta Obstet Gynecol Scand. 2008;87(10):1006–10. https://doi.org/10.1080/00016340802356909.
4. Signore C, Spong CY, Krotoski D, Shinowara NL, Blackwell SC. Pregnancy in women with physical disabilities. Obstet Gynecol. 2011;117(4):935–47. https://doi.org/10.1097/AOG.0b013e3182118d59.
5. Pannek J, Bertschy S. Mission impossible? Urological management of patients with spinal cord injury during pregnancy: a systematic review. Spinal Cord. 2011;49(10):1028–32. https://doi.org/10.1038/sc.2011.66.
6. Bughi S, Shaw SJ, Mahmood G, Atkins RH, Szlachcic Y. Amenorrhea, pregnancy, and pregnancy outcomes in women following spinal cord injury: a retrospective cross-sectional study. Endocr Pract: Off J Am Coll Endocrinol Am Assoc Clin Endocrinol. 2008;14(4):437–41. https://doi.org/10.4158/ep.14.4.437.
7. Skowronski E, Hartman K. Obstetric management following traumatic tetraplegia: case series and literature review. Aust N Z J Obstet Gynaecol. 2008;48(5):485–91. https://doi.org/10.1111/j.1479-828X.2008.00909.x.
8. Iezzoni LI, Chen Y, McLain AB. Current pregnancy among women with spinal cord injury: findings from the US national spinal cord injury database. Spinal Cord. 2015;53(11):821–6. https://doi.org/10.1038/sc.2015.88.
9. Baker ER, Cardenas DD. Pregnancy in spinal cord injured women. Arch Phys Med Rehabil. 1996;77(5):501–7.
10. Bertschy S, Bostan C, Meyer T, Pannek J. Medical complications during pregnancy and childbirth in women with SCI in Switzerland. Spinal Cord. 2016;54(3):183–7. https://doi.org/10.1038/sc.2015.205.
11. Westgren N, Hultling C, Levi R, Westgren M. Pregnancy and delivery in women with a traumatic spinal cord injury in Sweden, 1980-1991. Obstet Gynecol. 1993;81(6):926–30.
12. Le Liepvre H, Dinh A, Idiard-Chamois B, Chartier-Kastler E, Phe V, Even A, et al. Pregnancy in spinal cord-injured women, a cohort study of 37 pregnancies in 25 women. Spinal Cord. 2016; https://doi.org/10.1038/sc.2016.138.
13. Bertschy S, Geyh S, Pannek J, Meyer T. Perceived needs and experiences with healthcare services of women with spinal cord injury during pregnancy and childbirth - a qualitative content analysis of focus groups and individual interviews. BMC Health Serv Res. 2015;15:234. https://doi.org/10.1186/s12913-015-0878-0.
14. Mitra M, Long-Bellil LM, Iezzoni LI, Smeltzer SC, Smith LD. Pregnancy among women with physical disabilities: unmet needs and recommendations on navigating pregnancy. Disabil Health J. 2016; https://doi.org/10.1016/j.dhjo.2015.12.007.
15. Pebdani RN, Johnson KL, Amtmann D. Personal experiences of pregnancy and fertility in individuals with spinal cord injury. Sex Disabil. 2014;32(1):65–74. https://doi.org/10.1007/s11195-013-9319-3.
16. McLain AB, Massengill T, Klebine P. Pregnancy and women with spinal cord injury. Arch Phys Med Rehabil. 2016;97(3):497–8. https://doi.org/10.1016/j.apmr.2015.10.078.
17. American College of Obstetrics and Gynecology. ACOG committee opinion. Obstetric management of patients with spinal cord injuries. Number 275, September 2002. Committee on Obstetric Practice. American College of Obstetrics and Gynecology. Int J Gynaecol Obstet. 2002;79(2):189–91.
18. Craig DI. The adaptation to pregnancy of spinal cord injured women. Rehabil Nurs Off J Assoc Rehabil Nurses. 1990;15(1):6–9.
19. Cross LL, Meythaler JM, Tuel SM, Cross AL. Pregnancy, labor and delivery post spinal cord injury. Paraplegia. 1992;30(12):890–902. https://doi.org/10.1038/sc1992166.
20. Michau A, Dinh A, Denys P, Levy J, Chartier-Kastler E, Bernard L, et al. Control cross-sectional study evaluating an antibiotic prevention strategy in 30 pregnancies under clean intermittent self-catheterization and review of literature. Urology. 2016;91:58–63. https://doi.org/10.1016/j.urology.2016.02.007.
21. van Brummen HJ, Bruinse HW, van der Bom JG, Heintz AP, van der Vaart CH. How do the prevalences of urogenital symptoms change during pregnancy? Neurourol Urodyn. 2006;25(2):135–9. https://doi.org/10.1002/nau.20149.

22. Nel JT, Diedericks A, Joubert G, Arndt K. A prospective clinical and urodynamic study of bladder function during and after pregnancy. Int Urogynecol J Pelvic Floor Dysfunct. 2001;12(1):21–6.
23. Macejko AM, Schaeffer AJ. Asymptomatic bacteriuria and symptomatic urinary tract infections during pregnancy. Urol Clin N Am. 2007;34(1):35–42. https://doi.org/10.1016/j.ucl.2006.10.010.
24. Edwards JA, Reid YJ, Cozens DD. Reproductive toxicity studies with oxybutynin hydrochloride. Toxicology. 1986;40(1):31–44.
25. Koc O, Duran B. Role of elective cesarean section in prevention of pelvic floor disorders. Curr Opin Obstet Gynecol. 2012;24(5):318–23. https://doi.org/10.1097/GCO.0b013e3283573fcb.
26. Groen J, Pannek J, Castro Diaz D, Del Popolo G, Gross T, Hamid R, Karsenty G, Kessler TM, Schneider M, 't Hoen L, Blok B. Summary of European Association of Urology (EAU) guidelines on neuro-urology. Eur Urol. 2016;69(2):324–33. https://doi.org/10.1016/j.eururo.2015.07.071.
27. World Health Organization: Antimicrobial resistance: global report on surveillance. www.who.int (2014).
28. Morgan JC, Iyer SS, Moser ET, Singer C, Sethi KD. Botulinum toxin a during pregnancy: a survey of treating physicians. J Neurol Neurosurg Psychiatry. 2006;77(1):117–9. https://doi.org/10.1136/jnnp.2005.063792.
29. van Nieuwkoop C, den Exter PL, Elzevier HW, den Hartigh J, van Dissel JT. Intravesical gentamicin for recurrent urinary tract infection in patients with intermittent bladder catheterisation. Int J Antimicrob Agents. 2010;36(6):485–90. https://doi.org/10.1016/j.ijantimicag.2010.05.005.
30. Lamin E, Newman DK. Clean intermittent catheterization revisited. Int Urol Nephrol. 2016;48(6):931–9. https://doi.org/10.1007/s11255-016-1236-9.