The Effect of Age on Lower Urinary Tract Function: A Study in Women

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OBJECTIVES: To identify age-associated changes in female lower urinary tract function across a wide age spectrum, controlling for detrusor overactivity (DO).

DESIGN: Secondary analysis of a cross-sectional study of DO and aging. Eligible volunteers were stratified by age group and presence of DO.

SETTING: Community-based volunteers, evaluated in research laboratory.

PARTICIPANTS: Eighty-five ambulatory, nondemented, community-dwelling female volunteers, with and without bladder symptoms suggestive of DO, recruited by advertising, mean age 54 (range 22–90); 75% Caucasian, 21% African American.

MEASUREMENTS: Comprehensive assessment included bladder diary, uroflowmetry, and detailed videourodynamics. Predefined urodynamic and diary variables were examined for association with age and DO. Mean values of these variables were calculated for subgroups aged 20 to 39, 40 to 59, and 60 and older (14 subjects $\geq$70).

RESULTS: Maximum urethral closure pressure, detrusor contraction strength, and urine flow rate declined significantly with age ($P<.001$, $P<.001$, $P=.006$, respectively), regardless of whether DO was present. Most elderly individuals continued to empty their bladder almost completely, with normal voiding frequency. Mean number of nocturnal voids was less than one in all age groups. Bladder capacity did not decrease with age (mean 522 mL in oldest group) but was smaller in subjects with DO. Bladder sensation diminished significantly with age ($P<.001$) but was stronger in subjects with DO.

CONCLUSION: Female bladder and urethral function appear to deteriorate throughout adult life, whether DO is present or not. Specifically, detrusor contractility, bladder sensation, and urethral pressure decline. The common belief that bladder capacity shrinks with age may be related to DO rather than to aging itself. **J Am Geriatr Soc 54:405–412, 2006.**

Key words: bladder function; urinary incontinence; urodynamics; aging

In older people, increased voiding frequency, nocturia, urgency, urge incontinence, and poor bladder emptying are common and troublesome problems.[1] They have been attributed to a host of factors, including a reduction in bladder capacity,[2–5] increased bladder sensation,[4,6] and detrusor overactivity (DO, involuntary detrusor contractions).[1,7] Nevertheless, few studies have tried to define the normal changes that occur with aging in the lower urinary tract (LUT), and most of these were conducted before the advent of detailed urodynamic (physiological) testing, included few individuals, or did not consider the potential confounding effect of medication use or comorbidity. This situation is problematic, because assessment requires adequate norms. As part of a study designed with a different intent, data were collected that might shed light on the LUT changes that occur with aging.

Because DO is common in old age and has profound effects on LUT function, its presence may confound understanding of age-related changes in LUT function, especially if patients, rather than healthy subjects, are studied. To clarify the relationship, a group of volunteers was studied who were selected with ages evenly distributed across a wide range, in such a way that, in each age decade, approximately half had symptoms suggestive of DO. Using subjects with DO to control for its possible confounding effects, age-associated changes in LUT variables were identified that occurred or failed to occur regardless of whether DO was present.

Based on clinical experience and the literature, it was hypothesized that, with increasing age, there would be an increase in micturition frequency[4,8–10] and a decrease

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in bladder capacity,[2,11] bladder sensation,[11] detrusor contractility,[12,13] and urethral sphincter function.[2,14] Because these hypotheses are derived from studies with the limitations described above, they may reflect the effects of DO rather than other age-associated changes. Moreover, it is not clear whether such changes occur progressively throughout adult life or have an onset only in old age. Even though this is not a longitudinal study, the broad distribution of subjects' ages enabled the likelihood of progression up to early old age to be assessed.

METHODS

This was a secondary analysis of data collected for a study of bladder ultrastructure and DO in the same group of volunteers that will be published separately. The institutional review board of the University of Pittsburgh approved the study. Data were obtained and analyzed from female volunteers aged 20 and older, recruited between January 2002 and October 2003 through local advertising. To avoid the confounding effect of prostatic obstruction, only women were studied. Efforts were made to recruit, in each age decade, equal numbers of subjects who clearly did or did not have symptoms of overactive bladder. Methods, definitions, and units conform to the standards recommended by the International Continence Society.[15,16]

Exclusion criteria included dementia or Alzheimer's disease; diabetes mellitus; neurological disease such as stroke; multiple sclerosis or Parkinson's disease; disc disease; spinal cord injury or malformation resulting in gross neuropathy; detrusor-sphincter dyssynergia; current urinary tract infection; history of pelvic irradiation or bladder cancer; history of vitamin B_{12} deficiency; and history of alcohol abuse, radical hysterectomy, abdominoperineal resection, or agents acting on the cholinergic or sympathetic nervous system that were given for bladder problems and could not be stopped for 2 weeks.

All subjects provided written informed consent before detailed clinical evaluation. Assessment included a detailed history, physical examination (including neurological and cognitive testing), and a 3-day bladder diary. The diary included voiding times and voided volumes; timing, severity, and description of leakage episodes; and the time that the subject went to bed and awoke for each 24-hour period. Nighttime was defined as the period between going to bed with the intention to sleep and getting up in the morning. To permit the quantification of urine production, leakage volumes of 5, 15, or 60 mL were imputed for mild, moderate, or severe leakage episodes, respectively.[17] Detailed urodynamic testing included noninstrumented uroflowmetry; ultrasound and catheterized postvoid residual volume (PVR); fluoroscopically monitored provocative cystometry at 30 mL/min, using room-temperature Cystografin with simultaneous monitoring of abdominal pressure; isovolumetric testing; urethral pressure profilometry during rest, reflex testing, volitional squeezing, straining, and coughing; and seated pressure-flow studies. No limit on bladder volume was imposed other than subject discomfort. Provocation of DO or incontinence included coughing, suprapubic tapping, running water, hand washing, catheter manipulation, change of posture from supine to standing, heel jouncing, and a 2-minute wait with full bladder after sitting down on a commode.

To quantify detrusor contraction strength during voiding, the projected isovolumetric detrusor pressure, which is a modification of the Schaefer contractility parameter detrusor strength coefficient (DECO),[18] designed to be more satisfactory for assessment of older women, was used.[19] The quoted PVR values were the lowest of two or three values obtained after nonstrained free uroflows performed in private. Creatinine clearance was calculated using the Cockcroft-Gault equation.[20]

The term "detrusor overactivity" is defined as the urodynamic observation of involuntary bladder contraction during the filling phase.[15,16] It is believed to underlie overactive bladder symptoms (urgency, urge incontinence, increased frequency, nocturia), although the association with symptoms is not perfect; some symptom-free volunteers exhibit DO on urodynamic testing, whereas some patients with such symptoms do not, even with provocation.[7,21–23] Consequently, DO must be judged in the context of symptoms. To quantify the degree to which the urodynamic observation of DO (or none) was supported symptomatically, before performing the analyses a score (DO+) was devised to incorporate clinical and urodynamic data. The terms were weighted based on decades of experience. Content and face validity were ensured by basing the score on International Continence Society definitions of overactive bladder syndrome and DO. Cronbach alpha (based on the current data) was 0.77.

DO+ was computed blinded to information on the parameters investigated. Values of DO+ ranged from 8 to -6. Subjects whose score was 8 had urinary incontinence due to DO during urodynamic testing and had symptoms and a bladder diary congruent with this diagnosis. Subjects with a score of -6 had no DO during urodynamic testing, despite provocation, and no symptoms of DO according to clinical evaluation or bladder diary. Values close to 0 implied that symptoms and urodynamics were not entirely consistent. DO+ was used in the statistical analyses to identify the effects of DO and disentangle them from other effects of age.

SPSS (version 11.5, SPSS, Inc., Chicago, IL) was used for statistical analysis. Selected urodynamic and diary variables were grouped into five predefined domains (Table 1), representing various aspects of LUT function, together with two miscellaneous categories. Multiple linear regression analysis was used to examine associations between these variables and age (as a continuous variable) and DO. Standardized beta coefficients were presented to compare the association of age across the different variables. The only exception was for daytime and nocturnal voiding frequency, for which the bivariate association with age only was examined, because frequency contributed directly to DO+. Statistical significance was taken at two-tailed $P < .05$. For display in the tables and figures, the values of the variables were summarized in three subgroups (aged 20–39, 40–59, and ≥ 60).

RESULTS

Of 396 volunteers screened by telephone interview, 109 qualified and agreed to participate; of these, eight were excluded after clinical evaluation, and 16 withdrew consent, leaving 85 volunteers who completed the videourodynamic study. Subjects' clinical characteristics are displayed in

Table 1. Variables Describing Bladder and Sphincter Function by Age Group

Domain/Variable	All Subjects (N = 85)	Age 20–39 (n = 19)	Age 40–59 (n = 30)	Age ≥60 (n = 36)	Association with Age Regression Coefficient β* (*P*-value)
	Mean ± Standard Deviation				
Urine production					
24-hour urine production, mL	1,765 ± 758	1,748 ± 925	1,896 ± 701	1,656 ± 714	−0.10 (.40)
Diurnal urine production, mL	1,228 ± 589	1,252 ± 722	1,359 ± 559	1,097 ± 522	−0.18 (.11)
Nocturnal urine production, % of total	31 ± 12	28 ± 10	29 ± 10	35 ± 13	0.36 (.001)
Micturition frequency, voids/day					
Daytime frequency	7.5 ± 2.8	7.3 ± 3.1	8.0 ± 2.8	7.0 ± 2.6	−0.04 (.74)‡
Nocturnal voiding frequency	0.8 ± 1.0	0.5 ± 0.8	0.9 ± 1.0	0.9 ± 1.0	0.20 (.07)‡
Bladder capacity, mL					
Maximum cystometric bladder capacity, mL	493 ± 182	447 ± 211	490 ± 166	522 ± 178	0.13 (.22)†
Maximum single voided volume in bladder diary, mL	461 ± 180	415 ± 135	478 ± 190	472 ± 172	0.08 (.47)
Mean daytime voided volume in bladder diary, mL	219 ± 97	217 ± 83	226 ± 116	213 ± 86	−0.04 (.71)†
Mean nocturnal voided volume in bladder diary, mL	299 ± 120	281 ± 110	278 ± 123	329 ± 121	0.10 (.55)
Bladder sensation					
First sensation of bladder filling on cystometry, mL	118 ± 78	73 ± 46	104 ± 67	154 ± 85	0.45 (<.001)
First desire to void on cystometry, mL	179 ± 100	115 ± 60	168 ± 86	223 ± 110	0.43 (<.001)
Strong desire to void on cystometry, mL	317 ± 132	232 ± 105	328 ± 135	351 ± 126	0.33 (.002)†
Detrusor contractility					
Projected isovolumetric detrusor pressure projected isovolumetric pressure, cmH_2O	52 ± 13	62 ± 14	52 ± 14	46 ± 10	−0.46 (<.001)
Lowest postvoid residual volume in free uroflow study, mL	10 ± 17	10 ± 17	8 ± 12	12 ± 26	0.09 (.43)
Other voiding parameters					
Maximum flow rate in free uroflow, mL/s	25 ± 12	27 ± 11	27 ± 12	23 ± 12	−0.15 (.17)
Maximum flow rate in pressure-flow study, mL/s	22 ± 9	26 ± 7	24 ± 10	20 ± 7	−0.31 (.006)
Detrusor pressure at maximum flow, cmH_2O	29 ± 12	36 ± 17	28 ± 10	26 ± 10	−0.28 (.01)†
Urethral sphincter function					
Functional urethral profile length, cm	3.3 ± 0.8	3.5 ± 0.8	3.4 ± 0.7	3.2 ± 0.8	−0.05 (.65)
Maximum urethral closure pressure, cmH_2O	62 ± 27	89 ± 27	66 ± 24	45 ± 14	−0.63 (<.001)

* Multiple linear regression model.
† Additional significant association with detrusor overactivity score.
‡ Bivariate correlation with age.

Table 2, which shows that all were cognitively intact, mobile, and fully functional. Although 42% were aged 60 and older, only 14 subjects were aged 70 and older, including four aged 80 and older. Consistent with the criteria used for enrollment, roughly half of the subjects had symptoms suggestive of DO. Only four subjects used a medication that could affect bladder or sphincter function (other than estrogen), and all were in the oldest group, but all analyses described below were unchanged whether these four subjects were included or not. Urge incontinence was reported in the bladder diary of 27% of subjects, with no significant difference between the age groups.

Urodynamic and bladder diary values are shown in Table 1. Only nocturnal voiding frequency and lowest PVR after free uroflow had a significantly skewed distribution. The percentage of missing values was between 0 and 6% for each variable, except for pressure-flow parameters, for which it was 9%. The calculation of the mean nocturnal voided volume was based on the 48 subjects who voided at least once at night, and the mean number of incontinence episodes was based on the subjects who were incontinent according to their bladder diaries.

Bladder Capacity

Whether determined during urodynamics or from the maximum amount voided on the voiding diary, bladder capacity was within the normal range and did not change significantly with age (Table 1, Figure 1), although maximum cystometric bladder capacity depended significantly on DO (Table 1). It was approximately 100 mL smaller in those with DO and consistent symptoms than in those with neither symptoms nor DO.

Table 2. Characteristics of the Sample by Age Group

Characteristic	All Subjects (N = 85)	Age 20–39 (n = 19)	Age 40–59 (n = 30)	Age ≥60 (n = 36)
General health/function				
Age				
Mean ± SD	53.6 ± 16.8	29.3 ± 5.8	50.0 ± 5.1	69.4 ± 7.4
Range (median)	21.8–89.6 (54.2)	21.8–38.5 (30.0)	41.0–58.4 (49.8)	60.6–89.6 (66.6)
Caucasian/African American, %*	75/21	53/42	80/17	83/14
≥1 years of college, %	69	84	73	58
Creatinine clearance, mean ± SD† (ml/min)	103 ± 45	136 ± 46	110 ± 45	81 ± 31
Mini-Mental State Examination score, mean ± SD	29.0 ± 1.2	28.9 ± 1.0	29.3 ± 1.0	28.8 ± 1.4
Body mass index, median (kg/m^2)	27.4	26.0	27.6	27.5
Urogenital history				
Number of pregnancies, mean ± SD†	2.3 ± 2.1	1.1 ± 1.7	2.1 ± 1.5	3.1 ± 2.3
Number of vaginal deliveries, mean ± SD†	1.7 ± 1.6	0.8 ± 1.2	1.4 ± 1.2	2.5 ± 1.9
Urinary incontinence in history, n	47	8	17	22
Number of incontinence episodes in those with urinary incontinence	2.0 ± 1.9	1.6 ± 1.1	2.2 ± 2.4	2.0 ± 1.5
Duration of urinary incontinence, mean ± SD (days)	9.6 ± 12.8	4.9 ± 4.7	10.2 ± 13.1	11.3 ± 14.8
American Urological Association Symptom Index, mean ± SD	9.4 ± 5.8	9.6 ± 7.2	9.7 ± 5.9	8.9 ± 5.1
Bladder suspension surgery, n	8	0	2	6
Number of symptomatic urinary tract infections in previous year, mean ± SD	0.3 ± 0.9	0.7 ± 1.5	0.1 ± 0.4	0.2 ± 0.9
Estrogen medication (current), n	31	4	10	17
Specific bladder relaxants/anticholinergics, n	0	0	0	0
Drugs with potential to decrease detrusor activity, n‡	4	0	0	4
Urogenital examination, n				
Urodynamic stress urinary incontinence	13	1	5	7
Uterine descensus (Grade 1)	5	0	1	4
Cystourethrocele (mild)*	25	0	13	12
Rectocele (Grade 1)*	12	0	1	11
DO				
DO according to urodynamics, n (%)§	42 (49)	9 (47)	14 (47)	19 (53)
DO score, mean ± SD	−0.3 ± 4.2	−0.8 ± 4.5	−0.3 ± 4.3	−0.1 ± 4.1

* Significant difference between groups according to chi-square test ($P < .05$).
† Significant difference between groups according to one-way analysis of variance or Kruskal-Wallis test ($P < .05$).
‡ Subject 1 (amitriptyline 25 mg/d), Subject 2 (hyoscyamine 0.125 mg as needed), Subject 3 (amitriptyline 75 mg/d), Subject 4 (amitriptyline 10 mg/d); all subjects continued their regimens throughout the study.
§ Subjects intentionally selected to have symptoms suggesting detrusor overactivity in half the cases.
SD = standard deviation; DO = Detrusor overactivity.

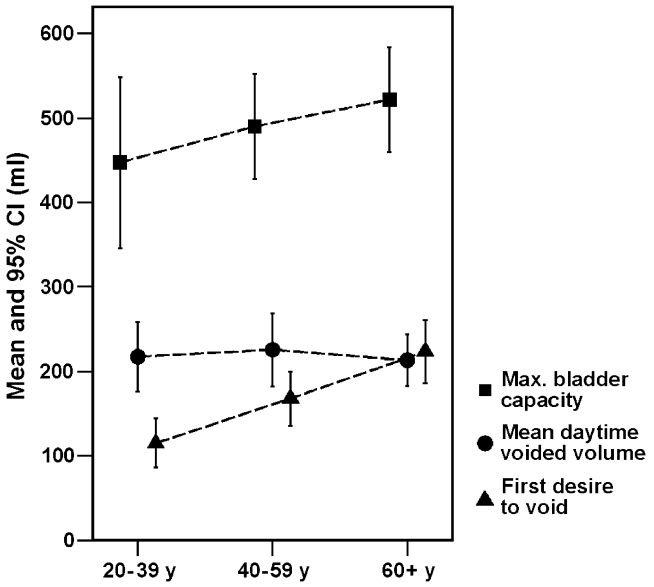

Figure 1. Bladder Capacity and Sensation in Female Volunteers (20–90 y) Values of three volume parameters (mean and 95% CI) in the three age groups: ■ Maximum cystometric bladder capacity, ● Mean daytime voided volume in 3-day bladder diary, ▲ Volume at first desire to void during filling cystometry. Volume at first desire to void shows a significant increase with age ($P < .05$). There is no significant change in maximum cystometric bladder capacity or mean voided volume.

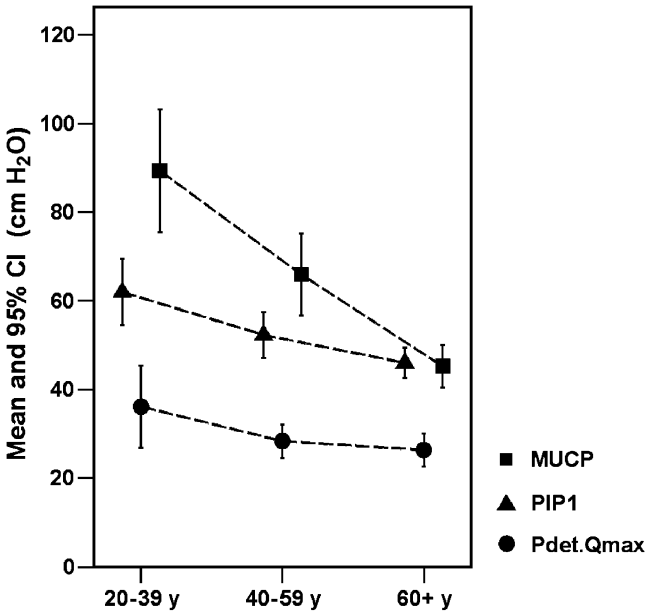

Figure 2. LUT Pressure Parameters in Female Volunteers (20–90 y) Values of three pressure parameters (mean and 95% CI) in the three age groups: ■ Maximum urethral closure pressure (MUCP); ● Contraction strength (projected isovolumetric pressure, PIP1), ▲ Detrusor pressure at maximum flow rate ($p_{det.Qmax}$) from pressure — flow study. All show significant decrease with age ($P < .05$). LUT = lower urinary tract.

Urine Production and Micturition Frequency

Overall, 24-hour urine production (mean 1,765 mL) was also within the normal range[24,25] and changed little with age (Table 1), although the proportion of urine excreted at night increased significantly with age ($\beta = 0.36$; $P = .001$). Micturition frequency showed no striking association with age. Daytime frequency remained, on average, eight voids per day or fewer even in the oldest group.

Bladder Sensation

Bladder sensation appeared to decline with age, regardless of which of the three definitions (Table 1) was used. Overall, the corresponding volumes increased by nearly 100 mL from the youngest to the oldest group (Figure 1), although the volume at strong desire to void also depended on DO (Table 1). It was approximately 100 mL smaller (implying stronger sensation) in those with DO and symptoms. These effects were still present in a subanalysis of the 28 nulliparous women in the study.

Detrusor Contractility and Other Voiding Parameters

Detrusor contractility was negatively associated with age, even after controlling for DO. Maximum voided flow rates diminished with age, whether measured during a pressure-flow study or during free uroflow (Table 1). There were no relevant age-dependent differences in voided volume that could have accounted for the decrease in flow rate. The pressure developed by the bladder, the detrusor pressure at maximum flow, also diminished significantly with age (Figure 2). Correspondingly, the detrusor contraction strength, as estimated by the projected isovolumetric detrusor pressure, decreased steadily and significantly with age, from a mean value of 62 cm H_2O in the youngest to 46 cm H_2O in the oldest group (Figure 2). In spite of this, the PVR (median 0 mL, interquartile range 0–13) did not increase significantly (Table 1). Even in the oldest group, its mean value was only 12 mL, and the median was 0 mL (interquartile range 0–14).

Urethral Sphincter Function

Urethral profile length did not change with age, but maximum urethral closure pressure (MUCP) showed a steady and highly significant decrease with age, from a mean value of 89 cm H_2O in the youngest group to 45 cm H_2O in the oldest (Figure 2). The age effect was still present in the regression model after controlling for the numbers of pregnancies and deliveries and in a subanalysis of the 28 nulliparous women in the study. Although the youngest group had a significantly higher proportion of African Americans than the other two age groups (Table 2), race was not significant in the regression analysis for MUCP and did not affect the relationship between age and MUCP.

DISCUSSION

The data from the current study reveal age-associated changes in urinary tract function regardless of whether individuals exhibit DO. As postulated, detrusor contractility, bladder sensation, and urethral sphincter function all decline from young adulthood through early old age, but contrary to the hypotheses, bladder capacity did not appear to diminish, nor did daytime micturition frequency increase with age after controlling for DO.

These conclusions apply to women, but there is no reason to believe that they do not apply to men without urethral obstruction.

To the authors' knowledge, this is the first comprehensive evaluation of the relationship between age and bladder function in a group of female volunteers who were carefully selected so as to enable age effects to be disentangled from those of DO. Nevertheless, the study has limitations. First, the oldest subgroup in the sample had a mean age of 69. Therefore, the results may not extend to the oldest old in the ninth or tenth decade. A second limitation is the assumption that change in LUT function other than DO represents "aging." In this context, the findings also may reflect still-undiscovered factors. Third, drugs with a theoretical potential to decrease detrusor activity were taken only by subjects in the oldest group, although there were only four such subjects, and significance levels in the linear regression models did not change if these subjects were excluded. Fourth, the estrogen status of the subjects was not studied in detail, because it was not part of the parent study, although some changes attributed to normal aging may be related to a decline in estrogen levels with menopause, aging, or both. Finally, because of the cross-sectional nature of the study and the selection referred to above, the sample is not representative of any particular population, and changes may reflect cohort effects, secular effects, or both;[26,27] this possibility is most likely for urethral sphincter function (see below). Longitudinal studies should be performed to confirm these conclusions. Nevertheless, the baseline characteristics for each age group reflect the typical, cognitively intact, functionally independent, American female, with a body mass index of about 27, a typical age-related creatinine clearance, and typical numbers of pregnancies in each age group. Furthermore, the values of the urodynamic and bladder function parameters (PVR, maximum flow rate, MUCP, functional urethral length, detrusor pressure at maximum flow, cystometric bladder capacity, and micturition frequency) are consistent with previously published results from Great Britain,[13,28] Austria,[2] Denmark,[29,30] Belgium,[31,32] Sweden,[33] and Japan.[4]

There were significant differences between the groups in mean numbers of pregnancies and vaginal deliveries, but inclusion of these variables had no effect on the interpretation of the regression models.

Urine Production and Micturition Frequency

Urine production and daytime voiding frequency remained close to normal values[24,25] through early old age (Table 1). Although nocturnal urine production increased with age, the mean number of nocturnal voids remained less than one even in the oldest age group. Nevertheless, this low number of nocturnal voids cannot necessarily be extrapolated to the general elderly population, especially because, even in the oldest group, only fully functional and healthy volunteers (e.g., no congestive heart failure, no diabetes mellitus) were included. Because bladder capacity and total fluid production remained constant, other factors such as hormonal changes or decreased renal function were likely to be responsible,[5,34] although in study subjects, there was no significant association between nocturnal voiding frequency ($\beta = -0.04$, $P = .78$) or nocturnal urine production ($\beta = -0.01$, $P = .92$) and estimated creatinine clearance. Similarly, others have found no association between nocturnal voiding frequency and renal function in older adults.[35]

Bladder Capacity

As shown in Table 1 and Figure 1, bladder capacity does not diminish with age per se, although it is smaller in subjects with DO, which may account for the decreased bladder capacity reported previously by others. One study describes, in a sample of 1,381 women with symptoms of LUT dysfunction (aged 20–95, mean 54.9), a decrease in maximal cystometric capacity in the eighth and ninth decades.[11] Another study reports an age-dependent reduction of cystometric capacity in a group of 183 incontinent women (aged 40–93, mean 59).[2] In both studies, approximately half of the subjects exhibited DO, but its confounding effects were not explored.

Bladder Sensation

Adequate sensory input is necessary for conscious bladder control. The finding of an age-associated decrease in bladder sensation (increasing volumes at first desire to void and at strong desire to void), combined with unchanged voided volumes, is of clinical importance; the larger the volume at which a person realizes the need to go to the bathroom, the shorter is the period of warning during which she can void at her convenience. The effect is likely to be greater in individuals with DO or urge incontinence. The literature on aging and bladder-filling sensation is limited, but another group[11] has described a similar finding, and reduced warning is a common finding in older people and is associated with more-severe urge incontinence.[36]

The age-associated decline in bladder sensation might reflect the secular effect of a larger number of deliveries (and potentially more damaging obstetric methods) in older women, although its presence in the subgroup of nulliparous subjects makes this possibility unlikely.

Detrusor Contractility and Other Voiding Parameters

The observations that detrusor contraction strength, detrusor pressure at maximum flow, and maximum flow rate all decline with age suggest a progressive deterioration of detrusor function. Others have found similar age-associated decreases for detrusor pressure and flow rate[4,13,37,38] and for detrusor contractility.[12,39] There are histological and ultrastructural changes in the bladders of elderly symptomatic patients,[40] and even the unobstructed, nonoveractive aging detrusor shows membrane changes (e.g., decrease of caveolae),[41] which could possibly be involved in abnormal excitation-contraction coupling. Furthermore, a decrease of acetylcholine release in human detrusor has been suggested with aging,[42] and in animal models a decline in estrogen levels leads to a loss of caveolae and development of a dense band pattern.[43] Therefore, the age-associated decrease in contractility observed in this study and others may reflect myogenic changes, neurogenic changes, or both.

Despite decreased detrusor contraction strength, bladder emptying remained surprisingly efficient into early old age. No significant age-associated increase of PVR was found in this sample, which is consistent with a Japanese study of 51 healthy volunteers (aged 36–83, mean 59.6)

without DO.[4] Earlier studies[13,39] reported an increase in PVR with age, but in population-based studies, it remained less than 100 mL in 90% of elderly women.[7,44]

Why does PVR remain small despite decreasing contraction strength? One explanation might be that PVR represents a different aspect of detrusor contractility, namely whether the detrusor contraction is adequately sustained.[45] Moreover, this apparent discrepancy may reflect the fact that organs have extensive physiological reserve. In the absence of superimposed pathology, age-related decline in this reserve generally does not result in change of resting organ function until advanced age. In this sense, development of elevated PVR may be an end stage of deteriorating function that is not reached until late old age, leading to the increased prevalence of detrusor hyperactivity with impaired contractile function that is most common in subjects older than those in the present study.[46]

Urethral Sphincter Function

The finding that MUCP decreases with advancing age is consistent with earlier studies.[2,14] As for bladder sensation, this may reflect a secular effect, in which older women not only had more pregnancies than younger women, but also had deliveries using obstetrical practices associated with more damage to the pelvic floor, but the change does not appear to be related to the higher number of pregnancies or deliveries seen in the older subjects, and it is present also in nulliparous subjects. Thus, it may reflect an age-associated loss of striated muscle in the female urethra.[47] Loss of urethral sphincter function is one of the factors that may set the stage for severe urge incontinence in old age.[17] Others have reported a higher maximal urethral closure pressure in African-American patients than in Hispanic, Asian, or Caucasian patients.[48] Some of the age-associated differences in maximal urethral closure pressure in the current study could be ascribed to racial differences because of the higher percentage of African-American subjects in the youngest group, but race was not found to be an important factor in the regression analysis for maximal urethral closure pressure.

In conclusion, this study has demonstrated that, through adult life until early old age, deterioration in female bladder and urethral function, including detrusor contractility, bladder sensation, and urethral pressure, occurs regardless of whether individuals exhibit DO. For women at least, the common belief that bladder capacity shrinks with age maybe related to DO rather than to aging itself.

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