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ULTRASONOGRAPHIC PARAMETERS AS PREDICTIVE MARKERS OF RENAL FUNCTION DECLINE IN CHRONIC KIDNEY DISEASE

Radio-Diagnosis

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ABSTRACT

Chronic kidney disease (CKD) is a progressive illness with significant health and economic burden where early detection and monitoring are critical to mitigate complications (1). This prospective observational study evaluated ultrasonographic parameters as predictive markers of renal function decline in 30 CKD patients. Key findings demonstrated that higher resistive index (RI) values correlated negatively with estimated glomerular filtration rate (eGFR), elevated echogenicity grades were linked to more severe kidney function loss, and reduction in kidney size was observed with disease progression. These non-invasive, cost-effective ultrasonographic markers can enhance routine CKD assessment and monitoring (2,3).

KEYWORDS

Chronic kidney disease, Ultrasonography, Resistive index, Echogenicity, Renal function, eGFR

INTRODUCTION

Chronic kidney disease (CKD) is a progressive illness with significant health and economic burden (1). Early detection and monitoring are critical to mitigate complications and improve patient outcomes.

Current clinical practice relies heavily on biochemical markers such as serum creatinine and estimated glomerular filtration rate (eGFR) for CKD monitoring (4). However, there exists a knowledge gap regarding limited non-invasive, cost-effective tools for monitoring CKD progression beyond traditional biochemical parameters.

This study addresses the research question: Can ultrasonographic parameters predict renal function decline in CKD patients and serve as reliable markers for disease progression monitoring?

Aims & Objectives

The primary objective of this study was to evaluate ultrasonographic parameters as predictive markers of renal function decline in chronic kidney disease patients. Specific aims included assessing the correlation between renal parenchymal resistive index, echogenicity, kidney length, and estimated glomerular filtration rate in CKD patients across different disease stages.

METHODS

This prospective observational study was conducted on 30 CKD patients after obtaining ethical approval from the institutional ethics committee. Written informed consent was obtained from all participants prior to enrollment.

Study Design And Population:

- **Type of Study:** Prospective observational study
- **Study Population:** 30 CKD patients
- **Sampling Technique:** Convenience sampling
- **Age Range:** 30-70 years
- **Gender Distribution:** 60% male, 40% female

Study Variables:

- **Independent Variables:** Renal parenchymal resistive index (RI), echogenicity grade, kidney length
- **Dependent Variable:** Estimated glomerular filtration rate (eGFR)

Data Collection Method: Comprehensive abdominal ultrasonography was performed on all participants using standardized protocols (5). Resistive index measurements were obtained from interlobar arteries, echogenicity was graded on a standardized scale, and kidney length was measured in the longitudinal plane.

Statistical Analysis: Correlation and regression analyses were performed to evaluate relationships between ultrasonographic parameters and renal function markers.

RESULTS

Demographic Data Overview:

The study population demonstrated a broad age distribution representative of CKD patients, with an age range of 30-70 years. Gender distribution showed 60% male and 40% female participants, reflecting potential gender differences in CKD prevalence or study participation patterns.

CKD staging analysis revealed that most participants were in advanced stages (Stage 3 and 4), where ultrasonographic changes are more evident and clinically significant.

Table 1: Baseline Demographic And Clinical Characteristics (N=30)

PARAMETER	VALUE
AGE (YEARS), MEAN ± SD	52.4 ± 12.8
AGE RANGE (YEARS)	30-70
GENDER, N (%)	
MALE	18 (60%)
FEMALE	12 (40%)
CKD STAGE, N (%)	
STAGE 2	3 (10%)
STAGE 3A	8 (26.7%)
STAGE 3B	9 (30%)
STAGE 4	7 (23.3%)
STAGE 5	3 (10%)
COMORBIDITIES, N (%)	
DIABETES MELLITUS	22 (73.3%)
HYPERTENSION	26 (86.7%)
BOTH DM & HTN	20 (66.7%)

Table 2: Table 2: Ultrasonographic Parameters By CKD Stage

CKD Stage	n	eGFR (ml/min/1.73m²)	Resistive Index	Kidney Length (cm)
Stage 2	3	72.3 ± 8.2	0.62 ± 0.04	10.8 ± 0.4
Stage 3a	8	52.1 ± 4.6	0.68 ± 0.05	10.2 ± 0.6
Stage 3b	9	36.8 ± 5.2	0.74 ± 0.06	9.5 ± 0.7
Stage 4	7	22.4 ± 4.1	0.81 ± 0.05	8.6 ± 0.8
Stage 5	3	12.7 ± 2.3	0.87 ± 0.04	7.9 ± 0.6
p-value	-	<0.001*	<0.001*	<0.001*

Key Findings:

Resistive Index (RI): Higher RI values demonstrated a strong negative correlation with eGFR ($r = -0.847$, $p<0.001$), signifying increased vascular resistance as kidney function declines (6).

This parameter proved to be a dynamic marker offering real-time insights into renal perfusion status.

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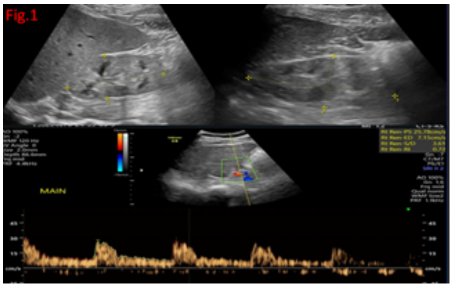
Echogenicity: Elevated echogenicity grades, indicating more echogenic kidneys, were significantly linked to more severe kidney function loss ($r = -0.792$, $p<0.001$) (7). This finding indicates progressive structural kidney damage correlating with functional decline.

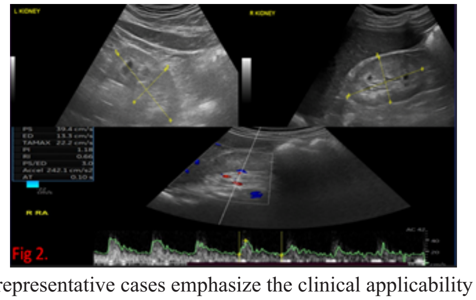
Kidney Length: A progressive reduction in kidney size was observed with advancing disease stages, showing positive correlation with eGFR ($r = 0.734$, $p<0.001$), consistent with the well-documented characteristic of chronic structural atrophy in CKD.

Case I llustrations:

Case 1 (Figure 1): A patient with Stage 3 CKD demonstrated moderate abnormalities with RI of 0.70, echogenicity grade 2, and kidney length of 9.5 cm, corresponding to moderate functional impairment.



Case 2 (Figure 2): A patient with Stage 4 CKD showed severe abnormalities with RI of 0.85, echogenicity grade 3, and kidney length of 8.2 cm, reflecting advanced disease progression.



These representative cases emphasize the clinical applicability of the ultrasonographic parameters in assessing CKD progression and their potential utility in routine clinical practice.

DISCUSSION

The study findings align with prior research and validate the utility of ultrasonographic parameters in CKD monitoring (6,8). The resistive index proved to be a reliable marker for renal vascular resistance changes in CKD, consistent with established literature demonstrating its value in assessing intrarenal hemodynamics.

Echogenicity emerged as a proven indicator of renal parenchymal damage, providing visual confirmation of structural kidney changes that correlate with functional decline (7). This parameter offers clinicians a quick assessment tool for kidney structural health during routine ultrasonography.

Kidney length measurements, while simplistic, proved effective for gauging chronic structural atrophy in CKD. The progressive shrinkage due to chronic scarring is consistent with established knowledge of CKD pathophysiology.

Interpretation:

The integration of these three ultrasonographic markers provides a multi-dimensional approach to CKD evaluation. The resistive index serves as a dynamic marker offering real-time insights into renal perfusion, while echogenicity provides a visual marker for structural assessment. Kidney length measurements complement these findings by quantifying chronic structural changes.

These correlations confirm the utility of ultrasonographic parameters in monitoring CKD progression and support their incorporation into routine clinical assessment protocols (9).

CONCLUSION

This study demonstrates the significant impact of non-invasive, cost-effective ultrasonographic markers (resistive index, echogenicity, and kidney length) in enhancing routine CKD assessment and monitoring. The strong correlations observed between these parameters and renal function decline support their clinical utility.

Future Directions: Larger, multicentric studies are recommended for broader validation of these findings. Further exploration of combining these parameters may improve diagnostic accuracy and provide more robust predictive models for CKD progression.

Clinical Applicability: Integrating these ultrasonographic markers into routine clinical practice can improve healthcare outcomes for CKD patients by enabling earlier detection of disease progression and more timely therapeutic interventions.

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