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Clinical Studies

Bladder management in patients undergoing spine surgery: An assessment of care delivery

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ABSTRACT

Background: Lower urinary tract dysfunction is common in the early postoperative phase after spine surgery. Although it is essential for an optimal patient management to balance benefits and harms, it is not known which patient benefit from a perioperative indwelling catheter. We therefore evaluated urological parameters prior and after spine surgery performing a quality assessment of our current clinical practice in bladder management.

Methods: Preoperatively, all patients completed the International Prostate Symptom Score and were interviewed for urological history. Decision for preoperative urethral catheter placement was individually made by the responsible anesthesiologist according to an in-house protocol. Within and between group analyses using univariate and probability matching statistics were performed for patients with intraoperative urethral catheter-free management ($n = 54$) and those with a preoperatively placed catheter ($n = 46$). Post void residual (PVR) was measured prior and after surgery or after removal of the urethral catheter, respectively. The outcome measures consisted of postoperative urinary retention (POUR) and postoperative urological complications (PUC), defined as POUR and any catheter-related adverse events.

Results: Hundred patients undergoing spine surgery were prospectively evaluated. Sixteen of the 54 (30%) patients with urethral catheter-free management developed POUR. Length of surgery and volume of intravenous infusion were associated with POUR ($p < 0.05$). In the 46 preoperatively catheterized patients, re-catheterization was required in 6 (13%). In a fairly homogenous subgroup of 72 patients with a probability of PUC between 15 and 40%, no significant association between intraoperative urethral catheter-free management and the occurrence of PUC was found (odds ratio 2.09, 95% confidence interval 0.69 to 6.33; $p = 0.193$).

Conclusions: In case of postoperative PVR monitoring allowing de novo catheterization as appropriate, urethral catheter-free management seems to be a valuable option in spine surgery since it does not to increase PUC but minimizes unnecessary catheterizations with their related complications.

Introduction

Postoperative urinary retention (POUR) is a frequent complication after anesthesia and surgery in general [1,2]. It is associated with an increasing age, duration and type of surgery and anesthesia, perioperative fluid status, the use of opioids for pain management, and neurological co-morbidities (e.g. stroke, spinal cord lesion, diabetic polyneuropathy etc.) [3–5]. Despite the easy diagnostic by ultrasound and treatment by catheterization, if missed, POUR can cause severe complications such as urinary tract and systemic infection, short- and long-term detrusor damage by bladder overdistention, and even kidney failure [3,6].

Patients undergoing spine surgery are under a special risk for POUR as they often experience a transient voiding dysfunction in the early postoperative phase likely due to the direct proximity of bladder-relevant nerve structures [7–11]. This risk might be increased by intraoperative complications besides general reasons such as duration of surgery, perioperative fluid management, and potentially slow postop-

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erative mobilization and these patients typically receive an indwelling urethral catheter.

However, on a short term this can cause discomfort, urethral injury, and urinary tract infection (which may even increase the risk for implant infection), prolonging the hospital stay [12,13]. In the long term, urethral manipulation can lead to urethral stricture with possible lifelong impairment of patients' quality of life (QoL) and consequent relevant economic burden [14,15]. Additionally, urinary retention is a feature of cauda equina syndrome possibly caused by postoperative epidural hematoma or abscess that could be masked by urethral catheterization [16].

Although urethral catherization may be important for patient management, it is not known which patients will benefit from an indwelling urethral catheter and which patients would fail a catheter-free management. We therefore evaluated surgical and urological parameters prior and after spine surgery performing a quality assessment of our current clinical practice in bladder management.

Patients & methods

Patients

Between 04/2018 and 08/2018, a series of 100 patients (46 females (46%) and 54 males (54%)) undergoing elective spine surgery were prospectively evaluated in our tertiary care academic orthopedic center (Balgrist University Hospital, University of Zürich, Zürich, Switzerland). Study exclusion criteria were emergency operations, age <18 years, surgery in an outpatient setting, patients relying on assisted bladder emptying on a regular basis (i.e. indwelling catheter, intermittent catheterization), status after urinary diversion, or status after urinary sphincter prosthesis implantation.

All patients gave a general written informed consent, in line with the local ethics committee (Kantonale Ethikkommission Zürich, Switzerland), agreeing for reuse of medical data for research purposes. The study was performed in accordance with the World Medical Association Declaration of Helsinki [17]. The study was performed in line with the International Conference on Harmonisation (ICH) Good Clinical Practice (GCP) Guidelines (E6) [18] and the International Organization for Standardization (ISO, 14,155).

Investigation and intervention

The indication for elective spine surgery was individually set at the in-house interdisciplinary spine board. Preoperatively, all patients were interviewed for urological history and neuro-urological relevant secondary diagnosis (e.g. diabetes mellitus, stroke, Parkinson's disease etc.) [19] by a staff neuro-urologist and completed an International Prostate Symptom Score (IPSS) [20] for evaluation of lower urinary tract symptom (LUTS) and their impact on QoL. Drugs with possible influence on the lower urinary tract (LUT) (such as alpha-blockers, antimuscarinics, opioids, antidepressants, neuroleptics etc.) were assessed.

Prior surgery, post void residual (PVR) was measured by b-mode ultrasound in all patients. In addition, the prostate size was determined by transabdominal ultrasonography.

Lumbar and thoracic procedures (i.e. lumbar spondylodesis, lumbar decompression, vertebroplasty, and scoliosis correction) were performed by a posterior approach, cervical operations by an anterior approach (anterior cervical discectomy and fusion). Preoperative urethral catheterization, infusion volume, blood loss, operation time, and the use of intra- and postoperative opioids were monitored.

Decision for preoperative urethral catheter placement was individually made by the responsible anesthesiologist according to the in-house protocol:

(1) in surgeries with an expected surgery time >3 h
(2) in surgeries >2 h with expected important intraoperative volume shift (bleeding, volume-dependency for hemodynamic reasons).

All patients planned for urethral catheter-free management were asked to empty the bladder immediately prior induction of anesthesia. In all other patients a urethral catheter was placed after introduction of anesthesia. Surgeries were performed in a lying position under general anesthesia using a propofol target controlled infusion for induction and maintenance, fentanyl for intraoperative analgesia and rocuronium as intraoperative muscle relaxant.

With the aim to assess the current care delivery, the anesthesiologist was blinded for the preoperative specific urological findings assessed by the urologist and relied on the information from the general preoperative anesthesia evaluation.

In urethral catheter-free managed patients ($n = 54$), the bladder volume was measured at regular intervals on the recovery ward by b-mode ultrasound until the patient could void (then recording the voided volume and PVR).

In case of preoperative catheterization ($n = 46$), the catheter was removed in the morning on the day following surgery or in case of required intensive care treatment, in the morning after transfer to the orthopedic ward. Voided volume and PVR (again by b-mode ultrasound) were measured at the day of catheter removal.

All patients with conspicuous urological findings were further evaluated and treated according best clinical practice by the in-house neuro-urology team.

Outcome measures

POUR and postoperative urological complication (PUC) were the evaluated outcomes. POUR was defined as failure to empty the bladder spontaneously despite a strong desire to void or suprapubic pain, bladder volume >550 mL without the possibility to initiate voiding, or a PVR ≥350 mL and the need for de novo catheterization in patients with a urethral catheter-free management. For patients with a preoperatively placed catheter, the same POUR criteria applied after removal of the catheter. PUC was defined as POUR or any catheter-related adverse events (e.g. urinary tract infection, gross hematuria etc.) Within and between-group analyses were performed for patients with urethral catheter-free management versus patients with a preoperatively placed catheter.

Statistical analysis

Data distribution was tested by Q-Q plots. Normally distributed data are presented as mean ± standard deviation (SD), skewed data as median and 25th and 75th percentile. Comparing unrelated samples, the unpaired *t*-test was used.

To evaluate risk factors for POUR (within-group analyses) univariate analyses (chi-square test, Fisher's exact test, and binary logistic regression) were performed for demographic, clinical, surgical, and anesthesiological factors. Due to the small number of cases we refrained from performing a multivariate analysis to adjust for possible confounding.

For between-group analyses (patient with urethral catheter-free management versus patients with a preoperatively placed catheter), we performed a probability matching to identify patients with similar baseline risk across the two groups. For the matching, we used patients' age, the American Society of Anesthesiology (ASA) classification (I, II, III) [21], whether a urological problem was present (yes/no), whether this was a revision surgery (yes/no), length of operation time (minutes), and length of hospital stay (days). Using these parameters, the probability of PUC for each patient was estimated.

Statistical analyses were performed using Stata 14.2 (StataCorp. 2015. *Stata Statistical Software: Release 14*. College Station, TX: StataCorp LP) and IBM's Statistical Package for the Social Sciences (SPSS) V22 (IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY, USA) with $p < 0.05$ considered statistically significant.

Table 1
Patients' characteristics.

	Urethral catheter-free intraoperative management		Preoperatively placed urethral catheter	
	Females	Males	Females	Males
Number of patients	21 (39%)	33 (61%)	25 (54%)	21 (46%)
Age [years]	61±14	56±16	67±16	65±11
Diagnosis				
Radiculopathy	12 (57%)	24 (73%)	12 (48%)	10 (48%)
Lumbar	10 (83%)	21 (88%)	10 (83%)	7 (70%)
Cervical	2 (17%)	3 (13%)	2 (17%)	3 (30%)
Spinal stenosis	5 (24%)	8 (24%)	6 (24%)	7 (33%)
Low back pain	4 (19%)	1 (3%)	6 (24%)	3 (14%)
Others*	–	–	1 (4%)	1 (5%)
ASA physical status classification system				
I	3 (14%)	4 (12%)	–	–
II	12 (57%)	23 (70%)	13 (52%)	14 (67%)
III	6 (29%)	6 (18%)	12 (48%)	7 (33%)
Urologically relevant secondary diagnoses**	6 (29%)	5 (15%)	13 (52%)	8 (38%)
Urological symptoms				
Storage symptoms	6 (29%)	1 (3%)	6 (24%)	7 (33%)
Voiding symptoms	1 (5%)	3 (9%)	–	4 (19%)
Combined symptoms	1 (5%)	–	1 (4%)	2 (20%)
IPSS				
Total IPSS score	5±5	4±4	6±4	10±6
QoL due to urinary symptoms	1±1	1±1	2±1	2±1
Post void residual prior surgery [mL]	10 (0–25)	0 (0–25)	0 (0–20)	20 (10–50)
Prostate volume*** [mL]	–	28±14	–	36±21

ASA=American Society of Anesthesiologists; IPSS=International Prostate Symptom Score; QoL=Quality of Life; secondary.
Others*: fracture, neoplasia; **Urologically relevant secondary diagnoses included: polyneuropathy, Parkinson's disease, hysterectomy, colposacropexy, diabetes; *** transabdominal ultrasonography.
Normally distributed data (age, total IPSS score, QoL due to urinary symptoms, and prostate volume) are presented as mean ± standard deviation, skewed data (post void residual prior surgery) as median and interquartile range. Dichotomous data are presented as absolute numbers and percentages (in brackets).
Percentages may not sum up to 100 due to rounding.

Results

Patients' characteristics are presented in Table 1, surgical and anesthesiological parameters in Table 2. Thirty-four percent (34/100) of all patients reported urological symptoms, 36% (36/100) had urologically relevant secondary diagnosis prior surgery.

Sixteen of the 54 (30%) patients with urethral catheter-free management developed POUR. Within-group analyses revealed a significant association between POUR and length of surgery and perioperative intravenous infusion volume (Table 3).

In the 46 (46%) patients with a preoperatively placed indwelling transurethral catheter (mean catheterization period 2 ± 1 days), re-catheterization was required in 6 (13%). No factors associated with POUR could be identified in this patient group (Table 3).

Including all patients no significant difference ($p > 0.05$) in length of hospital stay was found in patients with (7.4 ± 3.9 days) or without (6.6 ± 2.6 days) POUR. No patient exceeded bladder volumes >600 mL.

In a subgroup of patients with a probability of a PUC between 15 and 40% (72 patients; 53 without and 19 patients with PUC), representing a homogeneous population, we estimated the strengths of association of an indwelling catheter and the occurrence of PUC. The corresponding odds ratio was 2.09 (95% confidence interval 0.69 to 6.33; $p = 0.193$) indicating no significant association between preoperative catheterization and the occurrence of PUC.

Discussion

Main findings

Our findings suggest that urethral catheter-free management seems to be a valuable option in selected patients (i.e. time of surgery < 3 h and no expected relevant intraoperative volume shift) undergoing spine surgery since it does not increase the occurrence of PUC, in the case that PVR is monitored postoperatively allowing de novo catheterization as appropriate. Importantly, this approach minimizes unnecessary catheterizations and therefore catheter-related short- and long-term complications and facilitates the identification of patients at risk requiring further urological assessment and treatment.

Findings in the context of existing evidence

POUR is a common problem with various reported risk factors and an incidence between 5% and 70% [3]. Patients undergoing spine surgery are presumed to have an increased risk for POUR [22,23]. However, studies evaluating POUR after spine surgery are scarce and most report on retrospective case series. McLain et al. [11] found an incidence of POUR of 23.6% in patient undergoing spine surgery under general anesthesia, and Lee et al. [10] reported an incidence of 27.1%. A much lower incidence rate was described by Altschul et al. [8] (8.8%), Gandhi et al. [9] (5.6%), and Jung et al. [24] (11.1%). A recent prospective study [7] documented POUR in 16.5% of their 687 patients, a considerably lower percentage than in our prospective cohort (30% in patients with urethral catheter-free management, 13% in patients with a preoperatively placed catheter).

The high variability between studies is most likely due to the lack of generally agreed POUR defining criteria. Even if the general definition is considered an impaired voiding after a procedure despite a full bladder that results in an elevated PVR [3], the determined criteria are often arbitrary and vary widely. In a review article, Baldiani et al. [3] found not less than 18 different POUR definitions. Having no uniform criteria it must be considered that for every study the most applicable cut-off values will be chosen to support the outcomes, e.g. the evaluation of risk factors for POUR, the comparison of operation or anesthesiologicial techniques or as in our case, the evaluation for need of preoperative catheterization.

Focusing on a patient-centered approach we defined POUR as the need for de novo or re-catheterization due to failure to empty the bladder spontaneously despite a strong desire to void or suprapubic pain,

Table 2
Surgical procedures.

	Urethral catheter-free intraoperative management		Preoperatively placed urethral catheter	
Lumbar spondylodesis		12 (22%)		35 (76%)
Surgery duration [minutes]	157±34		176±45	
Levels	2±2		2±2	
Blood loss [mL]	420±140		530±325	
Perioperative intravenous infusion [mL]	1315±530		1900±630	
Length of hospital stay [days]	7±2		8±4	
Surgery-related adverse events	1 (8%)		9 (26%)	
Urinary retention[##]	7 (58%)		4 (11%)	
Lumbar decompression		33 (61%)		6 (13%)
Surgery duration [minutes]	82±34		90±40	
Levels	1±1		2±1	
Blood loss [mL]	125±110		200±90	
Perioperative intravenous infusion [mL]	970±415		1415±385	
Length of hospital stay [days]	5±2		7±2	
Surgery-related adverse events[#]	5 (15%)		0	
Urinary retention[##]	8 (25%)		1 (17%)	
Anterior cervical discectomy and fusion		7 (13%)		5 (11%)
Surgery duration [minutes]	92±39		167±60	
Levels	1±0		2±1	
Blood loss [mL]	170±95		280±185	
Perioperative intravenous infusion [mL]	1345±445		1200±415	
Length of hospital stay [days]	5±1		6±2	
Surgery-related adverse events[#]	0		1 (20%)	
Urinary retention[##]	1 (14%)		0	
Others[†]		2 (4%)	–	
Surgery duration [minutes]	30[*] / 32[**]		–	
Levels	1[*] / 1[**]		–	
Blood loss [mL]	0[*] / 10[**]		–	
Perioperative intravenous infusion [mL]	600[*] / 500[**]		–	
Length of hospital stay [days]	7[*] / 5[**]		–	
Surgery-related adverse events[#]	no[*] / no[**]		–	
Urinary retention[##]	-/-			

[#] Surgery-related adverse events are not including urological events (i.e. postoperative urinary retention).

[##] Urinary retention: need for postoperative de novo catheterization in patients with a urethral catheter-free management or re-catheterization in patients with a preoperatively placed catheter, after removal of the catheter, respectively.

[†] One vertebroplasty.

[*] (L1) and one kyphoplasty.

[**] (T7). Absolute values are presented for these two patients. For the other categories dichotomous data (surgical procedure, preoperative catheterization, surgery-related adverse events and postoperative urinary retention) are presented as absolute numbers and percentages (in brackets), normally distributed data as mean ± standard deviation.

Table 3
Results of univariate analyses for risk factors associated with POUR.

	Urethral catheter-free intraoperative management			Preoperatively placed urethral catheter		
	OR	95%-CI	*p*	OR	95%-CI	*p*
Sex	1.33	0.41–4.37	0.64	1.12	0.48–2.61	0.56
Age	0.99	0.96–1.04	0.93	1.06	0.97–1.16	0.17
ASA physical status classification system						
ASA I[**]	Ref.			–	–	–
ASA II	0.23	0.02–2.59	0.24	Ref.		
ASA III	0.56	0.14–2.19	0.4	0.12	0.01–1.08	0.06
Urological relevant secondary diagnosis[*]	2.42	0.62–9.54	0.21	2.93	0.48–18	0.15
Nocturia	0.9	0.48–1.69	0.74	0.83	0.36–1.89	0.65
IPSS: Total IPSS score	0.97	0.84–1.11	0.62	0.97	0.81–1.17	0.76
IPSS: QoL due to urinary symptoms	1.02	0.6–1.73	0.95	0.51	0.18–1.45	0.21
Post void residual prior surgery	0.99	0.96–1.03	0.74	1.01	0.99–1.03	0.07
Prostate volume[†]	1.01	0.95–1.01	0.8	1.02	0.96–1.07	0.56
Surgical level						
Cervical[**]	Ref.			Ref.		
Lumbo-thoracic	4.62	0.38–55.51	0.23	3.5	0.59–20.81	0.17
Lumbo-sacral	0.33	0.04–2.96	0.32	0	0	0.99
Surgery duration	1.02	1.00–1.03	0.01	0.99	0.98–1.01	0.66
Perioperative intravenous infusion	1	1–1.01	0.04	1	0.99–1.01	0.41
Surgery-related adverse events	1.21	0.2–7.4	0.83	1.17	0.62–2.11	0.43

POUR=postoperative urinary retention; ASA=American Society of Anesthesiologists; IPSS=International Prostate Symptom Score; QoL=Quality of Life; OR=Odds ratio; CI=confidence interval.

[*] Urological relevant secondary diagnosis included hysterectomy, colpo-sacropexy, diabetes, polyneuropathy, stroke, Parkinson's disease, and colectomy.

[**] Used reference value for categorial variables.

[†] Male patients only.

a bladder volume exceeding >500 mL without the possibility to initiate voiding, or a PVR ≥ 350 mL. This clinical definition provides protection for the LUT, balancing the harm of bladder overdistention and catheterization. However, it requires a defined algorithm and a more resource-consuming postoperative care.

Implications for practice

In our cohort of patients undergoing spine surgery, a priori preoperative or only postoperative catheterization if necessary did not show significant differences regarding complication rates. Implementing a bladder volume assessment algorithm in standard postoperative care as described by Lee et al. [10] or Hoke et al. [25] can safely prevent bladder overdistention and avoid unnecessary preoperative catheterization with the catheter-related short- and long-term complications. In a population planned for spine surgery without specific risk factors (such as older age, preexisting LUTS, neurogenic LUT dysfunction, and an expected duration of surgery >120 min), we propose (based on our findings and the literature) to refrain from preoperative catheterization but to closely monitor postoperative bladder volume by ultrasound and to place an indwelling catheter for at least 24 h if a) the patient reports a strong desire to void or suprapubic pain and is unable to urinate, b) if the bladder volume exceeds 550 mL without the possibility to initiate voiding or c) if the PVR exceeds 350 mL. In case of persistent LUTS after catheter removal, referral to a urologist is highly recommended.

Implications for research

To enhance research quality and allow a better comparability between studies it is crucial to formulate and establish a standardized, generally accepted POUR definition. Beside research aspects such a definition must meet clinical standards guaranteeing a safe patient-tailored management.

The complex control mechanisms of the LUT, involving both the central and peripheral nervous system, imply that many patients with indications for spine surgery have an increased risk for neurogenic LUT dysfunction and POUR. For better understanding of the pathophysiology involved, urodynamic assessments prior and after surgery as well as long-term urological outcomes would be of great interest warranting well sampled and powered prospective observational and interventional studies to evaluate measures directly improving care delivery. Results from our assessment lay an important data foundation for both kind of studies giving the fact, that the used POUR definition and the implemented criteria for preoperative catheterization allowed a positive balance between benefits and harms.

Limitations of the study

This study has several limitations. The analyzed cohort was relatively small, and the study was not conducted in a randomized design. For complex risk factor calculations, the required number of patients would have been much higher. However, our study was prospective and even more important, the study cohort represented patients seen in daily clinical practice undergoing spine surgery allowing for an assessment of care delivery. Based on our findings it will be possible to appropriately design prospective randomized controlled trials to consolidate our conclusions.

Conclusions

Based on our findings, urethral catheter-free management seems to be a valuable option in selected patients undergoing spine surgery since it does not increase PUC in case of postoperative PVR monitoring allowing de novo catheterization if needed. This strategy minimizes unnecessary catheterizations and catheter-related complications. However, more high-quality research, i.e. appropriately sampled and powered randomized controlled trials, is needed to evaluate specific risk factors, for which our present study provides an important data foundation.

Tweet: Urethral catheter-free management is a valuable option in spine surgery if postoperative PVR monitoring allows catheterization when needed.

Declaration of Competing Interest

The authors declare that they have no competing interests.

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Supplementary materials

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