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Original Article

Diagnostic Accuracy of Retrograde Urethrogram in Diagnosing Urethral Stricture Keeping Urethroscopy / Surgical Findings as Gold Standard

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ABSTRACT

Background: Urethral stricture is a clinically important cause of lower urinary tract obstruction in males and may lead to dysuria, weak urinary stream, urinary retention, recurrent infection, and impaired quality of life if diagnosis is delayed. Retrograde urethrography is widely used as an initial imaging investigation because it is accessible, inexpensive, and provides anatomical information about the urethral lumen, but its diagnostic performance should be evaluated against direct reference-standard findings. **Objective:** To determine the diagnostic accuracy of retrograde urethrography for detecting urethral stricture in symptomatic male patients, using urethroscopy or intraoperative surgical findings as the reference standard. **Methods:** This cross-sectional diagnostic accuracy study was conducted in the Department of Radiology, Liaquat National Hospital, Karachi, from January 2024 to June 2024. A total of 210 male patients aged 15–65 years with clinical suspicion of urethral stricture underwent retrograde urethrography, followed by comparison with urethroscopy or surgical findings. Sensitivity, specificity, positive predictive value, negative predictive value, and overall accuracy were calculated from a two-by-two diagnostic table. **Results:** Reference-standard confirmed urethral stricture was present in 117 patients (55.7%). Retrograde urethrography showed 113 true-positive, 90 true-negative, 3 false-positive, and 4 false-negative findings. Sensitivity was 96.6%, specificity 96.8%, positive predictive value 97.4%, negative predictive value 95.7%, and overall accuracy 96.7%. Bulbar urethra was the most frequent stricture site, observed in 124 patients (59.0%). **Conclusion:** Retrograde urethrography demonstrated high diagnostic accuracy for detecting urethral stricture and is a dependable first-line imaging modality for symptomatic male patients in tertiary-care practice. **Keywords:** Urethral stricture, Retrograde urethrography, Diagnostic accuracy, Urethroscopy, Surgical findings, Male lower urinary tract obstruction.

INTRODUCTION

Urethral stricture disease is a clinically important cause of lower urinary tract obstruction in males, characterized by narrowing of the urethral lumen due to fibrosis and scar formation. The condition may occur after pelvic or perineal trauma, urethral instrumentation, catheterization, infection, inflammation, or previous urological procedures, and it can affect men across a wide age range (1). Patients commonly present with weak urinary stream, straining, dysuria, post-micturition dribbling, recurrent urinary tract infection, incomplete bladder emptying, or acute urinary retention. When diagnosis is delayed, progressive obstruction may lead to recurrent infection, bladder dysfunction, upper urinary tract deterioration, and substantial impairment in quality of life. Early and accurate identification of the site, presence, and extent of urethral narrowing is therefore essential for timely management and treatment planning (2,3).

Several diagnostic approaches are used in the evaluation of suspected urethral stricture disease, including clinical assessment, uroflowmetry, retrograde urethrography, voiding cystourethrography, sonourethrography, urethroscopy, and intraoperative assessment. Among these, retrograde urethrography remains one of the most widely used first-line imaging investigations because it is relatively inexpensive, accessible, technically feasible, and capable of demonstrating the anatomical location and approximate length of anterior urethral strictures (4). By outlining the urethral lumen with contrast medium, retrograde urethrography can help distinguish bulbar, penile, and more extensive strictures, information that is central to selecting appropriate surgical or endoscopic management. Despite these advantages, its diagnostic performance may vary according to patient positioning, technique of contrast administration, degree of urethral distension, radiologist experience, and stricture characteristics such as length, severity, multiplicity, or location (5).

Accurate preoperative diagnosis is particularly important because treatment decisions in urethral stricture disease depend not only on confirming the presence of narrowing but also on defining its anatomical characteristics. Short, isolated strictures may be considered for endoscopic management in selected cases, whereas longer, recurrent, dense, or complex strictures often require reconstructive procedures. Underestimation of stricture length may lead to inadequate operative planning, while overestimation may result in unnecessary extension of treatment. Therefore, imaging findings must be interpreted against a reliable reference standard such as urethroscopy or intraoperative surgical assessment, where direct visualization permits confirmation of the presence and extent of urethral narrowing (6,7).

Although retrograde urethrography is routinely used in many clinical settings, evidence regarding its diagnostic accuracy remains variable across populations and institutions. Differences in imaging technique, equipment quality, interpreter expertise, reference-standard definition, and patient selection may influence reported sensitivity, specificity, and predictive values. In resource-limited healthcare systems, including many tertiary-care settings in Pakistan, retrograde urethrography is frequently relied upon for primary assessment before definitive intervention. However, locally generated evidence evaluating its diagnostic accuracy against urethroscopy or surgical findings remains limited. This gap is important because diagnostic performance observed in one healthcare environment may not be directly generalizable to another, particularly where patient characteristics, disease severity at presentation, operator experience, and access to advanced imaging differ (8,9).

The present study was therefore designed using a diagnostic-accuracy framework based on the PICO concept: male patients with clinical suspicion of urethral stricture represented the target population; retrograde urethrography served as the index test; urethroscopy or surgical findings served as the reference standard; and the primary outcomes were sensitivity, specificity, positive predictive value, negative predictive value, and overall diagnostic accuracy. By comparing retrograde urethrogram findings with reference-standard findings in symptomatic male patients managed at a tertiary-care hospital, this study aimed to determine whether retrograde urethrography provides sufficiently reliable diagnostic information for routine clinical decision-making. The objective of the study was to evaluate the diagnostic accuracy of retrograde urethrography in detecting urethral stricture among male patients, using urethroscopy or surgical findings as the reference standard.

MATERIALS AND METHODS

A cross-sectional diagnostic accuracy study was conducted in the Department of Radiology, Liaquat National Hospital, Karachi, over a six-month period January 2024 to June 2024. The study was designed to evaluate the diagnostic performance of retrograde urethrography for detecting urethral stricture in clinically suspected male patients, using urethroscopy or intraoperative surgical findings as the reference standard. A diagnostic accuracy design was selected because the primary purpose was to

compare the index imaging test against direct reference-standard confirmation and to estimate sensitivity, specificity, predictive values, and overall accuracy in a hospital-based clinical population.

A total of 210 male patients aged 15 to 65 years with clinical suspicion of urethral stricture were included. Eligible patients were those presenting with lower urinary tract symptoms suggestive of urethral narrowing, including dysuria, weak or difficult initiation of urinary stream, urinary retention, or post-micturition dribbling for more than one week, and who provided written informed consent for participation and diagnostic evaluation. Patients were excluded if they had a history of previous urethral surgery, congenital urethral abnormality, externally performed urethral imaging, refusal to undergo retrograde urethrography, or inability to complete the required diagnostic assessment (10). Consecutive sampling was used, and all eligible patients presenting during the study period were enrolled to minimize selection bias and improve representativeness of the symptomatic hospital population.

After enrollment, demographic and clinical information was recorded on a structured pro forma, including age, presenting urinary symptoms, history of diabetes mellitus, hypertension, and kidney disease. Each participant underwent retrograde urethrography as the index test in the radiology department using a standardized technique. Before imaging, patients were asked to empty the urinary bladder, and aseptic preparation of the external genitalia was performed. Local anesthetic gel was applied to reduce discomfort during the procedure. The patient was positioned obliquely, the penis was gently stretched to adequately profile the anterior urethra, and contrast medium was slowly introduced through the urethral meatus. Radiographic images were obtained to outline the urethral lumen and identify the presence, site, and estimated length of any narrowing. Stricture location was categorized as bulbar, penile, or diffuse according to radiographic appearance.

Retrograde urethrography was considered positive when focal or segmental narrowing of the urethral lumen consistent with urethral stricture was demonstrated on contrast imaging. It was considered negative when no luminal narrowing compatible with stricture was identified. The reference standard was urethroscopy or intraoperative surgical assessment, through which the urethral lumen was directly evaluated and the presence or absence of stricture was confirmed. Reference-standard findings were documented after the diagnostic procedure and were used for final classification of disease status. Cases were classified as true positive when retrograde urethrography and the reference standard both confirmed stricture, true negative when both were negative, false positive when retrograde urethrography suggested stricture but the reference standard did not confirm it, and false negative when retrograde urethrography was negative despite reference-standard confirmation of stricture.

The primary outcome variables were sensitivity, specificity, positive predictive value, negative predictive value, and overall diagnostic accuracy of retrograde urethrography. Sensitivity was defined as the proportion of reference-standard positive cases correctly identified by retrograde urethrography, whereas specificity was defined as the proportion of reference-standard negative cases correctly excluded by retrograde urethrography. Positive predictive value represented the probability that patients with a positive retrograde urethrogram truly had urethral stricture, and negative predictive value represented the probability that patients with a negative retrograde urethrogram were truly free of stricture. Overall diagnostic accuracy was calculated as the proportion of all correctly classified cases among the total study population. Secondary variables included patient age group, symptom profile, comorbid conditions, stricture site, and stricture length where available.

Bias was addressed by enrolling consecutive eligible patients, applying the same index-test protocol to all participants, using a direct reference-standard assessment for final disease classification, and recording findings in a uniform pro forma. Standardized positioning, contrast administration, image acquisition, and documentation procedures were used to reduce technical variation. Clinical and imaging variables were recorded before final diagnostic classification to maintain consistency in data capture. Potential confounding by age, symptoms, and comorbid conditions was assessed through

stratified analysis, and post-stratification comparisons were planned to evaluate whether diagnostic performance differed across clinically relevant subgroups.

The sample size consisted of 210 patients enrolled during the defined study period, which provided an adequate hospital-based diagnostic accuracy sample for estimating the performance of retrograde urethrography against reference-standard findings. Data were entered and analyzed using IBM SPSS Statistics version 25. Continuous variables such as age and stricture length were summarized using mean and standard deviation where normally distributed, while categorical variables such as age group, comorbidities, symptoms, stricture site, and diagnostic classification were summarized as frequencies and percentages. A two-by-two diagnostic table was constructed using retrograde urethrography findings against reference-standard findings. Sensitivity, specificity, positive predictive value, negative predictive value, and overall accuracy were calculated using standard diagnostic accuracy formulae. Chi-square testing was used for categorical comparisons after stratification, and a p-value of less than 0.05 was considered statistically significant.

Data completeness was checked before final analysis, and all enrolled patients with complete index-test and reference-standard findings were included in the diagnostic accuracy calculation. Data entry was reviewed for consistency, range errors, and duplicate entries before analysis. Ethical approval was obtained from the institutional ethics committee before commencement of the study. Written informed consent was obtained from all participants, and confidentiality of patient information was maintained throughout data collection, analysis, and reporting. All procedures were conducted according to institutional clinical standards for radiological and urological evaluation.

RESULTS

A total of 210 male patients with clinical suspicion of urethral stricture were included in the analysis. The largest age group was 31–45 years, comprising 86 patients (41.0%), followed by 15–30 years with 72 patients (34.3%). Patients aged 46–60 years accounted for 44 cases (21.0%), while only 8 patients (3.8%) were older than 60 years. Overall, 158 patients (75.2%) were 45 years or younger, indicating that most clinically suspected cases occurred among young and middle-aged men.

Table 1. Age Distribution of Study Participants

Age Group, Years	Number of Patients	Percentage
15–30	72	34.3
31–45	86	41.0
46–60	44	21.0
>60	8	3.8
Total	210	100.0

Comorbid conditions were present in a subset of patients. Diabetes mellitus was documented in 54 patients (25.7%), hypertension in 46 patients (21.9%), and kidney disease in 13 patients (6.2%). The majority of patients had no diabetes 156/210 (74.3%), no hypertension 164/210 (78.1%), and no kidney disease 197/210 (93.8%). Among urinary symptoms, dysuria was the most frequent complaint, reported by 194 patients (92.4%). Difficulty initiating urination was present in 139 patients (66.2%), post-micturition dribbling in 131 patients (62.4%), and urinary retention in 92 patients (43.8%).

Table 2. Clinical Characteristics and Presenting Symptoms

Variable	Present, n (%)	Absent, n (%)	Total
Diabetes mellitus	54 (25.7)	156 (74.3)	210
Hypertension	46 (21.9)	164 (78.1)	210
Kidney disease	13 (6.2)	197 (93.8)	210
Pain during urination	194 (92.4)	16 (7.6)	210
Difficulty starting urine	139 (66.2)	71 (33.8)	210
Urinary retention	92 (43.8)	118 (56.2)	210
Dribbling after urination	131 (62.4)	79 (37.6)	210

The most frequent anatomical site of urethral stricture on evaluation was the bulbar urethra, identified in 124 patients (59.0%). Penile urethral involvement was observed in 69 patients (32.9%), while diffuse

strictures were present in 17 patients (8.1%). Thus, localized bulbar and penile strictures together accounted for 193 cases (91.9%), whereas diffuse disease represented a smaller subgroup.

Table 3. Anatomical Site of Urethral Stricture

Site of Stricture	Number of Patients	Percentage
Bulbar urethra	124	59.0
Penile urethra	69	32.9
Diffuse stricture	17	8.1
Total	210	100.0

Retrograde urethrography findings were compared with urethroscopy or surgical findings as the reference standard. Retrograde urethrography correctly identified 113 true-positive cases and correctly excluded stricture in 90 true-negative cases. There were 3 false-positive cases, in which retrograde urethrography suggested stricture but the reference standard did not confirm it, and 4 false-negative cases, in which the reference standard confirmed stricture despite a negative retrograde urethrogram. Based on the reference standard, urethral stricture was present in 117 patients (55.7%) and absent in 93 patients (44.3%).

Table 4. Diagnostic Cross-Classification of Retrograde Urethrography Against Reference Standard

Retrograde Urethrography Result	Reference Standard Positive	Reference Standard Negative	Total
Positive	113	3	116
Negative	4	90	94
Total	117	93	210

Table 5. Diagnostic Performance of Retrograde Urethrography

Diagnostic Measure	Formula Basis	Value, %	95% Confidence Interval
Sensitivity	113 / 117	96.6	91.5–98.7
Specificity	90 / 93	96.8	90.9–98.9
Positive predictive value	113 / 116	97.4	92.7–99.1
Negative predictive value	90 / 94	95.7	89.6–98.3
Overall accuracy	203 / 210	96.7	93.3–98.4
False-positive rate	3 / 93	3.2	1.1–9.1
False-negative rate	4 / 117	3.4	1.3–8.5
Reference-standard prevalence	117 / 210	55.7	49.0–62.3

Using the diagnostic cross-classification, retrograde urethrography demonstrated sensitivity of 96.6%, indicating that it detected nearly all reference-standard confirmed strictures. Specificity was 96.8%, showing strong ability to exclude stricture among patients without reference-standard evidence of disease. The positive predictive value was 97.4%, and the negative predictive value was 95.7%. Overall diagnostic accuracy was 96.7%, with 203 of 210 patients correctly classified. The false-positive rate was 3.2%, and the false-negative rate was 3.4%.

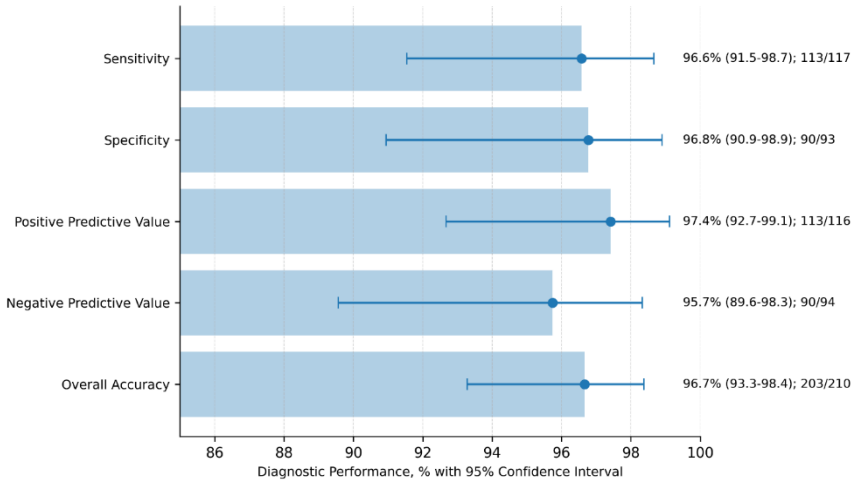

Figure 1. Diagnostic Performance Profile of Retrograde Urethrography for Urethral Stricture

Retrograde urethrography demonstrated consistently high diagnostic performance across all evaluated indices, with sensitivity of 96.6% based on 113/117 reference-standard positive cases and specificity of 96.8% based on 90/93 reference-standard negative cases. The positive predictive value was the highest estimate at 97.4%, indicating that nearly all positive retrograde urethrogram findings were confirmed by urethroscopy or surgical assessment, while the negative predictive value remained strong at 95.7%. Overall accuracy reached 96.7%, reflecting correct classification in 203 of 210 patients. The narrow confidence intervals across sensitivity, specificity, predictive values, and accuracy support a clinically stable diagnostic profile, with only 7 discordant classifications among the full cohort.

Overall, the results show that retrograde urethrography had strong diagnostic performance in symptomatic male patients, with high sensitivity and specificity and only 7 discordant cases among 210 evaluations. The burden of suspected disease was highest among men aged 31–45 years, dysuria was the dominant presenting symptom, and bulbar urethral involvement was the most frequent anatomical pattern. The diagnostic findings indicate that retrograde urethrography correctly classified more than nine out of every ten patients, supporting its clinical utility as an index imaging test for suspected urethral stricture in this study population.

DISCUSSION

Retrograde urethrography demonstrated high diagnostic performance for detecting urethral stricture in symptomatic male patients, with sensitivity of 96.6%, specificity of 96.8%, positive predictive value of 97.4%, negative predictive value of 95.7%, and overall accuracy of 96.7%. These findings indicate that retrograde urethrography correctly classified 203 of 210 patients, with only 7 discordant results when compared with urethroscopy or intraoperative surgical findings. The high sensitivity suggests that the test was effective in identifying most patients with true urethral stricture, while the high specificity indicates a strong ability to exclude stricture among patients without reference-standard evidence of disease. In clinical practice, this balance is important because missed strictures may delay definitive treatment, whereas false-positive findings may lead to unnecessary procedural planning or further invasive evaluation. The present findings therefore support the role of retrograde urethrography as a reliable initial anatomical assessment tool in male patients with suspected urethral stricture disease.

The diagnostic value of retrograde urethrography is clinically relevant because urethral stricture management depends on accurate preoperative identification of the presence, site, and extent of narrowing. In this study, reference-standard evidence of urethral stricture was present in 117 of 210 patients, giving a disease prevalence of 55.7% within the clinically suspected population. This relatively high prevalence reflects the selected symptomatic nature of the cohort and explains the strong positive predictive value observed. A positive predictive value of 97.4% means that nearly all patients with a positive retrograde urethrogram had confirmed stricture on direct assessment, supporting the usefulness of the investigation for surgical planning. Similarly, the negative predictive value of 95.7% indicates that a negative retrograde urethrogram was highly likely to correspond to absence of stricture, although the presence of 4 false-negative cases shows that negative imaging should still be interpreted in relation to persistent clinical suspicion and direct evaluation when symptoms remain significant.

The predominance of bulbar urethral involvement is consistent with the recognized anatomical pattern of male urethral stricture disease. Bulbar strictures accounted for 124 patients (59.0%), followed by penile strictures in 69 patients (32.9%) and diffuse strictures in 17 patients (8.1%). The bulbar urethra is particularly vulnerable to trauma, instrumentation-related injury, and inflammatory scarring, which may explain its higher involvement. This anatomical distribution is important because stricture location influences treatment choice, operative exposure, expected complexity, and the likelihood of recurrence. A diagnostic test that reliably localizes narrowing before intervention therefore has value beyond simple disease detection, especially in centers where reconstructive decisions depend heavily on contrast imaging findings (11,12).

The symptom profile also supports the clinical relevance of the evaluated population. Pain during urination was reported by 194 patients (92.4%), difficulty initiating urination by 139 patients (66.2%), post-micturition dribbling by 131 patients (62.4%), and urinary retention by 92 patients (43.8%). These symptoms reflect varying degrees of obstructive and irritative lower urinary tract dysfunction. The high proportion of patients with dysuria and voiding difficulty suggests that retrograde urethrography was applied in a clinically appropriate group rather than as a screening tool in low-probability patients (13). This distinction is important because predictive values are strongly influenced by disease prevalence; therefore, the observed positive and negative predictive values are most applicable to symptomatic male patients with clinical suspicion of urethral stricture rather than to unselected populations.

False-positive and false-negative findings were uncommon but clinically meaningful. The 3 false-positive cases may have resulted from transient urethral narrowing due to inadequate urethral distension, patient discomfort, sphincteric contraction, suboptimal positioning, or technical limitations during contrast administration. Conversely, the 4 false-negative cases may reflect very short strictures, incomplete contrast opacification, overlapping anatomical shadows, or under-recognition of subtle narrowing. These discrepancies highlight that retrograde urethrography is operator- and technique-dependent. Careful patient positioning, adequate penile traction, controlled contrast injection, high-quality image acquisition, and experienced interpretation are essential to maintain diagnostic accuracy (14,15). The low discordance rate in this cohort suggests that standardized technique can minimize these errors, but the presence of false results confirms that retrograde urethrography should be interpreted alongside clinical findings and reference-standard assessment where indicated.

The findings are also relevant for resource-limited healthcare environments where retrograde urethrography remains widely available, inexpensive, and practical compared with more advanced imaging modalities. In many tertiary-care hospitals, it continues to serve as the primary investigation for defining anterior urethral anatomy before endoscopic or reconstructive management. The observed accuracy of 96.7% supports its continued role as a first-line diagnostic modality in appropriately selected symptomatic male patients. However, retrograde urethrography primarily provides luminal information and may not fully characterize periurethral fibrosis, spongiofibrosis, or complex three-dimensional disease (16,17). In selected complex or recurrent cases, complementary modalities such as urethroscopy, sonourethrography, or combined imaging may provide additional information for operative planning.

The study has several methodological strengths. It included a clearly defined symptomatic male population, used consecutive sampling, applied retrograde urethrography to all included patients, and compared imaging findings with urethroscopy or surgical findings as the reference standard. The sample size of 210 patients provides a reasonable basis for estimating diagnostic performance in a hospital-based cohort. The diagnostic matrix was also internally consistent, allowing direct calculation of sensitivity, specificity, predictive values, false-positive rate, false-negative rate, and overall accuracy. These features strengthen the practical interpretability of the results.

Nevertheless, some limitations should be considered when interpreting the findings. The study was conducted at a single tertiary-care hospital, which may limit generalizability to other settings with different patient populations, imaging protocols, operator experience, and referral patterns. The study included only male patients aged 15 to 65 years, so the findings cannot be extended to female patients, pediatric populations, or older age groups outside the enrolled range. The analysis focused primarily on diagnostic classification and did not provide detailed agreement statistics for stricture length, interobserver variability, or diagnostic performance across subgroups such as age, symptom pattern, comorbidity status, and stricture site. Because treatment planning often depends on stricture length and complexity, future diagnostic work should include agreement analysis between radiographic and operative stricture measurements, preferably with confidence intervals and reproducibility assessment.

Overall, the study demonstrates that retrograde urethrography has strong diagnostic accuracy for identifying urethral stricture among symptomatic male patients, with high sensitivity, specificity,

predictive values, and overall accuracy. The predominance of bulbar strictures and the high frequency of obstructive urinary symptoms are clinically consistent with the expected presentation of male urethral stricture disease. The small number of false-positive and false-negative findings emphasizes that the test is highly useful but not infallible, and its accuracy depends on standardized technique and appropriate clinical interpretation. These results support retrograde urethrography as a dependable first-line imaging investigation for suspected male urethral stricture in tertiary-care practice, particularly when used as part of a structured diagnostic pathway that integrates symptoms, imaging, and direct reference-standard assessment.

CONCLUSION

Retrograde urethrography demonstrated high diagnostic accuracy for detecting urethral stricture in symptomatic male patients, with sensitivity of 96.6%, specificity of 96.8%, positive predictive value of 97.4%, negative predictive value of 95.7%, and overall accuracy of 96.7% when compared with urethroscopy or intraoperative surgical findings. The test correctly classified 203 of 210 patients, with only 3 false-positive and 4 false-negative results, indicating strong reliability for confirming and excluding urethral stricture in this clinical setting. Bulbar urethral involvement was the most frequent anatomical pattern, and dysuria, difficulty initiating urination, and post-micturition dribbling were common presenting symptoms. These findings support retrograde urethrography as a dependable first-line imaging modality for evaluating suspected male urethral stricture and guiding treatment planning in tertiary-care practice.

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