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Review Article

B-mode gray-scale ultrasound abnormalities in adult patients: A useful tool in diagnosis of kidney diseases

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Abstract

Ultrasound scanning of the urogenital tract has a pivotal role in revealing most etiologies of renal disease. Moreover, it is also of value in assessment of disease prognosis and its progression. In this review article, details of the examination technique, ultrasonic kidney norms and the clinicoradiological correlation regarding acute and chronic kidney disease are presented. Specific characteristics of diseases viz. acute and chronic glomerulopathy, diabetes, amyloidosis, chronic reflux nephropathy, Nephroangi sclerosis, vasculitis, nephrocalcinosis, cystic diseases of the kidney, renal infarction and obstructive uropathy are presented.

Keywords: acute, chronic, diagnosis, diseases, ultrasound, kidney.

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Introduction

Chronic kidney disease (CKD) is defined as persistent (> 3 months) evidence of; (a) structural kidney damage, (b) urine abnormality, and (c) decrease glomerular filtration rate than 80 ml/min/1.73 m² ¹. It is a serious health problem with patients risk of death from cardiovascular events is 20 times than to reach end-stage renal disease (ESRD) ². Worldwide; it affects 10-15% of the adult population globally ³. The prevalence has increased greatly in the past few decades. This is probably a combination of a true increase in prevalence (in an aging population that has an increasing burden of co-morbid disease that can affect the kidneys), and increased recognition of the presence of renal disease. Such prevalence shows wide variability across the world that is likely to reflect differences in its true incidence and in the availability of health-care resources for detection and treatment. Moreover, less than 5% of patients with early CKD report awareness of their disease ⁴.

Applications of ultrasonography (US) in kidney diseases

US of the urogenital tract has a pivotal role in revealing most etiologies of renal disease and to guide percutaneous procedures viz. kidney biopsy, aspiration of lesions and insertion of dialysis catheters. Moreover, it is also of value in assessment of disease prognosis and its progression. It is relatively inexpensive, fast-aid, and contrast- as well as radiation- free. Hence, it is the first-line imaging modality for evaluating azotemia patients for urinary obstruction and parenchymal abnormalities.

US and kidney norms

The US does not require any preparation of the patient. It is done with a curved array transducer with center frequencies of 3-6 MHz. Evaluation was by gray scale in B-mode. The US features of normal kidneys (Figure 1A) include; (a) longitudinal length 10-12 cm, (b) cortical thickness 1-2 cm, (c) hypoechoic cortex than liver and spleen, (d) regular and smooth surface, (e) more caudally positioned right kidney and dromedary hump in the left, (f) absence of cysts and calcifications, pelvicalyceal dilatation, and (g) normal renal vasculature and resistance index (RI) by Doppler study. On the other hand; US feature of CRD include; (a) reduced renal length than 9 cm, (b) reduced cortical thickness than 6 mm, (c) marginal irregularities, (d) presence of cysts and calcifications ⁵. Increase cortical echogenicity is seen even in acute kidney injury viz. proliferative glomerulopathy and is not akin to CKD unless persistent indicating glomerular sclerosis. Furthermore, pelvicalyceal dilatation is seen in extrarenal pelvis and acute obstruction. The former is a benign phenomenon and the latter may not lead to chronic damage if adequately managed at an early stage. Reduced renal cortical thickness is a clear sign of CKD due to obstructive uropathy ⁶. US of the kidneys is done first in supine position with the liver and spleen used as an acoustic window and to assess echogenicity. The right oblique position may be used for evaluation of the right kidney while the can be assessed in more posterior and lateral position than right due to colonic gas.

Clinicordiological correlation:

Patients with kidney disease; may manifest; (a) normal US features indicating acute kidney injury, (b) feature/s of CKD indicating either CKD or acute on top of CKD. The latter, diagnosis can be established by its associated; (a) history for rate of disease progression, (b) physical examination for manifestations of new insult, (c) laboratory investigations for deterioration of kidney function, electrolyte impact and toxins, (d) autoimmune work up, (e) individualized vascular studies, and lastly (f) kidney biopsy if indicated and accessible.

US abnormalities of CKD:

1. Normal-sized kidneys with normal-sized yet echogenic cortex (Figure 1B) associated with advance CKD indicates; significant diffuse glomerulosclerosis. The most common etiology is diabetic glomerulosclerosis if history of long-standing diabetes and significant proteinuria (up to nephrotic syndrome) and without clinical or immunological evidence of autoimmune disease. The only differential diagnosis is kidney amyloidosis ⁷. In the latter; clinical history is useful for underlying conditions and the spleen is usually enlarged > 12 cm. Since cortical hypoechogenicity is due to decrease glomerular vascularity; acute primary or secondary glomerulopathy may have similar pattern but history of acute insult is evident. Lack of typical history of diabetic glomerulosclerosis (Vida supra) and/or CKD of obscure etiology, with such US picture, indicate kidney biopsy for definitive diagnosis and prognosis.
2. Bilateral normal-sized or smaller kidneys with normal cortical echogenicity and size yet with diffuse and mild irregular outline in seen in nephroangiosclerosis (Figure 1C). This should not be confused with smooth indentations of persistent fetal lobulations (Figure 1D). In advanced stages of uncontrolled Nephroangiosclerosis; the kidneys are bilaterally small with thin and scarred echogenic cortex (Figure 2A) which is similar to chronic reflux nephropathy except for the latter having unequal size kidneys, apical scars and thinner discontinuous cortex due to multiple scars (Figure 2C & D).
3. Small-sized kidneys with adequate cortical thickness indicate moderate non-diabetic chronic (primary or secondary) glomerulopathy (Figure 2B).
4. Unequal kidney size (> 1 cm) is seen in; (a) chronic reflux nephropathy which is usually associated with apical and multiple cortical scars and thin cortex (Figure 2C & D), (b) vasculopathy viz. kidney infarcts (Figure 3), (c) renovascular disease, (d) vasculitis especially polyarteritis nodosa. Since it is a diffuse decrease renal due to stenosed major renal artery; it is rarely associated with scars contrary to polyarteritis nodosa which manifests large ones due to large infarcts ⁸.
5. In advanced parenchymal kidney disease and dialysis patients; kidney US may reveal only small and echogenic kidneys and has limited diagnostic etiology (Figure 3B).

However, it may disclose a premalignant acquired disease of the kidneys (Figure 3C) ⁹.

6. Medullary nephrocalcinosis is caused increase urinary excretion of calcium and/or oxalate. It is seen as calcifications in papilla, medullary calcifications with/without renal stones (Figure 3D). It is seen in primary hyperparathyroidism, hypervitaminosis D, sarcoidosis, hyperoxaluria, distal renal tubular acidosis and medullary sponge kidney, ¹⁰. Etiological diagnosis can be established by laboratory testing for levels of parathyroid hormone, 1,25-dihydroxycholecalciferol, angiotensin converting enzyme inhibitor, urine oxalates as well as urine pH in acidotic patients and IVP for the latter 2 causes.
7. Dilated kidney pelvis with normal cortex indicates recent obstruction and favorable prognosis contrary to thin and echogenic cortex which indicate long-standing obstructive disease (Figure 4A & B). Moreover; it may reveal the cause of obstruction as pelviureteric junction stenosis (Figure 4B), stage-horn pelvic stones (Figure 4C) or papillary tumors (4D).
8. Cystic diseases of the kidney, in adult, include; (a) benign cysts, and (b) autosomal dominant (adult) polycystic kidney disease (ADPKD). Excessive benign cyst formation may mimics ADPKD and raises concern since prognosis of the latter is ominous. ADPKD is (a) an autosomal dominant hereditary disease leading, mathematically, disease in half of the future children, (b) associated with subsequent hypertension and development of end-stage kidney disease. To differentiate; ADPKD is associated with (a) similar disease in parents unless subsequent to mutation, (b) bilateral kidney enlargement with bilateral extensive cyst formation in both cortex and medulla (Figure 5A, B, C & D). Moreover, genetic testing (PKHD1 mutations) is also available for confirmation of ADPKD ¹¹.
9. Kidney masses include; (a) benign cysts, (b) solid masses viz. angiomyolipomata, adenocarcinoma and (c) cystic degeneration in cancer (Figure 5A, B, C & D). The latter, unlike benign cysts, has vasculature by Doppler ultrasonography and enhancement after CT with contrast.
10. Renal infarcts, though uncommon, are more frequently seen following the wide-spread use of oral contraceptive ¹². It can be identified by finding a non-perfused triangular lesion with its cortical base and extension towards the medulla (Figure 3). Diagnosis can be confirmed by CT with contrast.

Finally; this review was an attempt to provide a practical approach for the use of ultrasound examination in establishing non-invasive diagnosis and prognosis of kidney diseases in adult patients. Its role in vascular (perfusion and renovascular) studies, transplanted kidney as well as pediatric and in-utero ones were beyond the scope of this review. In conclusion; US is an essential, fast, cost-effective and non-invasive tool in diagnosis and management of kidney diseases.

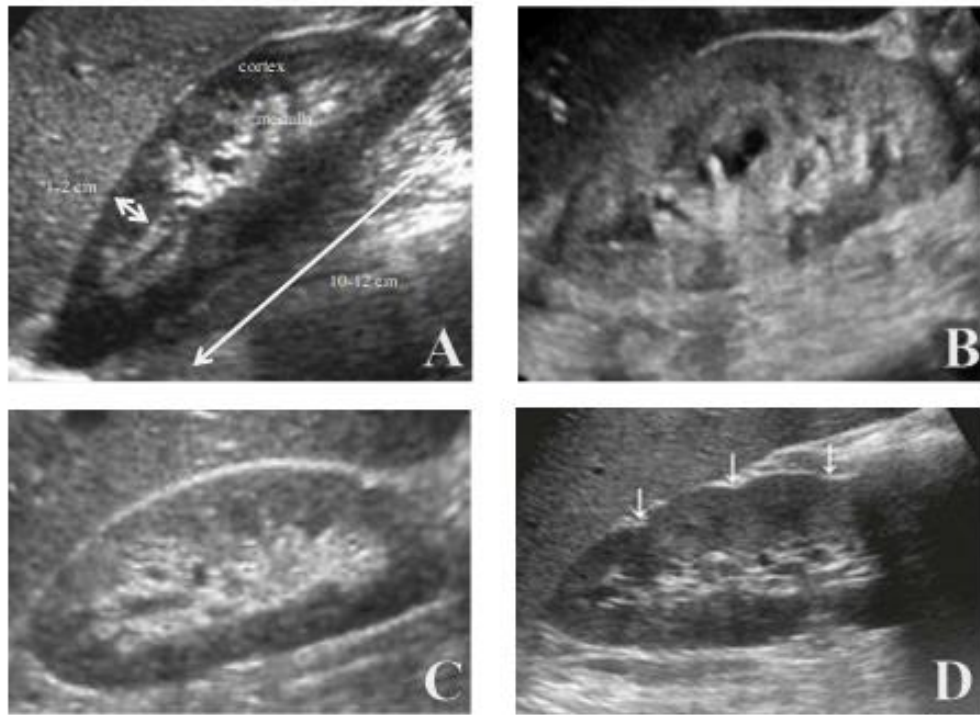


Figure 1: Longitudinal ultrasonic view of kidneys with; (A) normal features, (B) diabetic glomerulosclerosis, (C) nephroangiosclerosis, (D) persistent fetal lobulations.

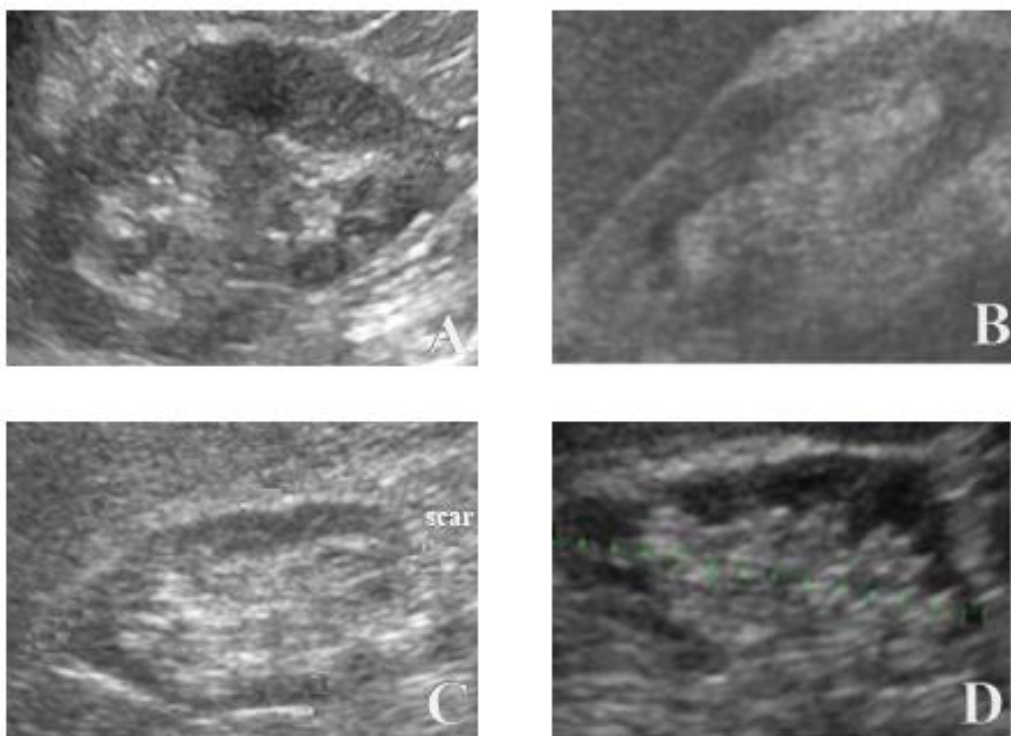


Figure 2: Longitudinal ultrasonic view of kidneys with advanced stage of; (A) nephroangiosclerosis, (B) chronic glomerulopathy, (C) chronic pyelonephritis (reflux nephropathy) with apical scar, and (D) chronic pyelonephritis with multiple cortical scars.

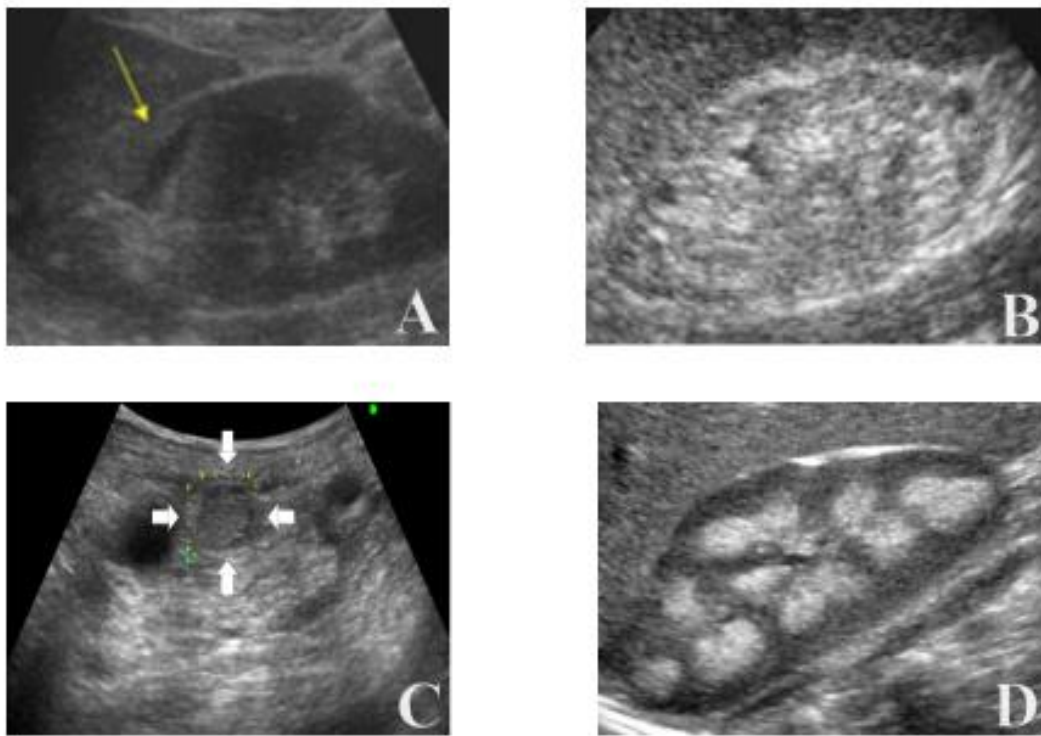


Figure 3: Longitudinal ultrasonic view of kidneys with; (A) renal infarct, (B) advanced disease, (C) tumor on top of acquired cystic disease, and (D) nephrocalcinosis.

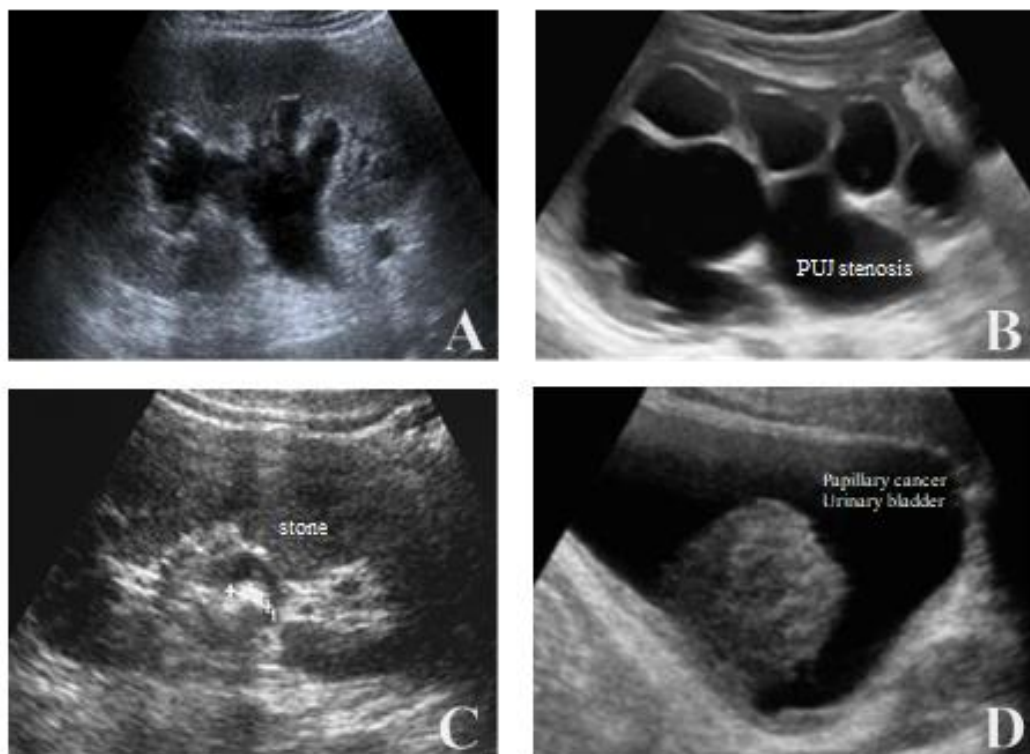


Figure 4: Longitudinal ultrasonic view of kidneys with; (A) early stage of hydronephrosis, (B) long-standing obstruction due to pelviureteric junction (PUJ) stenosis, and (C) hydronephrosis due to stagehorn pelvic calculus. View (D) shows urinary bladder with tumor.

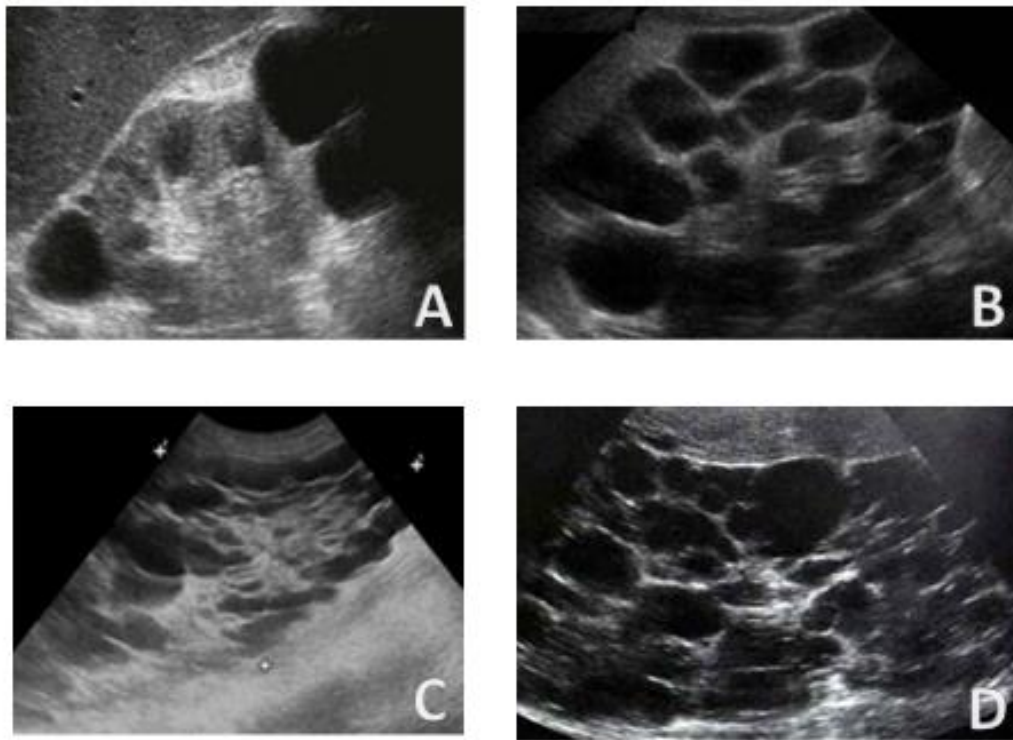


Figure 5: Longitudinal ultrasonic view of kidneys with; multiple benign cysts at early stage (A) and advanced stage (B) compared to (C) early stage of APCKD and (D) advanced stage of APCKD.

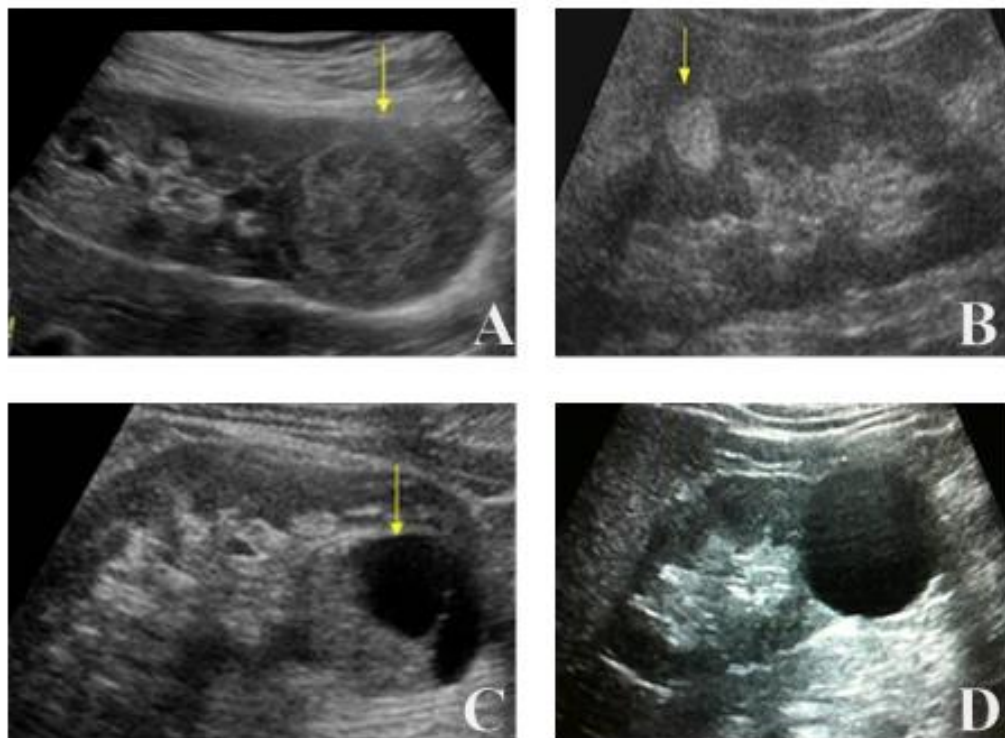


Figure 6: Longitudinal ultrasonic view of kidneys with; (A) adenocarcinoma, (B) angiomyolipoma, (C) cystic degeneration in adenocarcinoma, and (D) large benign cyst.

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