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Original Research

A Grading System for Urinary Dysfunction Enabling Risk-Stratified Management After Vaginal Delivery Based on a Prospective Observational Study

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Abstract

Background: Urinary dysfunction is a common complication following vaginal delivery, yet the lack of a standardized assessment system results in delayed diagnosis and suboptimal treatment. This study aims to develop a novel urinary function grading system to evaluate the urogynecological impact of childbirth, identify associated risk factors, and guide the development of evidence-based, targeted nursing interventions. **Methods**: In this prospective observational study, 370 primiparous women who experienced spontaneous vaginal delivery at Nanfang Hospital between 1 January 2020 and 1 January 2021 underwent systematic urological evaluations during hospitalization and at a 6-week follow-up. Urinary function was graded (I–IV) based on post-void residual (PVR) volume and clinical symptoms: Grade I, normal function (PVR <50 mL without voiding dysfunction); Grade II, mild dysfunction (urinary frequency with PVR <50 mL); Grade III, moderate dysfunction (PVR >50 mL); and Grade IV, severe dysfunction (urinary retention requiring catheterization or stress urinary incontinence [SUI]). Urodynamic parameters, including urinary interval, urine volume, initiation time, and voiding duration, were collected for statistical analysis. **Results**: Progressive deterioration of urinary parameters was significantly associated with increasing severity grades (I–III) (all $p < 0.001$). On postpartum day 1, 74.054% of women exhibited urinary dysfunction, which declined markedly over time. By day 14 postpartum, 10.270% of women developed SUI, with a higher proportion initially classified as Grade I (84.211%). The age, neonatal weight, total duration of labor, operative vaginal delivery, episiotomy, and labor analgesia were significantly associated with urinary function grading (all $p < 0.05$). Among these, prolonged labor, labor analgesia, and operative vaginal delivery emerged as independent risk factors for Grade IV urinary dysfunction (all $p < 0.05$). **Conclusions**: The grading system enables risk-stratified management of postpartum urinary function, promoting early identification and timely intervention for urinary dysfunction. Clinically, emphasis should be placed on managing high-risk factors and providing targeted nursing care to mitigate the impact of vaginal delivery on maternal urinary function. Further studies are needed to validate and refine this grading system.

Keywords: vaginal delivery; urinary function grading system; postpartum women

1. Introduction

The physiological mechanism of micturition involves the relaxation of the pelvic floor muscles and urethral sphincter, coordinated with the contraction of the detrusor muscle and an increase in intra-abdominal pressure to facilitate urine expulsion [1]. Vaginal delivery can result in anatomical structural damage and physiological dysfunction in women, leading to diminished strength of the pelvic floor muscles [2], as well as impairment in connective tissues and nerves, and causing periurethral and vulvar edema [3]. Over time, these issues may contribute to the development of stress urinary incontinence (SUI) and postpartum urinary retention (PUR) [4,5].

Postpartum urinary dysfunction refers to any significant impairment in bladder emptying or storage function following vaginal delivery. This includes symptoms such as urinary frequency, straining, incomplete voiding, and involuntary leakage. These dysfunctions arise from pelvic injuries related to childbirth that disrupt the neuromuscular coordination involved in micturition. Severe urinary dysfunction (Grade IV) indicates critical manifestations that require immediate intervention, such as urinary retention needing catheterization due to an inability to void completely or SUI with involuntary leakage during physical exertion (e.g., coughing/sneezing).

SUI and PUR, as forms of severe urinary dysfunctions, are significant issues in postpartum rehabilitation. They not only affect women's quality of life but also lead to physical and psychological problems, including urinary tract infections, depression, and anxiety [6]. Notably, the prevalence of SUI and PUR remains high among women undergoing vaginal delivery, with reported rates of SUI ranging from 30% to 40% [7] and PUR ranging from 0.18% to 14.6% [8]. The increasing trend in delayed childbearing age, along with age-related declines in physiological resilience, further exacerbates the prevalence of these conditions. Therefore,

early identification of high-risk populations and timely interventions are crucial in reducing the incidence of SUI and PUR and enhancing the quality of postpartum recovery.

Currently, there are no standardized clinical guidelines or preventive strategies for SUI and PUR [8]. This lack often results in underdiagnosis and delays in treatment for severe urinary dysfunction, posing a significant challenge in clinical management. Furthermore, early-stage manifestations of urinary dysfunction are frequently overlooked. It remains uncertain whether women experience varying levels of urinary dysfunction beyond PUR and SUI after vaginal delivery, or before the manifestation of PUR and SUI. This knowledge gap complicates the provision of evidence-based diagnoses and can lead to delays in treatment, especially for those with covert PUR and SUI. Given the lack of standardized urinary dysfunction grading in obstetric literature, we adapted the Saito system, originally developed for postoperative urinary complications in colorectal surgery. However, it is limited by its lack of dynamic monitoring throughout postpartum recovery phases and inadequate integration of obstetric-specific risk factors. Thus, this study validated its efficacy using urodynamic parameters. Furthermore, incorporating an analysis of factors affecting postpartum urination has enhanced the comprehensiveness of the grading management system.

This study aims to develop a grading system (I–IV) based on dynamic urodynamic parameters. By quantifying indicators such as voiding intervals and residual urine volume, it aims to achieve early risk stratification of postpartum urinary dysfunction and provide a basis for precise nursing interventions.

2. Materials and Methods

2.1 General Information

A prospective analysis was conducted on 370 first-time mothers with singleton pregnancies who received regular antenatal care and delivered vaginally at term (37–42 weeks of gestation) at Nanfang Hospital between 1 January 2020 and 1 January 2021. The sample size was calculated using the formula for estimating a population proportion: $n = (Z^2 \times p \times (1 - p))/E^2$. With: $Z = 1.960$ (95% confidence level), $p = 0.360$ (a conservative prevalence estimate of severe urinary dysfunction, including late-pregnancy (urinary incontinence) UI and 6-week postpartum UI based on data from Zhu *et al*. [9]), $E = 0.050$ (margin of error), this yielded $n = 355$. Accounting for 10% attrition, the target was 395. Due to coronavirus disease 2019 (COVID-19) restrictions, enrollment was limited to 370 participants, which still exceeds the minimum required sample size (355) and achieves post-hoc power of 92.1% for detecting Grade IV dysfunction ($\alpha = 0.05$).

All participants were able to complete regular postpartum follow-ups and had no cognitive or behavioral impairments. Exclusion criteria included pre-existing urological disorders, urinary tract infections, indwelling catheters extending into the third stage of labor, severe pregnancy-related complications, intrapartum complications, and multiparity.

This study was approved by the Medical Ethics Committee of Nanfang Hospital (approval number: NFEC-2018-253-1), and written informed consent was obtained from all participating women and their families.

2.2 Observation Parameters

The urinary function assessment framework, adapted from Saito *et al*. [10], was employed to monitor postpartum urinary recovery, aiming to enable early detection of covert dysfunction and timely intervention. Postpartum urinary function was classified into four grades (I, II, III, IV) based on combined urodynamic and clinical criteria, with higher grades indicating more severe urinary dysfunction. The grading criteria were defined as follows: Grade I: Normal urinary function, with no signs of urinary dysfunction. Grade II: Mild urinary dysfunction, characterized by urinary frequency and a post-void residual (PVR) urine volume <50 mL. Grade III: Moderate urinary dysfunction, rarely requiring catheterization, with a PVR urine volume >50 mL. Grade IV: Severe urinary dysfunction, including urinary incontinence or retention necessitating catheterization [10]. The urodynamic parameters for urinary function grading included intervals between voluntary voiding, voided volume per micturition, time to initiate voiding, and duration of voiding [11]. Postpartum voiding intervals, time to initiate voiding, and duration of voiding were recorded by the mothers themselves using stopwatches. Voided volumes were measured using standardized graduated measuring cups and documented accordingly. Nurses collected these data daily and maintained formal records. Additionally, PVR urine volume was measured using GE portable ultrasound machine [model: vscan 1.2; GE Medical Systems (China) Co., Ltd., Wuxi, Jiangsu, China] after voluntary voiding [12].

2.3 Methods of Observation

During hospitalization, the study first examined whether independent risk factors for postpartum urination affected the grading of postpartum urinary function in women. These factors included: age at first delivery, body mass index (BMI) in the third trimester, neonatal birth weight, total duration of labor, perineal integrity, use of labor analgesia, and operative vaginal delivery. Simultaneously, participants were instructed to maintain a regular diet and fluid intake, urinate frequently, and attempt to empty their bladder every 2–3 hours. Second, the presence and severity of urinary dysfunction were assessed. PVR urine volume was measured using ultrasound to grade urinary function, and urodynamic parameters for urinary function grading were observed. Before discharge, patients were educated on activities to avoid within 42 days postpartum to prevent an increase in intra-abdominal pressure that could

Table 1. Analysis of urodynamic parameters for maternal urinary function grading (Median, [P25~P75]).

Urodynamic parameters	Grade I (n = 96)	Grade II (n = 120)	Grade III (n = 136)	Grade IV (n = 18)	Z	*p*-value
Intervals between voluntary voiding (h)	2.500 [2.000∼3.500]	3.000 [2.000∼4.000]	4.100 [4.000∼5.000]	–	69.154	<0.001
Voided volume (mL)	200.000 [90.000∼412.500]	400.000 [300.000∼500.000]	520.000 [250.000∼600.000]	–	92.084	<0.001
Voiding initiation time (min)	2.000 [1.000∼7.000]	2.000 [2.000∼6.000]	5.000 [2.000∼8.000]	–	18.153	<0.001
Duration of voiding (min)	2.000 [1.000∼2.000]	2.000 [1.500∼3.000]	5.000 [2.000∼10.000]	–	13.737	<0.001

Data are presented as (Median, [P25~P75]). All variables violated normality (Shapiro-Wilk $p < 0.001$). –, not quantifiable due to urinary retention/incontinence. n, number of samples.

negatively impact long-term urinary function and its grading. During follow-up, urinary function recovery was evaluated at 7 days, 14 days, 28 days, and 42 days postpartum. If no postpartum SUI was detected within 42 days postpartum, participants were asked whether they had undergone any rehabilitation therapies or pelvic floor muscle training that might influence urinary function grading. Those who had therapies and training were excluded to prevent confounding effects on urinary function grading. Additionally, it was ensured that none of the enrolled participants were lost to follow-up within 42 days postpartum.

2.4 Statistical Analysis

Statistical analysis was conducted using SPSS software (version 21.0; Shanghai Cabe Information Technology Co., Ltd.; Shanghai, China). Continuous variables (presented as mean ± SD) were compared using ANOVA. Categorical variables (presented as n (%)) were analyzed using Pearson's chi-square or Fisher's exact tests. Normal measurements (including age, BMI, neonatal weight, and duration of labor) were expressed as $\bar{x} \pm$ SD; a *t*-test was employed for comparisons between two groups. Non-normal measurements, such as urodynamic parameters, were reported using median and quartiles, with the non-parametric rank sum test applied. Independent associations between each risk factor and the occurrence of different grades were analyzed using one-way logistic regression. The factors included in the single-factor logistic regression analysis were those with $p < 0.05$, and variables with $p < 0.05$ in the univariate analysis were included in the multivariate logistic regression. Results were expressed as odds ratios (OR) with corresponding 95% confidence intervals (CIs) and probability values. A significance level of $p < 0.05$ was considered statistically significant.

3. Results

3.1 Analysis of Urodynamic Parameters for Postpartum Urinary Function Grading

Urodynamic parameters for grading postpartum urinary function showed an increasing trend as the grading level rose from Grade I to Grade III. Specifically, women classified as Grade III urinary function exhibited significantly prolonged intervals between voluntary voiding, increased voided volume, lengthened time to initiate voiding, and extended duration of voiding compared to those with Grade I and Grade II urinary function. The differences between these grades were statistically significant (all $p < 0.05$). For women with Grade IV urinary function, the urodynamic parameters could not be quantified due to urinary retention or SUI (Table 1).

3.2 Grading of Maternal Urinary Function

On postpartum day 1, 74.054% (274/370) of the women exhibited varying degrees of urinary dysfunction. However, the incidence of urinary dysfunction decreased rapidly as the puerperium progressed. By postpartum day 7, there were no cases of Grade II or Grade III urinary dysfunction observed. Postpartum stress urinary incontinence (PSUI) (Grade IV_B) was noted by postpartum day 14, with an incidence of 10.270% (38/370) (Table 2).

3.3 Analysis of the Relationship Between Initial Urinary Function Grading and Postpartum SUI

Using the initial urinary function grading from postpartum day 1 as a reference, the incidence of SUI was followed up at postpartum day 7, day 14, day 28, and day 42. The results showed that PSUI (PSUI) emerged by postpartum day 14 (Table 2). Among these cases, women classified as Grade I urinary function on day 1 accounted for 84.211% (32/38). As the puerperium progressed, the incidence of PSUI in women with Grade I urinary function decreased, while gradually increasing in those with Grade IV_A (PUR requiring catheterization) gradually increased (Fig. 1).

3.4 Univariate Analysis of Factors Affecting Postpartum Urinary Function Grading

BMI in the third trimester had no significant impact on urinary function grading ($p > 0.05$). In contrast, age, neonatal weight, the total duration of labor, operative vaginal delivery, episiotomy, and labor analgesia showed statistically significant differences in urinary function grading ($p < 0.05$). Patients with Grade IV urinary dysfunction had a

Table 2. Grading of maternal urinary function.

Observation time	Grade I (%)	Grade II (%)	Grade III (%)	Grade IV (%)	
				Grade IV_A	Grade IV_B
1 d postpartum	96 (25.946)	120 (32.432)	136 (36.757)	18 (4.865)	0 (0.000)
7 d postpartum	370 (100.000)	0 (0.000)	0 (0.000)	0 (0.000)	0 (0.000)
14 d postpartum	332 (89.730)	0 (0.000)	0 (0.000)	0 (0.000)	38 (10.270)
28 d postpartum	332 (89.730)	0 (0.000)	0 (0.000)	0 (0.000)	38 (10.270)
42 d postpartum	330 (89.189)	0 (0.000)	0 (0.000)	0 (0.000)	40 (10.810)

Grade IV_A, PUR requiring catheterization; Grade IV_B, PSUI; Data are presented as n (%). PUR, postpartum urinary retention; PSUI, postpartum stress urinary incontinence.

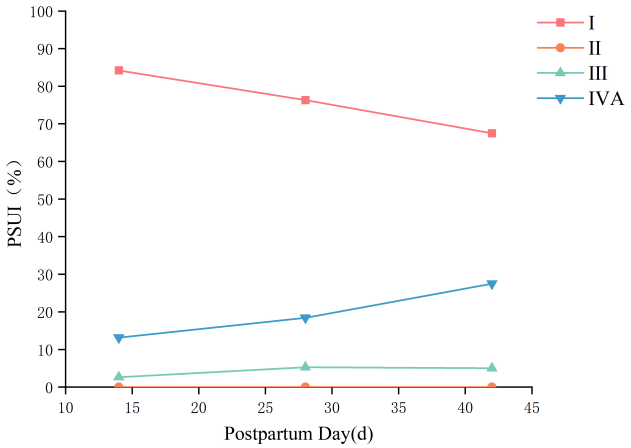

Fig. 1. Relationship between urinary function grading on postpartum day 1 and the incidence of PSUI. I–III, postpartum women with grade I–III urinary function on postpartum day 1; IV_A, postpartum women with grade IV_A (PUR requiring catheterization) on postpartum day 1.

longer total duration of labor and a higher rate of operative vaginal delivery compared to those with Grades I–III. Additionally, the rates of episiotomy and labor analgesia were significantly lower in Grade IV patients (Table 3). Post-hoc analyses revealed specific inter-grade differences in labor duration (Grade IV > Grade I, $p < 0.001$; Grade IV > Grade II, $p = 0.003$), episiotomy rates (Grade I > Grade IV, $p < 0.001$), and operative delivery (Grade IV > Grade III, $p = 0.008$). Other pairwise comparisons were non-significant (all $p > 0.05$).

3.5 Multivariate Logistic Regression Analysis of Factors Affecting Postpartum Urinary Function Grading

A logistic regression analysis was performed using significant factors identified from the univariate analysis as independent variables, with urinary function grading as the dependent variable. This grading was based on the 42-day postpartum follow-up results, where Grade I = 0 and Grade IV = 1. The results indicated that the total labor duration (OR = 17.250, $p < 0.001$, 95% CI: 3.520–84.780), labor analgesia (OR = 1.131, $p = 0.020$, 95% CI: 1.041–1.228), and operative vaginal delivery (OR = 3.440, $p = 0.012$, 95% CI: 1.040–11.430) were independent risk factors for Grade IV urinary dysfunction (Table 4).

4. Discussion

4.1 Urodynamic Parameters as Early Warning for Urinary Dysfunction

By examining urodynamic parameters across different grades of postpartum urinary function, the study demonstrated that higher severity levels are associated with prolonged voiding intervals, delayed initiation time, and longer voiding durations. These findings suggest that postpartum women have experienced pelvic floor neuromuscular impairment and an underactive bladder [13], disrupting normal voiding patterns. Typically, a normal PVR is less than 50 mL, while a high PVR indicates bladder dysfunction. Excessive bladder distension can compress the detrusor muscle and the parasympathetic nerve fibers within the bladder wall, thereby affecting the postpartum woman's ability to urinate [14]. A previous study attributes these issues to the mechanical stretching and compression of the pelvic floor structures caused by fetal head descent during vaginal delivery, which can lead to nerve demyelination, denervation, and muscular injury [15], with severe cases progressing to SUI. Additionally, the voided urine volume increased and exhibited a skewed distribution at higher grades. This is probably attributed to distinct compensatory mechanisms. Some patients may exhibit an enlarged bladder capacity due to chronic bladder overdistension, while others might maintain urinary function adaptively through residual neuromuscular function.

It is important to note that as the urinary function grades increase, the risk of postpartum women developing severe complications, such as urinary retention and urinary incontinence, also rises. These conditions not only exacerbate maternal discomfort but can also lead to complications such as urinary tract infections [8], significantly impairing postpartum recovery and quality of life. Therefore, dynamic monitoring of urinary function parameters during the puerperium can provide early warning of urinary dysfunction, enabling timely interventions to enhance urinary function and prevent complications such as urinary retention.

Table 3. Univariate analysis of factors influencing the grade of postpartum urinary function.

Factors	Grade I (n = 96)	Grade II (n = 120)	Grade III (n = 136)	Grade IV (n = 18)	χ^2/F	*p*-value
Age (years)	27.000 ± 2.700	28.000 ± 3.090	27.000 ± 2.670	27.000 ± 3.660	3.230	0.022
BMI (kg/m^2)	24.500 ± 3.130	25.100 ± 2.380	24.900 ± 2.190	25.000 ± 2.610	1.053	0.369
Neonatal weight (kg)	3.210 ± 0.380	3.170 ± 0.370	3.380 ± 0.510	3.130 ± 0.320	7.700	<0.001
Duration of labor (h)	7.800 ± 1.660	9.560 ± 1.550	10.400 ± 1.220	12.370 ± 2.180	109.212	<0.001
Episiotomy [n (%)]	78 (81.250)	96 (80.000)	108 (79.410)	16 (27.590)	69.295	<0.001
Labor analgesia [n (%)]	41 (42.710)	41 (34.170)	68 (50.000)	10 (17.240)	20.188	<0.001
Operative vaginal delivery [n (%)]	11 (11.460)	12 (10.000)	12 (8.820)	13 (22.410)	7.870	0.049

Data are presented as mean ± standard deviation and n (percentage); χ^2, chi-square. Statistical significance $p < 0.05$. F-values shown for maternal age, BMI, neonatal weight, duration of labor (ANOVA); χ^2-values shown for episiotomy, labor analgesia, operative delivery (chi-square). BMI, body mass index.

Table 4. Multivariate logistic regression analysis of factors affecting postpartum urinary function grading.

Variables	B	SE	Wald	OR	95% CI	*p*-value
Episiotomy	0.061	0.033	3.349	1.063	0.996–1.134	0.067
Duration of labor	2.847	0.811	12.445	17.250	3.520–84.780	<0.001
Labor analgesia	0.123	0.042	5.426	1.131	1.041–1.228	0.020
Operative vaginal delivery	1.235	0.612	6.358	3.440	1.040–11.430	0.012

B, coefficient value; SE, standard errors; Wald, Wald value; OR, odds ratio; CI, confidence interval. Statistical significance $p < 0.05$.

4.2 Urinary Function Grading and Its Association With PSUI

Previous studies have reported wide variations in the incidence of voiding dysfunction, with PUR ranging from 1.5% to 17.9% and SUI from 10% to 63% [14,16]. Despite different reports in the various incidences of PUR and SUI, unrecognized cases make it uncertain to determine the true incidence. Applying the grading system proposed by Saito *et al*. [10], it was found that on postpartum day 1, only 25.946% of the 370 women with full-term singleton pregnancies had normal urinary function (Grade I), while 74.054% exhibited varying degrees of urinary dysfunction, characterized by residual urine in the bladder following voluntary voiding. Due to the nonlinear biomechanical behavior of the female pelvic floor, urinary dysfunction exhibits significant individual variability [17,18], including covert urinary retention, overt urinary retention, refractory urinary retention, PSUI, and occult incontinence [19,20]. As postpartum physiological recovery progressed, the incidence of urinary dysfunction decreased rapidly, which may be due to the recovery of critical muscle tissues and damaged nerves.

Data revealed that women with SUI appeared on postpartum day 14, mainly originating from those with Grade I on postpartum day 1, suggesting that even mild urinary dysfunction may evolve into more severe impairment. A possible explanation is that women with Grade I urinary function on postpartum day 1, who initially showed no signs of urinary dysfunction, might have had undetected injuries to the pelvic floor muscles, fascia, or nerves that had not yet manifested as urinary dysfunction. A study utilizing pelvic floor (Magnetic Resonance Imaging) MRI to investigate anatomical changes in primiparous women who developed SUI following vaginal delivery demonstrated that these women exhibited an increased posterior urethrovesical angle, greater urethral mobility, a shortened functional urethral length, and a shorter bladder neck funneling [21]. Concurrently, hormonal fluctuations during pregnancy lead to increased degradation of collagen fibers within the urethral sphincter. Subsequent stretching of the musculature during childbirth causes further significant damage. This damage, compounded by injury to muscle tissue and ligaments during vaginal delivery [22], along with disruption to the periurethral nerves and supporting structures, collectively contributes to the occurrence of postpartum urinary leakage. As postpartum women gradually increased their physical activity after discharge, the pressure on the pelvic floor tissues increased, often leading to the onset of SUI. Many women became aware of this condition due to involuntary urine leakage during coughing or sneezing, contributing to the challenge of early detection [23]. Therefore, even women with mild urinary dysfunction, such as Grade I, should undergo postpartum urinary function monitoring and care to enable early prevention, detection, and treatment, thereby preventing progression to more severe conditions such as urinary incontinence or retention.

The study also observed an increase in the incidence of SUI developing from PUR during the days 14–42 postpartum. Some women with Grade IV$_A$ (PUR) required long-term indwelling catheters due to urinary retention during and after delivery. Changes in the anatomical position of the bladder angle and funneling of the urethral orifice reduced urethral resistance, contributing to the development

of PSUI [21,24]. The incidence of urinary incontinence in Grade IV patients gradually increased as the puerperium progressed, possibly due to concurrent covert stress urinary incontinence that became symptomatic as the pelvic organs returned to their normal positions. This highlights the importance of graded management and postpartum care for urinary dysfunction.

Although this study did not conduct a detailed reliability assessment, the design of the urinary function grading system was developed based on established literature and standard methods from clinical practice. Future studies should assess the reliability and validity of the grading system through multicenter studies and randomized controlled trials, with particular attention to inter-observer and intra-observer agreement. We recommend that subsequent research include more participants and utilize standardized assessment tools to ensure the reliability and reproducibility of the results.

4.3 Independent Risk Factors Affecting Postpartum Urinary Function Grading

Numerous studies have identified independent risk factors influencing postpartum urinary function, including BMI in the third trimester, labor analgesia, prolonged labor, operative vaginal delivery, maternal age at first delivery, neonatal birth weight, and episiotomy [25–27]. This study observed whether these independent risk factors affected postpartum urinary function grading. Univariate analysis revealed that BMI in the third trimester did not significantly influence urinary function grading ($p > 0.05$), suggesting improved maternal health awareness and prenatal care. Compared to women with Grade I–III urinary function, those with Grade IV dysfunction had a longer total duration of labor, a higher rate of operative vaginal delivery, and significantly lower rates of episiotomy and labor analgesia ($p < 0.05$). Possible explanations include: prolonged labor and operative vaginal delivery cause greater damage, leading to more severe urinary dysfunction and higher grading levels; women with episiotomy may refrain from voiding due to pain, and women with labor analgesia may experience reduced bladder sensation due to the effects of neuraxial anesthesia, resulting in milder urinary dysfunction and lower grading levels [20]. Epidural anesthesia is the most effective method for labor analgesia and applies even to high-risk pregnant populations, such as those with multiple gestations or preterm labor. Epidural analgesia has been shown to reduce the probability of severe postpartum hemorrhage in women undergoing vaginal delivery. Compared to higher concentrations, the use of lower concentrations of local anesthetics can decrease the incidence of maternal urinary retention. However, when compared to systemic opioid analgesia, epidural analgesia is associated with a higher incidence of motor blockade and urinary retention [28]. Additionally, those receiving neuraxial analgesia tend to have a longer duration of labor [29]. Severe urinary dysfunction (Grade IV) occurs only when bladder pressure and volume exceed the controllable range in women with episiotomy or labor analgesia. These findings highlight the need for medical staff to prevent prolonged labor, improve the quality of operative vaginal delivery, and manage voiding in women with episiotomy or labor analgesia within the range of Grade III urinary dysfunction, thereby preventing progression to Grade IV.

After multivariable adjustment for episiotomy, analgesia, and neonatal weight, logistic regression analysis identified total duration of labor, labor analgesia, and operative vaginal delivery as independent risk factors for Grade IV urinary dysfunction. Although these factors demonstrated statistical significance, the potential influence of residual confounding factors cannot be excluded, necessitating further validation through randomized controlled trials. Longer labor duration was associated with more severe urinary dysfunction. Compared to studies by Kekre *et al*. [30] and Fritel *et al*. [31], this study suggests that bladder emptying issues should be addressed when the total duration of labor is $\geq$8~9 h, and both PUR and SUI should be prevented when the total duration is $\geq$10~11 h. Women requiring operative vaginal delivery may have multiple high-risk factors, and the likelihood of pelvic floor, soft tissue, and lower urinary tract injuries increases, leading to higher rates of PUR and SUI [32]. Thus, operative vaginal delivery is also an independent risk factor for Grade IV urinary dysfunction.

4.4 Nursing Recommendations for Managing Postpartum Urination Based on the Urinary Function Grading System

To implement the postpartum urinary function grading system in routine postpartum care, we have developed a clinical practice framework aimed at improving urinary function based on study findings, influencing factors, and monitoring parameters of urinary function grading. This initiative seeks to alleviate urinary dysfunction in women after childbirth and to support postpartum recovery. However, we emphasize that broader application requires validation across diverse populations and extended observation periods, including multiparous births and longer follow-up time from six months to a year. Specific nursing measures are outlined as follows:

Grade I urinary function: Implement routine nursing measures. For women with operative vaginal delivery and a total labor duration of $\geq$10~11 h, administer stool softeners after delivery as a standard practice.

Grade II urinary function: Advise women to increase fluid intake, void frequently, and engage in pelvic floor muscle training (PFMT).

Grade III urinary function: Nursing staff should closely monitor urinary parameters to facilitate early warning and timely intervention. If the interval between voidings exceeds 4 h, consider inducing voiding. If the voided volume exceeds 500 mL, allow more time for bladder emp-

tying. If the voiding initiation time is $\geq$5 min, encourage stronger voiding efforts. If the voiding duration is $\geq$5 min, allow additional time for voiding. If the total duration of labor is $\geq$11 h, refer to the management methods for Grade IV urinary function. In summary, the goal is to control urinary dysfunction within the Grade III range.

Grade IV urinary function: SUI treatment options include PFMT, medication, mid-urethral slings surgery, and bulking agent injection. For PUR, catheterization is required to address bladder emptying issues.

Additionally, for women with risk factors for PSUI or those predicted to develop PSUI during hospitalization, provide early targeted lifestyle guidance. These women should be taught pelvic floor muscle training techniques during pregnancy [33] or before discharge and advised to initiate early pelvic floor rehabilitation therapy.

4.5 Limitations

This study presents several limitations. First, this study employs a single-center prospective observational design that does not control for differences in intervention among different nursing teams, which may introduce confounding bias. Second, the 42-day follow-up period is insufficient for assessing the long-term outcomes related to urinary dysfunction, such as the one-year incidence of SUI. Consequently, this study likely underestimates true SUI incidence and cannot assess the grading system's predictive value for chronic dysfunction, and future research should extend follow-up to validate the predictive efficacy of the grading system. Third, the study population was limited to primiparous women who had vaginal deliveries, excluding multiparous women or those who delivered via cesarean section. Multiparous women may experience cumulative childbirth-related pelvic floor injuries, which could influence the incidence and severity of urinary dysfunction when compared to primiparous women. As a result, the generalizability of the findings is restricted. Fourth, due to the inability to monitor the urinary parameters of PUR and SUI, as well as limitations in assessment methods, monitoring data for these parameters could not be obtained. As an observational study, residual confounding may persist despite multivariate adjustments. Future studies should extend follow-up periods and optimize the methods of urinary parameter measurement to refine the grading system for functional disorders. Besides, this study lacks a detailed reliability and validity assessment, including inter-observer and intra-observer agreement. Future studies should assess the reliability and validity of the grading system through multicenter studies and randomized controlled trials to ensure its reproducibility and accuracy across different settings and operators.

5. Conclusions

By classifying the severity of urinary dysfunction into four categories (I–IV), this grading system can be applied to risk-stratified management of postpartum urinary dysfunction, advancing timely diagnosis and intervention. Given the high prevalence of urinary disorders and potential progression from mild to severe dysfunction, it is recommended that healthcare providers manage risk factors, especially prolonged labor and instrument-assisted delivery, and offer individualized care to enhance recovery outcomes.

Availability of Data and Materials

The data that support the findings of this study are not openly available due to reasons of sensitivity and privacy protection and are available from the corresponding author upon reasonable request. Data is located in controlled access data storage at Nanfang Hospital.

Author Contributions

YO designed and performed the research, collected and analyzed the data, and also participated in drafting the manuscript. MY analyzed and interpreted the data, and was primarily responsible for drafting and critically revising the manuscript. Both authors read and approved the final manuscript. Both authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

The study was carried out in accordance with the guidelines of the Declaration of Helsinki. This study has been approved by the Medical Ethics Committee of Nanfang Hospital, Southern Medical University (approval number: NFEC-2018-253-1). Informed consent was obtained from all individual participants included in the study.

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Conflict of Interest

The authors declare no conflict of interest.

Declaration of AI and AI-Assisted Technologies in the Writing Process

During the preparation of this work, the authors used DeepSeek and chatGPT-3.5 in order to check spell and grammar. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

Supplementary Material

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.31083/CEOG41109.

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