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Portable Bladder Ultrasound Reduces Incidence of Urinary Tract Infection and Shortens Hospital Length of Stay in Patients With Acute Ischemic Stroke

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Background: Urinary tract infection (UTI) during acute ischemic stroke is associated with a longer hospital length of stay and unfavorable functional outcomes. **Objective:** We investigated the benefits of portable bladder ultrasound (PBU) scanning during acute ischemic stroke. **Methods:** We retrospectively reviewed patients with acute ischemic stroke from January 2011 to February 2017. Patients were divided into group 1 (PBU not available) and group 2 (PBU available), before or after the split date, April 9, 2014. Portable bladder ultrasound scanning was conducted by nurses to measure postvoid residual urine volume in patients with impaired consciousness and/or dependent ambulation. **Results:** In total, 1928 patients were enrolled, of whom 109 (5.7%) had UTI and 901 (46.7%) experienced unfavorable outcomes (modified Rankin scale score ≥ 3). Multivariate analysis revealed that factors that influenced UTI were age of 75 years or older, female gender, initial total National Institutes of Health Stroke Scale (NIHSS) score of 5 or higher, initial NIHSS conscious score of 1 or higher, initial NIHSS leg score of 2 or higher, and urinary catheterization. Factors influencing unfavorable outcomes were similar to those influencing UTI but further comprised UTI. C-statistic for UTI detection was 0.864 for model fitting, including significant factors in logistic regression. Compared with group 1, group 2 had a higher incidence of urinary catheterization (13.1% vs 8.2%), a lower incidence of UTI (4.0% vs 6.9%), and a shorter length of stay (11.9 vs 13.6 days). **Conclusions:** Portable bladder ultrasound scanning reduced the incidence of UTI and shortened length of stay. We suggest routine PBU procedures for patients with acute ischemic stroke who fulfill the AGN3 criteria for a high risk of UTI.

KEY WORDS: acute ischemic stroke, length of stay, ultrasonography, urinary retention, urinary tract infection

Urinary tract infection (UTI) is one of the most common infections in patients hospitalized for a stroke and is associated with a longer hospital length of stay and unfavorable functional outcomes.[1–3] The pontine micturition center plays the major role in promoting normal micturition by coordinating both the contraction of the bladder detrusor muscle and the relaxation of the external urethral sphincter muscle (Figure 1). The pontine micturition reflex is controlled by inhibitory input from the medial frontal lobe, cingulate gyrus, hypothalamus, and periaqueductal gray.[4,5] A lesion above the pontine micturition center

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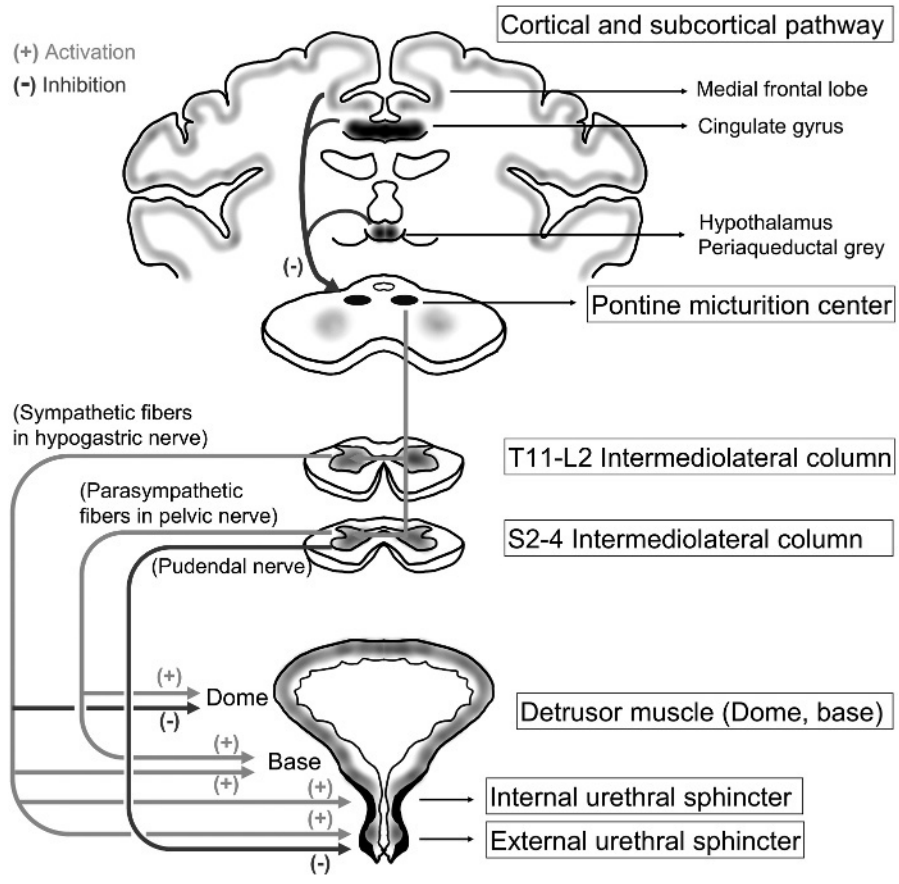

FIGURE 1. *Diagram of urinary control system.*

may cause uninhibited overactivity of the bladder with urinary incontinence.[6] A lesion at the brainstem interrupts the descending pathway from the pontine micturition center and may cause an emptying disorder of the bladder, engendering urinary retention. Factors associated with UTI after an acute stroke include direct brain injury to the central micturition pathway causing detrusor areflexia in the cerebral shock stage[7] or detrusor external sphincter dyssynergia,[8] lower urinary tract dysfunction, premorbid dysuria due to diabetic cystopathy, benign prostate hypertrophy, or other causes of neurogenic bladder, prolonged urinary catheterization, and inadequate local hygiene. The reported incidence of lower urinary tract dysfunction after a stroke varies from 53% to 64%, with common symptoms involving urinary frequency and incontinence.[9] Thomas et al[10] reported urinary incontinence in 46% to 60% of patients admitted to hospital after a stroke. Although urinary incontinence often leads to reduced quality of life, acute urine retention is the most common cause of UTI and has been reported in 29% to 47% of patients with an acute stroke.[8,11]

Postvoid residual urine volume is the most important indicator in any noninvasive evaluation of the function of the lower urinary tract system.[12] Portable bladder ultrasound (PBU) scanning is an effective and reproducible bedside procedure for evaluating postvoid residual urine volume.[13] It has garnered clinical acceptance and has replaced the relatively invasive intermittent catheterization for estimating bladder volume. Since 2014, we have formally established a PBU scanner in our stroke ward for measuring postvoid residual urine volume, along with a protocol for selecting candidate patients with acute ischemic stroke for PBU scanning. In this study, we attempt to (1) investigate the effect and benefits of PBU in the incidence of UTI, length of stay, and functional outcomes of patients with acute ischemic stroke; (2) predict factors influencing UTI and unfavorable outcomes; and (3) establish new simple criteria for being suitable candidates of patients for PBU study.

Methods

Study Cohort

We retrospectively reviewed medical records of all registered inpatients with acute ischemic stroke from January 1, 2011, to February 28, 2017. Patients who were directly admitted to the intensive care unit were excluded. Since April 9, 2014, a PBU scanner has been used in our stroke ward for measuring postvoid residual urine volume. All the inpatient medical records were divided into group 1 (from January 1, 2011, to April 8, 2014; PBU scanner unavailable) and group 2 (from April 9, 2014, to February 28, 2017; PBU scanner

available). This study was approved by the hospital's institutional review board (06-XD40-083).

Chart Review

We collected the following details relating to each patient: age, gender, total National Institutes of Health Stroke Scale (NIHSS; an 11-item scale scoring 0–42, each of which scores a specific ability between 0 and 4; the higher the score, the more severe of disability; Figure 2)[14] score, NIHSS conscious score, and NIHSS leg score on admission, the necessity for indwelling urinary catheterization, postvoid residual urine volume, the occurrence of UTI, and hospital length of stay. To emphasize the correlation between the independent ambulatory ability from the bed to the toilet and the quality of urination function, we further collected NIHSS conscious scores of 1 or higher (ranging from "not alert" to "coma") and NIHSS leg scores of 2 or higher (ranging from "some effort against gravity" to "flaccid") as predictors of UTI. To simplify and address the predictors of functional status to ensure rapid clinical application, this study did not include medical parameters that require detailed analysis procedures, such as parameters related to hypertension, diabetes mellitus, hyperlipidemia, history of prostate disease, type of ischemic stroke, or location of the infarct area.

Instrument

The criteria for undergoing PBU scanning were relatively relaxed for the patients in group 2: impaired consciousness and/or dependent ambulation within 5 days of hospitalization. For at least 2 consecutive days, each patient was subjected to PBU scanning once a day for measuring postvoid residual urine volume. The larger amount of postvoid residual urine was chosen as the recorded volume. Portable bladder ultrasound was conducted by trained nurses using a portable SonoSite Titan ultrasound system (SonoSite, Bothell, Washington), which contained a 2- to 5-Hz transducer with real-time B-mode imaging for suprapubic scanning. The technique of performing PBU is simple, and it might take only 20 minutes or less for a new nurse to learn. The PBU scanning process was performed within 15 minutes after voiding in clear patients or after changing the wet-in diaper in unconscious patients. The postvoid residual urine volume estimation was performed using the equation of Height $\times$ Width $\times$ Depth $\times$ 0.52 mL after obtaining horizontal and vertical plane images of the bladder.[15,16]

Definitions and Measurements

A hospital-acquired UTI was defined as symptomatic pyuria that required antibiotic treatment, in patients for whom a clear urinary analysis was previously obtained at admission. Outcomes were evaluated using the NIHSS, the Barthel index (a 10-item scale scoring 0–100 with 5-point increments; the higher the score, the better activities of daily living),[17] and the modified Rankin scale (a grading scale scoring 0–6 with 1-point increments; the higher the score, the more severe the disability)[18] at discharge. A modified Rankin scale score of 3 or higher (moderate disability, requiring some help but able to walk without assistance) was considered an indicator of an unfavorable outcome.

Statistic Analysis

A 2-sample t test was conducted to evaluate the differences in the means of continuous variables. The χ^2 and Fisher exact tests were used for categorical comparisons of data. Significant predictors (age and total NIHSS score on admission) in the univariate analyses were transformed into dichotomous variables, with the optimal cutoff levels determined according to the Youden index by using receiver operating characteristic curves plotted for UTI and unfavorable outcomes; the variables were then included in a multiple logistic regression model to identify the most important factors associated with UTI and unfavorable outcomes. The predictive performance levels of the variables were compared using C-statistic for UTI. Comparisons of C-statistic were conducted according to the method developed by DeLong et al[19] in 1988. The receiver operating characteristic curve comparisons were executed using R software (version 2.15.3, pROC package). A $P < .05$ was considered to indicate statistical significance. All statistical analyses were performed using SPSS (version 24; SPSS, Inc, Chicago, Illinois).

Results

Characteristics of Patients

In total, 1928 inpatient medical records were enrolled in the study, with 1104 medical records in group 1 and 824 medical records in group 2. Table 1 presents the clinical features of the patients. On average, the patients in group 2 were older than those in group 1 by 1.6 years. In both groups, female patients were older than their male counterparts. Moreover, group 2 had a lower percentage of female patients. The comparison revealed no differences between the groups in terms of the total NIHSS score, NIHSS conscious score, or NIHSS leg score on admission. Furthermore, 10.3% of all patients received urinary catheterization, and the percentage of patients receiving such catheterization was higher in group 2 (13.1%) than in group 1 (8.2%).

Complications and Outcomes

Urinary tract infection occurred in 109 of the 1928 patients (5.7%), and the occurrence rate was higher

Simplified version of National Institutes of Health Stroke Scale		
Category	Description	Score
1a. Level of Consciousness (alert, drowsy, etc)	Alert Drowsy Stuporous Coma	0 1 2 3
1b. LOC Questions (Month, age)	Answers both correctly Answers one correctly Incorrect	0 1 2
1c. LOC Commends (Open, close eyes, make fist, let go)	Obeys both correctly Obeys one correctly Incorrect	0 1 2
2. Best Gaze (Eyes open – patient follows examiner's finger of face)	Normal Partial gaze palsy Forced deviation	0 1 2
3. Visual (Introduce visual stimulus/threat to patient's visual field quadrants)	No visual loss Partial hemianopia Complete hemianopia Bilateral hemianopia	0 1 2 3
4. Facial Palsy (Show teeth, raise eyebrows and squeeze eyes shut)	Normal Minor Partial Complete	0 1 2 3
5a. Motor Arm – Left (Elevated extremity to 90^0 and score drift/movement)	No drift Drift Can't resist gravity No Effort against gravity No movement Amputation, joint fusion (explain)	0 1 2 3 4 9
5b. Motor arm – Right (Elevated extremity to 90^0 and score drift/movement)	No drift Drift Can't resist gravity No Effort against gravity No movement Amputation, joint fusion (explain)	0 1 2 3 4 9
6a. Motor leg – Left (Elevated extremity to 30^0 and score drift/movement)	No drift Drift Can't resist gravity No Effort against gravity No movement Amputation, joint fusion (explain)	0 1 2 3 4 9
6b. Motor leg – Right (Elevated extremity to 30^0 and score drift/movement)	No drift Drift Can't resist gravity No Effort against gravity No movement Amputation, joint fusion (explain)	0 1 2 3 4 9
7. Limb ataxia (Finger-nose, heel down shin)	Absent Present in one limb Present in two limbs	0 1 2
8. Sensory (Pin prick to face, arm, trunk and leg – compare side to side)	Normal Partial loss Sever loss	0 1 2
9. Best Language (Name items, describe a picture and read sentence)	No aphasia Mild to moderate aphasia Severe aphasia Mute	0 1 2 3
10. Dysarthria (Evaluate speech clarity by patient repeating listed words)	Normal articulation Mild to moderate dysarthria Near to unintelligible or worse Intubated or other physical barrier	0 1 2 9
11. Extinction and Inattention (Use information from prior testing to identify neglect or double simultaneous stimuli testing)	No neglect Partial neglect Complete neglect	0 1 2

FIGURE 2. *Simplified version of the National Institutes of Health Stroke Scale.*

TABLE 1 Summary of Clinical Features in 1928 Patients With Acute Ischemic Stroke

Characteristics	Total (Jan 1, 2011, to Feb 28, 2017; n = 1928)	Group 1 (Jan 1, 2011, to Apr 8, 2014; n = 1104)	Group 2 (Apr 9, 2014, to Feb 28, 2017; n = 824)	P[a]
Mean age, y	70.6 ± 13.6	70.0 ± 13.5	71.6 ± 13.8	.007
Male/female	68.3/73.8	68.6/72.8	69.2/75.4	<.001
Total NIHSS score on admission	5.4 ± 5.3	5.3 ± 5.0	5.5 ± 5.7	.274
Total NIHSS score at discharge	4.3 ± 5.5	4.3 ± 5.5	4.3 ± 5.4	.923
Barthel index score at discharge	72 ± 32	73 ± 31	71 ± 34	.168
Modified Rankin scale score at discharge	2.4 ± 1.6	2.4 ± 1.6	2.5 ± 1.6	.168
Length of stay	12.9 ± 11.9	13.6 ± 12.6	11.9 ± 10.8	.002
Female gender[b]	811 (42.0%)	490 (44.4%)	321 (39.0%)	.017
NIHSS conscious score ≥ 1[b]	229 (11.9%)	125 (11.3%)	104 (12.6%)	.394
NIHSS leg score ≥ 2[b]	470 (24.4%)	260 (23.6%)	210 (25.5%)	.355
Urinary catheterization[b]	199 (10.3%)	91 (8.2%)	108 (13.1%)	<.001
Urinary tract infection[b]	109 (5.7%)	76 (6.9%)	33 (4.0%)	.007
Modified Rankin scale score ≥ 3[b]	901 (46.7%)	513 (46.5%)	388 (47.1%)	.818

Abbreviation: NIHSS, National Institutes of Health Stroke Scale.
[a]Two-sample *t* test.
[b]χ^2 Test.

in group 1 (6.9%) than in group 2 (4.0%). The average length of stay of all patients was 12.9 days; it was 1.7 days shorter in group 2. Unfavorable outcomes (modified Rankin scale score ≥ 3) were noted in 901 of all patients (46.7%). No differences were observed between groups 1 and 2 in terms of the total NIHSS score, Barthel index score, or modified Rankin scale score at discharge. The PBU scanning was performed on 31% of the patients (254/824) in group 2. The receiver operating characteristic curve analysis revealed that the optimal postvoid residual urine volume cutoff point for predicting UTI was 100 mL. Of the 254 patients in group 2, 97 (38%) were found to have a postvoid residual urine volume of 100 mL or greater during the PBU examination; among these 97 patients, 18 received subsequent urinary catheterization.

Factors Influencing Urinary Tract Infection and Unfavorable Outcomes

Table 2 presents the results obtained from the univariate analyses of the correlation between clinical features, UTI, and unfavorable outcomes in all 1928 patients. The 109 patients with UTI during hospitalization and the 901 patients who experienced unfavorable outcomes had similar clinical characteristics. Compared with the remaining patients, the patients with UTI and those with unfavorable outcomes were

TABLE 2 Correlation of Clinical Features With Urinary Tract Infection and Unfavorable Outcomes in 1928 Patients With Acute Ischemic Stroke

	Urinary Tract Infection[a]			Unfavorable Outcome (Modified Rankin Scale Score ≥ 3)[a]		
Characteristics	Y (n = 109)	N (n = 1819)	P	Y (n = 901)	N (n = 1027)	P
Age, y	77.6 ± 11.2	70.2 ± 13.7	<.001	75.4 ± 12.6	66.4 ± 13.2	<.001
Female gender[b]	71 (65.1%)	740 (40.7%)	<.001	450 (49.9%)	361 (35.2%)	<.001
Total NIHSS score on admission	12.3 ± 8.4	4.9 ± 4.7	<.001	8.3 ± 6.2	2.8 ± 2.2	<.001
NIHSS conscious score ≥ 1 on admission[b]	46 (42.2%)	183 (10.1%)	<.001	199 (22.1%)	30 (2.9%)	<.001
NIHSS leg score ≥ 2 on admission[b]	67 (61.5%)	403 (22.2%)	<.001	409 (45.5%)	61 (5.9%)	<.001
Urinary catheterization	49 (44.9%)	150 (8.2%)	<.001	177 (19.6%)	22 (2.1%)	<.001
Length of stay	27.8 ± 16.8	12.0 ± 10.9	<.001	19.3 ± 13.8	7.2 ± 5.6	<.001
Total NIHSS score at discharge	11.2 ± 8.8	3.8 ± 4.9	<.001	7.4 ± 6.7	1.6 ± 1.5	<.001
Barthel index score at discharge	27.9 ± 28.6	74.5 ± 30.7	<.001	44.9 ± 28.7	94.9 ± 9.3	<.001
Modified Rankin scale score at discharge	4.3 ± 1.1	2.3 ± 1.5	<.001	7.4 ± 6.7	1.6 ± 1.5	<.001

Abbreviation: NIHSS, National Institutes of Health Stroke Scale.
[a]Two-sample *t* test.
[b]χ^2 Test.

older; comprised a higher percentage of women; had higher total NIHSS scores, NIHSS conscious scores of 1 or higher, and NIHSS leg scores of 2 or higher on admission; and had higher modified Rankin scale but lower Barthel index scores at discharge. In addition, a higher percentage of patients with UTI and those with unfavorable outcomes received urinary catheterization during hospitalization. The hospital length of stay for patients with UTI and patients with unfavorable outcomes were 15.8 and 12.1 days longer than those for patients without UTI and patients with favorable outcomes, respectively.

For aim 2, we used the receiver operating characteristic curve analysis and found that an age of 75 years or older and an NIHSS score of 5 or higher on admission were the optimal cutoff levels for UTI and unfavorable outcomes. A multivariate logistic regression analysis revealed that the following were significant predictors of UTI: age of 75 years or older, female gender, a total NIHSS score of 5 or higher, an NIHSS conscious score of 1 or higher, an NIHSS leg score of 2 or higher on admission, and urinary catheterization (Table 3). The significant predictors of unfavorable outcomes were similar to those of UTI but further included UTI (odds ratio, 2.95; 95% confidence interval, 1.32–6.58; $P = .008$).

Table 4 presents the C-statistic estimated from the stepwise forward regression models for the detection of UTI for each factor. A C-statistic of 0.864 was estimated for the detection of UTI from a fit model of the 6 significant predictors obtained from the regression analysis in Table 3. By contrast, the C-statistic for the detection of UTI was 0.717 when the total NIHSS score was 5 or higher on admission. Adding urinary catheterization, an NIHSS conscious score of 1 or higher on admission, and the female gender to the regression model resulted in significant stepwise improvements of the C-statistic from 0.717 to 0.853 ($P < .05$). However, adding an NIHSS leg score of 2 or higher on admission and an age of 75 years or older did not significantly improve the predictive value for UTI.

Discussion

Urinary Tract Infection and Unfavorable Outcomes

Patients who experienced unfavorable outcomes and those who developed UTI shared similar clinical predictors in this study. They were older; comprised a higher percentage of women; had higher total NIHSS, NIHSS conscious, and NIHSS leg scores on admission; received more urinary catheterization; and had a longer length of stay. Although patients in group 2 had a higher frequency of urinary catheterization, they had a lower incidence of UTI and a shorter length of stay. Urinary catheterization has both positive and negative consequences.[3] Proper recognition of urinary retention and early urinary catheterization may reduce the risk of UTI; however, prolonged urinary catheterization may cause UTI.

Patients with acute ischemic stroke who are dependent in their daily ambulation are at risk of incomplete emptying of urine during urination, which would result in various postvoid residual urine volumes. A gradual increase in postvoid residual urine volume may cause overflow incontinence resembling that patients could still void urine well. Therefore, we added the NIHSS conscious and leg scores to the regression model as independent factors that contribute to urinary retention. Only 31% of the patients in group 2 received PBU scanning. Of these patients, 38% had postvoid residual urine volume of 100 mL or greater, which was found to be the optimal cutoff point for predicting UTI.

The New AGN3 Criteria

We did not compare the location and size of cerebral infarct with the pattern of urinary dysfunction. It is more crucial for medical care providers to quickly screen patients who are at risk of UTI. Previous research revealed that urinary retention was common in patients with aphasia, cognitive impairment, poor functional status, and diabetes mellitus.[11] Research also recommended the collection of premorbid histories of prostate

TABLE 3 Regression Model of Factors Influencing Urinary Tract Infection and Unfavorable Outcomes in 1928 Patients With Acute Ischemic Stroke

	Urinary Tract Infection		Unfavorable Outcome (Modified Rankin Scale Score ≥ 3)	
Characteristics	OR (95% CI)	*P*	OR (95% CI)	*P*
Age ≥ 75 y	1.72 (1.10–2.70)	.018	3.44 (2.70–4.37)	<.001
Female gender	1.86 (1.20–2.87)	.006	1.33 (1.05–1.68)	.020
Total NIHSS score ≥ 5 on admission	2.79 (1.56–4.96)	<.001	6.23 (4.76–8.16)	<.001
NIHSS conscious score ≥ 1 on admission	1.87 (1.15–3.04)	.011	1.89 (1.16–3.09)	.011
NIHSS leg score ≥ 2 on admission	1.72 (1.05–2.82)	.033	3.58 (2.53–5.08)	<.001
Urinary catheterization	4.12 (2.61–6.52)	<.001	4.63 (2.71–7.91)	<.001
Urinary tract infection			2.95 (1.32–6.58)	.008

Abbreviations: CI, confidence interval; NIHSS, National Institutes of Health Stroke Scale; OR, odds ratio.

TABLE 4 C-statistic for Prediction of Urinary Tract Infection

Characteristics	C-statistic (95% CI)	P[a]
Total NIHSS score on admission ≥ 5	0.717 (0.670–0.763)	—
Includes urinary catheterization	0.807 (0.766–0.847)	<.001
Further includes NIHSS conscious score ≥ 1	0.829 (0.789–0.869)	.009
Further includes female gender	0.853 (0.820–0.886)	.033
Further includes NIHSS leg score ≥ 2	0.857 (0.825–0.889)	.509
Further includes age ≥ 75 y	0.864 (0.835–0.894)	.501

Abbreviations: CI, confidence interval; NIHSS, National Institutes of Health Stroke Scale.
[a]Compared with previous one.

disease and stress incontinence to monitor urinary function. However, whether urinary dysfunction after a stroke was affected by direct brain lesions or by indirect functional impairment, or both, is unclear.[9]

We developed a new criteria (AGN3) comprising the 3 clinical features of age (A), gender (G), and initial stroke severity, as determined by the NIHSS (N3; total NIHSS score, NIHSS conscious score, and NIHSS leg score), to screen patients at risk of UTI. Physicians or nurses can easily collect these clinical features on admission, even if they do not possess detailed information about the location of the stroke, the special neurological test for aphasia, or comorbidity conditions. Research recommended the execution of PBU scanning on all patients immediately after a stroke.[11] With the help of the AGN3 criteria, performing PBU on all patients after an acute stroke is unnecessary. To save time and medical human resources costs, we may consider that PBU only be performed on patients at a high risk of UTI, as determined by the AGN3 criteria including age of 75 years or older, female gender, initial NIHSS score of 5 or higher, NIHSS conscious score of 1 or higher, and NIHSS leg score of 2 or higher.

Benefits of Portable Bladder Ultrasound Examination

Portable bladder ultrasound scanning is a rapid, convenient, and reliable examination to detect postvoid residual urine volume at bedside.[13] Teng et al[13] reported that a BladderScan device with 3-dimensional imaging provided similar accurate postvoid residual urine measurements as did intermittent catheterization; moreover, nurses could operate the bladder ultrasound easily. Conventional ultrasound devices entail estimating postvoid residual urine volume by using equations and horizontal and vertical plane images of the bladder.[15,16] Nevertheless, the measurement accuracy might be affected by the bladder volume status, particularly in situations involving different bladder configurations.[20] However, the greatest benefit of PBU scanning is not how accurate the measurement might be but the subsequent clinical decision-making process,[13] such as the appropriate bladder training program, the necessity of catheterization, and early detection of UTI with proper treatment. In this study, only one-third of the patients in group 2 received PBU scanning. A higher number of patients could have met the criteria but did not receive PBU scanning. Nevertheless, this partial patient group study demonstrated that PBU scanning significantly reduces the incidence of UTI and shortens hospital length of stay. We believe that the benefits of PBU scanning would be greater, even a significant better outcome, if this procedure had been performed on all patients who met the AGN3 criteria.

Role of Nurses in Performing Portable Bladder Ultrasound

The decision of PBU scanning depended on relaxed criteria by the awareness of physicians and nurses regarding a patient's daily urine output, as well as a physical or visual examination of a patient's bladder. Because physicians are usually too busy to be excessively engaged in performing PBU scanning, it is more convenient and efficient for nurses to perform such examination at the bedside. Nowadays, the benefits and contributions of advanced practice nurses in improving the quality of healthcare have been well established.[21,22] The advanced practice nurse, particular clinical nurse specialist or nurse practitioner, may play an additional important role in performing PBU scanning with more accurate results.

Limitations

This study has some limitations. First, in this retrospective study, the authors used relaxed criteria to determine which patients received PBU scanning. A prospective study with the newly developed AGN3 criteria will provide more information on the benefits of PBU scanning. Second, group 2 patients were, on average, older than group 1 patients, and group 2 contained more women than group 1 did. Urinary tract infection occurred more in older female patients; however, the incidence of UTI was lower in group 2 patients. The effects of these 2 factors on UTI were discrepant in group 2. Third, PBU procedures were performed by various nurses who were responsible for the bedside care. Although the nurses were adequately trained to perform the procedures, we expected detection errors. Advanced practice nurses seem to be the most suitable medical care providers to perform PBU procedures.

What's New and Important

- Urinary retention is the major cause of UTI in patients with acute ischemic stroke.
- Applying PBU scanning by nurses to measure postvoid residual urine volume significantly reduces the incidence of UTI and shortens hospital length of stay.
- Routine PBU procedures may be considered for patients who fulfill the following AGN3 criteria: total NIHSS score of 5 or higher, NIHSS conscious score of 1 or higher on admission, female gender, NIHSS leg score of 2 or higher on admission, and age of 75 years or older, particularly for the first 3 criteria.

Conclusion

Portable bladder ultrasound scanning reduced the incidence of UTI and shortened hospital length of stay in patients with acute ischemic stroke. We may consider routine PBU procedures for patients who fulfill the AGN3 criteria, including total NIHSS score of 5 or higher, NIHSS conscious score of 1 or higher on admission, female gender, NIHSS leg score of 2 or higher on admission, and age of 75 years or older, particularly for the first 3 criteria. A prospective study with AGN3 criteria is necessary to validate the benefits of PBU scanning.

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