Postoperative Bladder Catheterization Based on Individual Bladder Capacity

A Randomized Trial

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ABSTRACT

Background: Untreated postoperative urinary retention can result in permanent lower urinary tract dysfunction and can be prevented by timely bladder catheterization. The author hypothesized that the incidence of postoperative bladder catheterization can be decreased by using the patient's own maximum bladder capacity (MBC) instead of a fixed bladder volume of 500 ml as a threshold for catheterization.

Methods: Randomized parallel-arm and single-blinded comparative effectiveness trial conducted in 1,840 surgical patients, operated under general or spinal anesthesia without an indwelling urinary catheter. Patients were randomized to either use their individual MBC (index) or a fixed bladder volume of 500 ml (control) as a threshold for postoperative bladder catheterization. Preoperatively, the MBC was determined at home by voiding in a calibrated bowl. All other bladder volumes were measured by ultrasound. Postoperatively, bladder catheterization was performed when spontaneous voiding was impossible, and the ultrasound measurement exceeded the threshold for the group in which the patient was randomized (500 or MBC). The primary outcome was the incidence of bladder catheterization.

Results: The average MBC in the control group was 582 ml (±199 ml) and in the index group 611 ml (±209 ml). The incidence of catheterization decreased from 11.8% (107 of 909 patients) in the control group to 8.6% (80 of 931) in the index group (relative risk 0.73, 95% CI 0.55 to 0.96, *P* = 0.025). There were no adverse events in either group.

Conclusions: In patients undergoing surgery under general or spinal anesthesia using the MBC rather than a fixed 500 ml threshold for bladder catheterization is a safe approach that significantly reduces the incidence of postoperative bladder catheterizations. (ANESTHESIOLOGY 2015; 122:46-54)

AFTER almost any surgical procedure, the recurrence of spontaneous voiding can be impaired. If the delay of spontaneous voiding results in bladder distension beyond the maximum bladder capacity (MBC), postoperative urinary retention (POUR) is present.[1] In-and-out bladder catheterization is the standard treatment for POUR.[2,3] The incidence of POUR is unknown; estimates vary between 5 and 70%, depending on the definition applied. Definitions of POUR, as part of clinical protocols for postoperative bladder catheterization, are often based on expert opinion and vary between hospitals.[4–6] If POUR is left untreated, overdistension of the bladder wall may occur, which can damage the detrusor muscle, potentially leading to a complete inability to void with the need for lifelong intermittent self-catheterization.[7–9] This is especially the case if the duration of the overdistension exceeds 2 to 3 hours.[10,11]

What We Already Know about This Topic

- Postoperative urinary retention is a potential complication of surgery and anesthesia
- It is unclear at what volume we should consider bladder catheterization

What This Article Tells Us That Is New

- In a prospective trial involving 1,840 patients, maximum bladder capacity was determined before surgery
- Using predetermined maximum bladder capacity, the authors demonstrated that a reduction in the need for postoperative bladder catheterization could be achieved

In the Western world alone, more than 70 million people undergo surgery each year. Even if the risks of serious permanent sequelae of POUR are very low, it would still affect

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thousands of patients annually. However, reliable data on how often patients develop permanent postoperative bladder damage are scarce and mostly rely on case reports. On the other hand, preemptive in-and-out catheterization in every surgical patient to prevent overdistension is a procedure most patients prefer to avoid. Bladder catheterization costs money, nursing time, and bears its own risks (trauma, infection).[12,13] To prevent bladder overdistension, portable bedside ultrasonography can be used to determine bladder volumes postoperatively.[14–16] Surprisingly, there is no evidence as to what constitutes a "safe" maximum bladder volume in surgical patients, but is it likely to vary between patients. Bladder volumes between 400 and 600 ml are commonly used as thresholds for bladder catheterization to prevent POUR.[4–6,17]

In a previous study, measuring maximum bladder volumes in volunteers, large bladder volumes with large interindividual variations (200 ml to more than 1 l)—independent of age, sex, or height—were observed (average bladder volume 567 ± 190 ml).[18] Therefore, we hypothesized that many surgical patients are catheterized "too early" when an arbitrary, but commonly accepted limit for a maximum bladder volume of 500 ml is used, instead of the patient's individual MBC. But, on the other hand, patients may also be catheterized "too late" if their MBC is smaller than 500 ml. Knowledge of a patient's individual MBC combined with postoperative serial ultrasound measurements of actual bladder volume might reduce the incidence of POUR and will result in a more selective use of perioperative bladder catheterization. Such practice potentially reduces both overtreatment (unnecessary catheterizations and its attendant risk) and undertreatment (late catheterization with the risk of an overdistended bladder).

The current randomized trial investigated the superiority of using the patient's individual MBC (index group) as a threshold for postoperative bladder catheterization, as compared to a fixed volume of 500 ml (control group).

Materials and Methods

Participants

Written informed consent was obtained from all patients. All consecutive patients who visited the preanesthesia assessment clinic (PAC) at the Medical Center Leeuwarden (a large referral hospital in The Netherlands) were invited to participate in this study. Eligible patients were clinical patients undergoing elective surgical procedures and patients undergoing surgical procedures performed in day care. They were 18 yr or older and were planned for surgical intervention under general or spinal anesthesia without the anticipated need for an indwelling catheter preoperatively. Consenting patients agreed to follow the instructions for measuring their individual MBC at home, to be randomized to one of the two parallel study arms, and to complete the questionnaires as required by the study protocol.

This study was conducted in compliance with Helsinki Guidelines (2008 revision) and started after approval from

the Ethical Review Board of the Medical Center Leeuwarden (protocol no. TPO 523) and after approval from the Central Committee for Human Studies (Centrale Commissie voor Mensgebonden Onderzoek [CCMO] registered trial database no: NL 21058.099.07 www.ccmo.nl, The Hague, The Netherlands). The study is registered in the Current Controlled Trials database no: ISRCTN97786497 (http://www.controlled-trials.com/ISRCTN97786497).

Measurements

Following the advice from our consulting urologist consenting patients were asked to completely empty their bladder at their preoperative visit at the PAC to be able to measure their residual bladder volumes by ultrasound (BladderScan; Verathon Inc., Bothell, WA). Ultrasound residual urine volume measurements were performed by the PAC-nursing staff and research assistants.[19,20] All consenting patients received a measuring bowl (Glaswarenfabrik Karl Hecht KG, 97647 Sondheim/Rhône, Bayern-Germany) and instructions how to measure their maximum voided volumes at home. They were asked to measure the maximum voided bladder volume at least three times in the weeks before the operation: two times during the day and once immediately after waking up in the morning. They were instructed to postpone voiding until a strong urge appeared. The feel of a strong urge is different for each patient, but we considered this voided volume as the maximum bladder volume that could be determined noninvasively in a stress-free environment and would still be safe, without any burden for the patient. The MBC was then calculated as the reported maximum voided volume at home (in the calibrated bowl) plus the residual volume measured at the PAC (by ultrasound).

It was unknown if catheterization based on the expected larger bladder volume limit might harm bladder function. For this safety reason, all patients were asked to complete two standard lower urinary tract symptoms questionnaires at home. Both questionnaires had to be answered before surgery, but were repeated also a day, a week, and a month after surgery by telephone or e-mail. Any disturbances—changes in voiding pattern—that could have been caused by reaching larger bladder volumes or by catheterization could then be recorded.

The first questionnaire was the International Prostate Symptoms Score (IPSS) with questions about possible voiding complaints such as hesitancy, incomplete emptying, or nighttime voiding. Each answer was recorded on a scale from 0 (no, does not happen) to 5 or 7 (happens all the time). The second questionnaire was about the possible change, pre- and postoperatively, of lower urinary tract symptoms on the Quality of Life (QoL).[21,22]

Randomization

A computer program randomly assigned 2,500 case record form numbers in a 1:1 ratio to the control group or to the index group (1,250 numbers for each group). Patients received an information folder with their case record form number

printed, and a calibrated bowl to measure the voided volume. The folder contained information about the study, including the two questionnaires, instructions on how to perform the MBC measurements at home, together with a form on which to record the MBC measurements and an informed consent form. After surgery, upon arrival at the postanesthesia care unit (PACU), the patients case record form number was coupled to either the control or to the index group according to the preoperatively performed randomization. The research assistant was the only person aware of the group randomization.

Control Treatment

In the control group, a fixed volume of 500 ml was set as the threshold volume, above which catheterization was performed if the patient was unable to void spontaneously. Postoperatively, after arriving at the PACU, the patient's bladder was scanned by the research assistant. If the patient was not able to void spontaneously or had no urge to void and the scanned bladder volume was less than the 500 ml, a subsequent scan was performed after 1 h. The patient's bladder was scanned every hour at the PACU and on the way to the surgical ward. If the patient was able to void spontaneously before the 500 ml limit was reached, prevoiding volume and subsequently the residual volume was measured. However, if a patient had a strong "painful" urge less than the bladder volume limit and was unable to void spontaneously, catheterization was performed to relieve the patient. When the scanned bladder volume was larger than 500 ml, POUR was diagnosed and patients were encouraged to void spontaneously.

If spontaneous voiding was not possible, bladder in-and-out catheterization was performed, regardless if the patient expressed sensation of urge.

Index Treatment

In the index group, the calculated individual MBC (maximum voided volume at home plus residual volume measured at the PAC) was set as a threshold volume for catheterization. Postoperatively, the same procedure was used for the control group, except for the different threshold definition.

In both study, arms anesthesia technique, type of local anesthetic, and volume of fluids infused during the perioperative period were at the discretion of the attending anesthesiologist who was unaware of the group assignment. All data were recorded in the case record form.

Outcome

The primary outcome was the incidence of bladder catheterization in each treatment group. Secondary outcomes included incidence of POUR according to the bladder volume thresholds per group (control >500 ml; index >MBC) and the postoperative IPSS and QoL scores.

Another secondary outcome was the number of patients in whom catheterization could have been avoided, which could retrospectively only be determined in the control group. "Avoidable catheterization" was defined as catheterization

in the presence of a measured bladder volume larger than 500 ml, but smaller than the patient's individual MBC. Those patients would possibly not have been catheterized if they were randomized in the index group where their MBC would be used as threshold instead of 500 ml. Finally, we also calculated the number of patients in the control group with MBCs less than 500 ml in which bladder catheterization happened "too late" compared to their MBC, and the number of patients in the MBC group with a MBC less than 500 ml who would not have been catheterized if they had been randomized in the 500-ml group.

Statistical Analysis

In a pilot study, measuring ultrasound bladder volumes at the PACU for a 1-month period, we recorded how often patients had a measured bladder volume larger than 500 ml (this is the bladder volume limit used in our hospital protocol for POUR). Approximately 20% of the patients had a measured bladder volume 500 ml or greater. However, the incidence of postoperative bladder catheterization at the PACU differed per day (incidence varying between 0 and 10% per day) and depended not only on the measured bladder volume, but also on the nurse or anesthesiologist who took care of the patient. We did not register how often patients were able to void spontaneously after reaching the volume limit of 500 ml or were postoperatively catheterized at the surgical wards. This is the first study about the incidence of postoperative bladder catheterization, comparing a fixed volume limit *versus* a variable volume limit (MBC) and consisting of measurements at the PACU and at the wards. But for our sample size estimation, we used only the data of the incidence of reaching a bladder volume 500 ml or greater at the PACU. Accordingly, using the MBC approach for POUR, with expected larger maximum allowable bladder volumes, the incidence of POUR in the intervention group was expected to decrease by half (difference 10%). To be able to detect a more conservative absolute difference of 5%, a level of significance of 0.05 (two sided), and power of 80%, 906 patients per group were needed to test the hypothesis.

All analyses were performed according to intention to treat. The incidence of postoperative bladder catheterization at the PACU (primary outcome) in the index and control groups was compared by estimating the relative risk (RR) with 95% CI and corresponding *P* value using the log-binomial regression model. Differences in IPSS and QoL scores (secondary outcome) were estimated with median interquartile ranges at 1 day, 1 week, and 1 month after surgery separately. Mann–Whitney tests were used to calculate *P* values for the differences between the groups.

Preplanned subgroup analyses consisted of two possible risk factors for bladder catheterization and POUR: sex (male *vs.* female) and anesthesia technique (general *vs.* spinal). *Post hoc* subgroup analysis consisted of age, duration of surgery, and total fluid volume (both infused and taken orally by the patient). *P* values for differences in treatment effects

in subgroups were estimated by adding both the risk factor and the interaction between treatment and the risk factor to the log-binomial regression model. Subsequently, RRs with 95% CIs for each subgroup were estimated.

Analyses were performed using SPSS version 17 (IBM Corporation, Somer, NY).

Blinding

Only the research assistant, who performed all ultrasound measurements, knew in which group the patient was randomized. During the entire study, anesthesia team, nursing staff, patients were not aware of the group allocation and the result of the ultrasound measurements (single blinded). The PACU nurse—or after discharge from the PACU, the ward nurse—who was responsible for the patient, was asked by the research assistant to perform bladder catheterization when the patient's scanned bladder volume was larger than 500 ml (control group) or when the bladder volume was larger than the patient's MBC (index group) and the patient was unable to void spontaneously.

Results

Recruitment

Between May 2008 and June 2009, 4,500 consecutive surgical patients were asked to participate in the study, after receiving approval from the Ethical Review Board. Ultimately, 1,840 patients who fulfilled the inclusion criteria and who gave informed consent participated in the study (fig. 1). They were analyzed for the primary endpoint bladder catheterization. Fewer patients (n = 1,792) were available to compare the incidence of POUR. Twenty-six patients in the control group and 22 patients in the index group had to be excluded because their bladder volumes could not be measured, as they had voided before the bladder was scanned (n = 19 in the control group and n = 18 in the index group, respectively). In another 11 patients scanning was impossible because the abdominal region above the pubic bone could not be reached (n = 7 vs. n = 4 patients, respectively). Thirty patients could not be reached by telephone or e-mail for collecting the secondary outcomes IPSS en QoL scores (n = 14 vs. n = 16 patients, respectively) leaving 1,762 to be analyzed for this outcome. Demographic and clinical parameters of the patients were comparable in the two groups (table 1).

Outcomes

Bladder Capacity. In the control group, the average MBC was 582 ml with an SD of 199 ml. The average MBC in the index group was 611 ml with an SD of 209 ml.

Primary Outcome

The incidence of bladder catheterization in the control group was 11.8% (107 of 909 patients) compared to 8.6% (80 of 931 patients) in the index group (RR, 0.73; 95% CI, 0.55 to 0.96; P = 0.025) (table 2). The risk difference was 3.2 (11.8 to 8.6) and the number needed to treat was 31.

In the control group 43% (n = 376) of the patients reached the 500 ml bladder volume threshold (POUR present) of which 72.6% voided spontaneously and 27.4% were catheterized because of the inability to void spontaneously. In the index group 32% (n = 288) of the patients had POUR, of which 77.4% voided spontaneously and 22.6% had to be catheterized (RR, 0.82; 95% CI, 0.63 to 1.08; P = 0.160) (table 3).

In evaluating this outcome across the above-mentioned subgroups, all tests for interactions were nonsignificant (table 2). However, male patients in the control group were catheterized more often compared to the index group, 14.5 versus 9.5%. For female patients this was 9.6% versus 7.8%, respectively (P = 0.48). In patients receiving spinal anesthesia, the overall incidence of bladder catheterization decreased from 24.4% in the control group to 16.3% in the index group. For patients receiving general anesthesia this was 5.9 versus 5.0%, respectively.

In *post hoc* analyses also no significant interaction between treatment and age (P = 0.10), duration of surgery (0.89), and total volume infused (0.64) was observed. Of note, when scanned bladder volume on arrival at the PACU was greater than 250 ml (196 patients in the control and 214 in the index group), the likelihood of subsequent bladder catheterization was higher (33% in the control vs. 18% in the index group) than when bladder volume was less than 250 ml (5.5 vs. 5.6%, respectively).

Secondary Outcomes

Avoidable Catheterizations. In the control group, 37.1% (39 of 105 of the patients) would not have been catheterized if they were randomized in the MBC group. Their measured bladder volume was smaller than their MBC (but >500 ml). Also in the control group, 25 (7.9%) patients with MBC smaller than 500 ml were catheterized "too late" according to their MBC. Finally, in the MBC group, 36 (12.3%) patients had a MBC smaller than 500 ml and were catheterized because they had reached their MBC value and were unable to void spontaneously despite a scanned bladder volume smaller than 500 ml. These patients would likely not have been catheterized if they had been randomized in the 500-ml group.

International Prostate Symptoms and QoL Score

Median IPSS and QoL scores of the control and index group at 1 day, 1 week, and 1 month after surgery were very similar (table 4). No significant differences were observed.

Discussion

This large randomized study is the first to address POUR and the need for bladder catheterization from the perspective of the patient's individually measured MBC in a large cohort of surgical patients. Using the MBC (index group) instead of a fixed bladder volume of 500 ml (control group), the absolute incidence of bladder catheterization decreased from 11.8 to 8.6% (absolute difference 3.2) or a number needed to treat of 31.
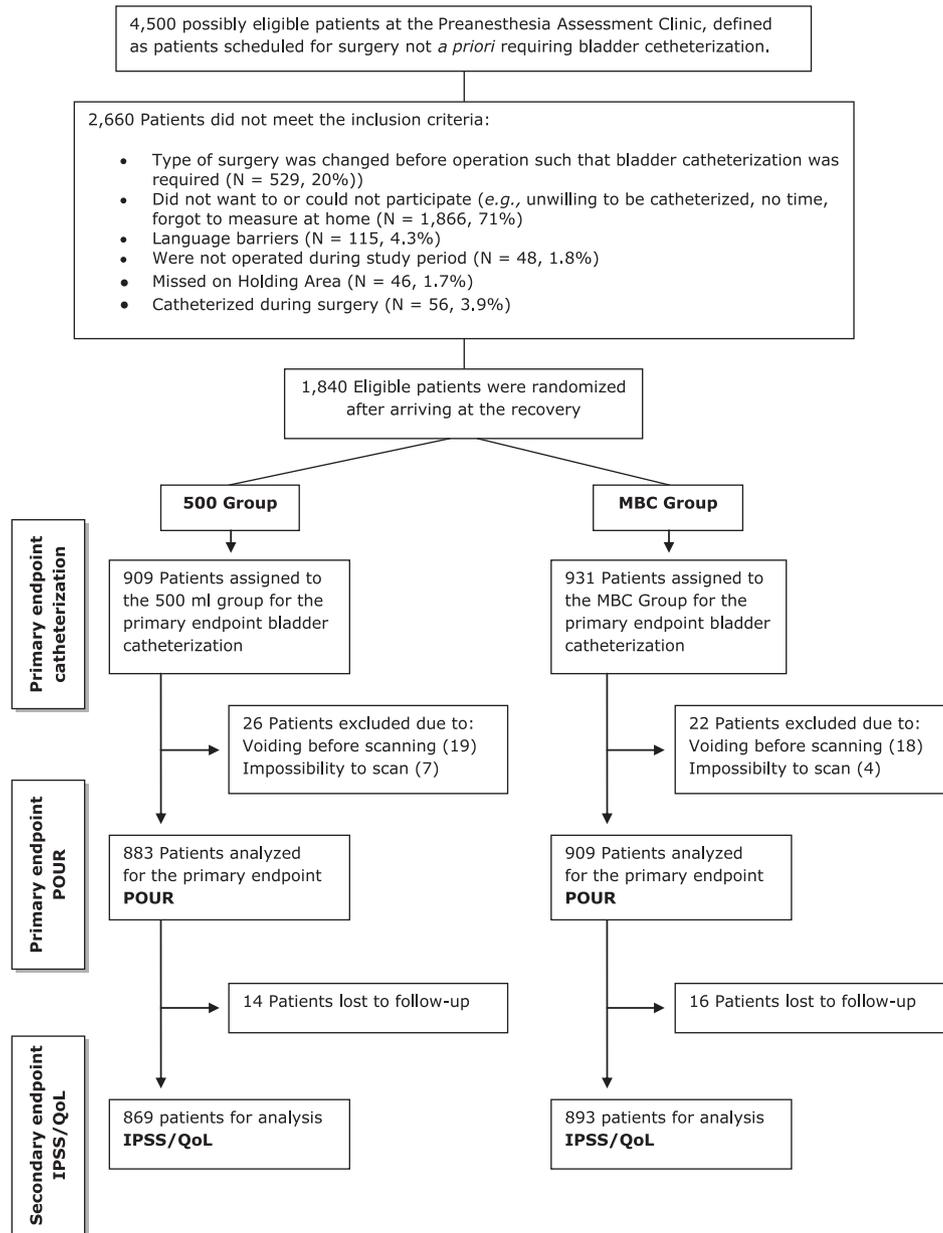
Fig. 1. Flow diagram of the patients through the phases of the randomized trial. IPSS = International Prostate Symptoms Score; MBC = Maximum Bladder Capacity; POUR = Post Operative Urinary Retention; QoL = Quality of Life Score.

In the subgroup analyses, we found no significant effect modification by sex or anesthesia technique. Nonetheless, we observed some differences in bladder catheterization across subgroups that may be clinically meaningful, but these will need further study to confirm or refute their relationship with the intervention. For example, using the MBC as threshold appeared to decrease the incidence of bladder catheterization more often in male patients and in patients receiving spinal anesthesia. Adequately powered studies in selected subgroups of surgical patients are needed to determine if these differences are statistically and clinically relevant.

This study also shows that most patients who had reached their volume limit were able to void spontaneously, although in the index group less patients reached the threshold than in the control group (table 3). However, the proportion of patients who were able to void spontaneously was similar in both groups (approximately 75%). As observed earlier,[15] patients arriving at the PACU with a bladder volume 250 ml or greater were at higher risk for POUR and bladder catheterization.

In the current study, the average MBC (approximately 600 ml) for all included patients was larger than the normally used threshold volume for catheterization of 500 ml, suggesting that the current 500 ml limit may be too conservative. More than 66% of the included patients had a MBC larger than 500 ml (fig. 2). Male patients had a slightly larger average MBC than female patients (619 vs. 579 ml). However, this sex difference can likely be considered clinically

Table 1. Demographic and Clinical Characteristics of Patients across the Two Treatment Groups (1,840 Patients)

	Control Group n = 909	MBC Group n = 931
Patient Data		
Women, No. (%)	508 (56)	490 (53)
Age, mean (SD), yr	48.5 (15)	47.9 (15)
Height, mean (SD), cm	175 (10)	176 (10)
Weight, mean (SD), kg	80.1 (16)	81.4 (17)
BMI, mean (SD), kg/m^2	26.2 (5)	26.3 (5)
Type of Surgery, No. (%)		
Head/neck	219 (24)	203 (22)
Thoracic/breast	85 (9)	75 (8)
Spine	31 (3)	36 (4)
Abdominal	231 (25)	272 (29)
Extremities	343 (38)	345 (37)
Study Data		
MBC, mean (SD), ml	582 (199)	611 (209)
Residual volume, mean (SD), ml	33 (61)	33 (53)
Voided before surgery, No. (%)	854 (94)	874 (94)
Time before surgery, mean (SD), min	59 (59)	59 (48)
Volume at holding, mean (SD), ml	44 (69)	52 (81)
General anesthesia, No. (%)	622 (68)	636 (68)
Spinal anesthesia, No. (%)	287 (32)	295 (32)
Articaine, No. (%)	213 (74)	234 (79)
Bupivacaine, No. (%)	74 (26)	61 (21)
Total volume infused, mean (SD), ml	1,475 (580)	1,492 (647)
Procedure time, mean (SD), ml	61 (37)	61 (40)

BMI = body mass index; MBC = maximum bladder capacity.

irrelevant, bearing in mind the 7% underestimation of the ultrasound device.[18] The average maximum scanned postoperative bladder volume for patients who had reached the POUR criteria was even larger: 660 ml in the control group and 648 ml in the index group. Obviously, fewer patients would have been catheterized if we had selected 600 ml as the threshold in the control group.

For both the control and index group, the need for postoperative bladder catheterization after spinal anesthesia was substantially higher than after general anesthesia (table 2). In patients who had received bupivacaine, the absolute probability of being catheterized postoperatively decreased from 63% in the control group to 44% in the index group (RR = 0.71; table 5). It is known that local anesthetics used for spinal anesthesia can impair bladder function for several hours.[23,24] Still, no prospective randomized controlled trials have compared the incidence of POUR and bladder catheterization after general *versus* spinal anesthesia. The current study shows that for both groups, the probability of being catheterized after spinal anesthesia, using local anesthetics without adding opioids, is about two times higher than after general anesthesia when using the short acting local anesthetic articaine and about 10 times higher when using the long acting local anesthetic bupivacaine.

The large absolute difference between the control and index group after spinal anesthesia (8.1%) can be explained by the fact that in the index group bladder volume thresholds were typically larger than 500 ml. This larger volume limit gave patients more time to reach the threshold and allowed more time for regression of the spinal block. The ability to void spontaneously may then have returned before the MBC was reached, leading to a reduction in the number of bladder catheterizations.

None of the differences in IPSS and QoL scores reached statistical significance (table 4). Patients who reported a relatively high IPSS preoperatively also had high scores postoperatively and *vice versa*. Bladder damage is likely to occur only when the bladder has been distended for a longer period of time (2 to 3 h).[9–11] None of our patients had a distended bladder for more than an hour, and we postulate that no serious complication of the lower urinary tract could or had occurred in any of the studied patients because we used a strict protocol of measuring bladder volumes each

Table 2. Incidence of Bladder Catheterization in the Preplanned and *Post Hoc* Subgroup Analyses

	Control Group n = 909	Index Group n = 931		
	Catheterization	Catheterization	RR (95% CI)	*P Value**
Females	49/508 (9.6)	38/490 (7.8)	0.80 (0.54–1.21)	0.477
Males	58/401 (14.5)	42/441 (9.5)	0.66 (0.54–0.96)	
General	37/622 (5.9)	32/636 (5.0)	0.85 (0.53–1.34)	0.411
Spinal	70/287 (24.4)	48/295 (16.3)	0.67 (0.48–0.93)	
Age ≥ 60 yr	42/236 (17.8)	39/230 (17.0)	0.95 (0.64–1.42)	0.104
Age < 60 yr	65/673 (9.7)	41/701 (5.9)	0.61 (0.42–0.88)	
Volume ≥ 1.5 l	46/381 (12.1)	33/404 (8.2)	0.68 (0.44–1.03)	0.643
Volume < 1.5 l	61/528 (11.6)	47/527 (8.9)	0.77 (0.54–1.11)	
OR time ≥ 60 min	67/378 (17.7)	48/371 (12.9)	0.73 (0.52–1.03)	0.894
OR time < 60 min	40/531 (7.5)	32/560 (5.7)	0.76 (0.48–1.19)	

Numbers are expressed as numbers and percentages.

*P values for interaction.

Control group = threshold bladder volume ≥500 ml; index group = threshold bladder volume ≥ maximum bladder capacity; OR time = duration of surgery; RR = relative risk; volume = total volume infused or taken till spontaneous voiding/catheterization.

Table 3. Patients Who Reached POUR: Voiding Spontaneously or Were Catheterized (n = 1,792)

	Control Group n = 883	Index Group n = 909
Voiding less than threshold	505 (56.8)	611 (67)
Catheterized less than threshold	2 (0.2)	10 (1)
Reaching volume threshold (=POUR)	376 (43)	288 (32)
Spontaneous voiding	273 (72.6)	223 (77.4)
Catheterization*	103 (27.4)	65 (22.6)

Data are expressed as numbers and percentages.
*Nonsignificant (relative risk, 0.82; 95% CI, 0.63 to 1.08; P = 0.160).
Control group = threshold bladder volume ≥ 500 ml; index group = threshold bladder volume ≥ maximum bladder capacity; POUR = postoperative urinary retention.

Table 4. IPSS and QoL Scores Pre- and Postoperatively (n = 1,762)

|	Control Group n = 869 Median (IQR)	Index Group n = 893 Median (IQR)	P Value
IPSS score			
Preoperative	5.0 (2 to 9)	5.0 (2 to 9)	0.52
1 day after surgery	5.0 (2 to 9)	5.0 (1 to 9)	0.83
1 week after surgery	4.0 (1 to 8)	4.0 (1 to 7)	0.37
1 month after surgery	4.0 (1 to 8)	4.0 (1 to 8)	0.32
QoL score			
Preoperative	1.0 (0 to 2)	1.0 (0 to 2)	0.51
1 day after surgery	1.0 (0 to 2)	1.0 (0 to 2)	0.95
1 week after surgery	1.0 (0 to 2)	1.0 (0 to 2)	0.43
1 month after surgery	1.0 (0 to 2)	1.0 (0 to 2)	0.35

P values were based on Mann–Whitney U test.
IPSS = International Prostate Symptom Score; IQR = interquartile ranges; QoL = Quality of Life.

hour until spontaneous voiding or bladder catheterization had occurred.

We anticipated that the method of assessing maximum voided bladder volume at home would be safe and reproducible and expected that it could be accomplished with minimal patient burden. From a subset of 822 patients who were specifically asked about their experiences with the MBC home measurement procedure, only three patients indicated that they would have problems when asked to perform it again before an operation, and eight patients found voiding in a measuring bowl difficult. These results were irrespective of age and sex. All patients were motivated to perform the estimation of their MBC at home, if it could help to prevent unnecessary bladder catheterization.

A limitation of our pragmatic study design is that several other factors that potentially can influence the incidence of POUR were not standardized. The selection of anesthetic technique and type of local anesthetic used for spinal anesthesia, as well as the amount of fluids infused were left at the discretion of the anesthesia team. Age, history of voiding problems, and type of operation all can influence the incidence and frequency of catheterization.[4–6] Still, as a result
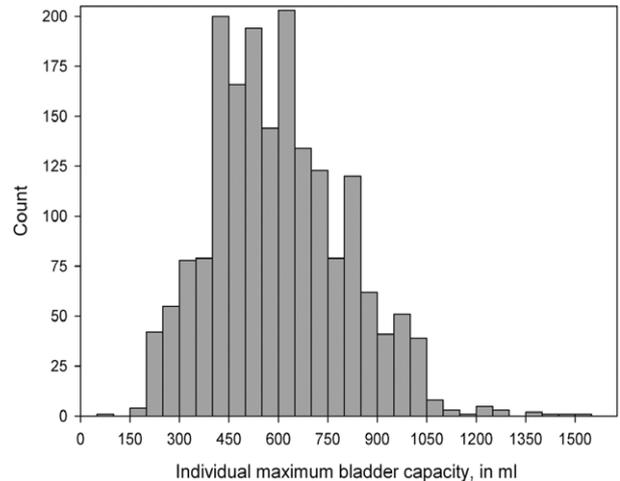
Fig. 2. Ranges of maximum bladder capacities of all patients (n = 1,840) calculated as maximum voided volume + residual volume.

of randomization and a sufficiently large sample size, the two study groups were well balanced with respect to demographic variables and clinical characteristics (table 1).

Of 4,500 patients asked to participate, only 1,840 were included the study. For almost 1,900 patients the main reason not to participate was mention of the word "bladder catheterization" and explanation about the aim of the study could not change their mind. This suggests that an element of denial may have been present. Other stated reasons for refusal were that it would be too cumbersome or it would cost too much time (fig. 1).

By measuring MBC at home in a large sample of surgical patients and measuring IPSS en QoL scores pre- and postoperatively, we were able to establish safe bladder volume ranges. None of the patients had significantly worsened postoperative IPSS or QoL scores. Only three patients developed a urinary tract infection the first month after the operation. Taken together, this suggests that a regimen consisting of serial postoperative ultrasound measurements can prevent overdistension and bladder damage. The current study also suggests that patients older than 60 yr will benefit less from measuring their MBC at home (which may be a more cumbersome procedure for them).

For patients younger than 60 yr who are at risk for bladder catheterization, measuring MBC preoperatively will decrease the chance of being catheterized postoperatively (table 2).

In summary, this large randomized study shows that measuring MBC preoperatively can decrease the incidence of postoperative bladder catheterization. Asking elective surgical patients, who may be at risk for postoperative bladder catheterization, to determine their MBC at home is a low cost, low-tech approach to reduce the potential need for postoperative bladder catheterization. Taking into account the very large number of surgical patients operated every year millions of unnecessary "too early" catheterizations can

Table 5. Spinal Anesthesia: Articaine *vs.* Bupivacaine (n = 1,840)

| | Control Group n = 287 | Index Group n = 295 | | |
	Catheterization	Catheterization	RR (95% CI)	*P Value*
Total	70/287 (24.4)	48/295 (16.3)	0.67 (0.48 to 0.93)	0.01*
Articaine	24/213 (11.3)	19/234 (8.1)	0.74 (0.39 to 1.40)	0.35
Bupivacaine	46/74 (62.2)	27/61 (44.3)	0.71 (0.42 to 0.95)	0.03*

Numbers are expressed as numbers and percentages.
*Significant.
Control group = threshold bladder volume ≥ 500 ml; index group = threshold bladder volume ≥ maximum bladder capacity; RR = relative risk.

safely be prevented when this strategy is implemented in the relevant clinical practice guidelines.

Competing Interests

Dr. Brouwer received an allowance for travel and accommodation from Verathon (IJsselstein, The Netherlands) for lecturing on postoperative bladder retention for colleagues, but no speaking or consultancy fees. All other authors have no relationship with industry. The research assistants and 4th year medical students received travel allowances and were paid for the number of hours worked. The other authors declare no competing interests.

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Figuier's Forlorn Figure: Horace Wells and the "Humbug Affair"
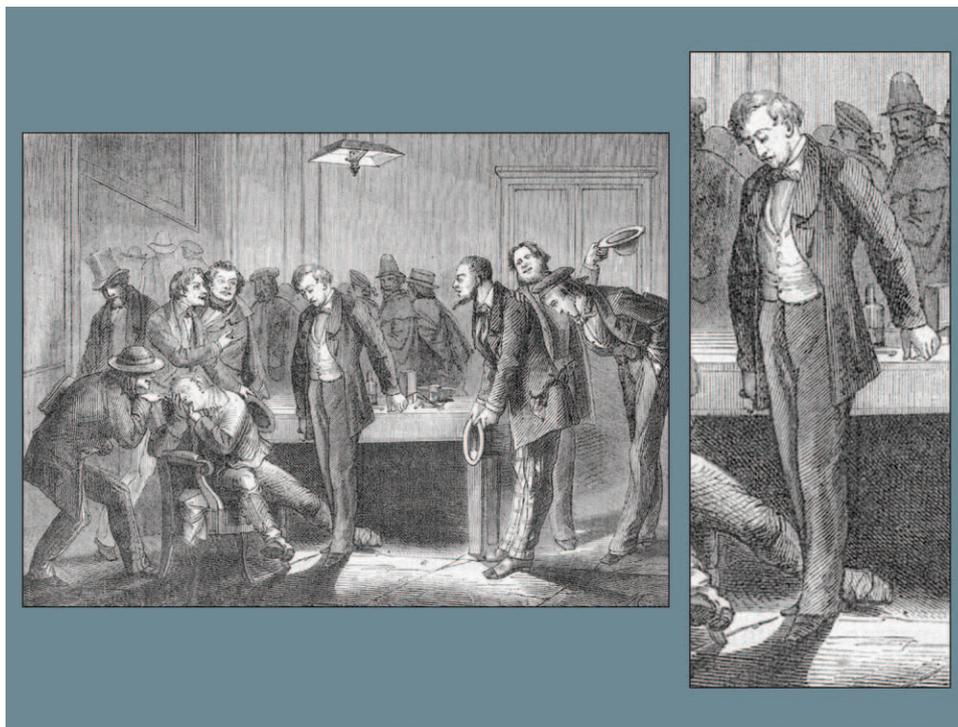
From Paris, France, in 1868, Furne, Jouvet and Company published the second volume of author Louis Figuier's *Les Merveilles de la Science ou Description Populaire des Inventions Modernes* [The Wonders of Science or Popular Description of Modern Inventions]. This volume focused on telegraphy, electroplating, ballooning, and etherization. In Chapter 3, on page 645, figure 341 (*left*) depicts an anguished medical student–turned–dental patient seated next to the forlorn standing figure of dentist Horace Wells (close up, *right*). The illustration's legend translates to: "Horace Wels' [*sic*] experience, of the extraction of a tooth, after the inspiration of nitrogen protoxyd [nitrous oxide] made before the students of a Boston hospital." This incomplete anesthetic would later be dubbed the "Humbug Affair" by Wells' detractors. (Copyright © the American Society of Anesthesiologists, Inc.)

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