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Doppler Ultrasound Evaluation of Renal Allograft: Experience at BSMMU, Bangladesh

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Abstract

***Background:** Renal transplantation is the treatment of choice for patients with end-stage renal disease (ESRD). Doppler ultrasound is the primary imaging modality for evaluating renal allografts, providing critical insights into graft morphology, vascular integrity, and complications.*

***Objective:** This study aims to assess the role of Doppler ultrasound in evaluating renal allografts at Bangabandhu Sheikh Mujib Medical University (BSMMU), Bangladesh, with a focus on graft function, perfusion, and post-transplant complications.*

***Methods:** A purposive sampling technique was employed to select 43 renal transplant recipients at BSMMU. B-mode and Doppler ultrasound were utilized to assess graft size, echogenicity, cortico-medullary differentiation, collecting system, and vascular structures. Parameters such as peak systolic velocity (PSV), resistive index (RI), and pulsatility index (PI) were analyzed using MS Office tools.*

***Results:** Normal graft function was associated with a PSV range of 80–118 cm/sec and an RI <0.7. Complications were categorized based on onset time, including acute tubular necrosis, rejection, thrombosis, and stenosis. Increased cortical echogenicity, reduced renal sinus echogenicity, and high-resistance waveforms were indicative of graft rejection. Significant renal artery stenosis was characterized by PSV >250 cm/sec and a systolic velocity ratio >3.*

***Conclusion:** Doppler ultrasound is a non- invasive, first-line diagnostic tool for assessing renal allografts and detecting major post-transplant complications. However, it has limitations in distinguishing between acute rejection, tubular necrosis, and immunosuppressive toxicity. Supplementary imaging modalities like CT, MRI, or angiography may be required for inconclusive cases.*

Keywords: *Doppler ultrasound, Graft rejection, Renal allograft, Resistive index, Peak systolic velocity, Transplantation.*

Introduction

Renal transplantation is the preferred treatment for patients with end-stage renal disease (ESRD), offering improved survival and quality of life compared to long-term dialysis [1]. Despite advancements in immunosuppressive therapy and surgical techniques, renal allograft dysfunction remains a significant concern, necessitating early and accurate diagnosis of

complications [2,3]. Doppler ultrasound has emerged as the first-line imaging modality for evaluating renal allografts due to its non-invasive nature, real-time assessment capabilities, and cost-effectiveness [4]. It provides essential information regarding graft morphology, perfusion, and vascular integrity, aiding in the early detection of complications such as rejection, thrombosis, and stenosis [5]. The role of B-mode and Doppler ultrasound in renal transplantation is well established. B-mode imaging allows assessment of graft size, echogenicity, cortico-medullary differentiation, and the collecting system, while Doppler imaging evaluates arterial and venous perfusion [6]. Parameters such as peak systolic velocity (PSV), resistive index (RI), and pulsatility index (PI) provide insight into vascular status and function [7]. A normal allograft typically exhibits an RI of <0.7, whereas increased resistance may indicate rejection, acute tubular necrosis, or other vascular complications [8,9]. Post-transplant complications are categorized based on their time of onset. Immediate complications (within the first week) include acute tubular necrosis, accelerated acute rejection, and vascular thrombosis [10]. Early complications (1–4 weeks) comprise acute rejection, urinary fistulas, and ureteral obstruction, while late complications (beyond four weeks) involve chronic rejection, renal artery stenosis, and recurrence of primary kidney disease [11]. Among these, vascular complications such as renal artery stenosis, venous thrombosis, and pseudoaneurysms significantly impact graft survival, making Doppler ultrasound an invaluable tool for early intervention [12,13]. Despite its advantages, Doppler ultrasound has limitations, particularly in differentiating between acute rejection, drug toxicity, and ischemic injury, which may present with similar sonographic findings [14]. In cases of inconclusive results, computed tomography (CT), magnetic resonance imaging (MRI), or angiography may be required for further evaluation [15]. This study aimed to assess the role of Doppler ultrasound in the evaluation of renal allografts at Bangabandhu Sheikh Mujib Medical University (BSMMU), Bangladesh. The findings will contribute to optimizing the use of ultrasound in post- transplant monitoring and improving graft outcomes.

Methogology

This prospective observational study was conducted at Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, Bangladesh, from January 2012 to December 2015. A total of 43 renal transplant recipients were enrolled using a purposive sampling technique. All patients underwent Doppler ultrasound evaluation to assess graft morphology, vascularity, and complications. B-mode ultrasound was used to examine graft size,volume, parenchymal echogenicity, corticomedullary differentiation, collecting system, and surrounding soft tissue structures. Doppler ultrasound assessed renal arterial perfusion, venous patency, and hemodynamic parameters, including peak systolic velocity (PSV), resistive index (RI), and pulsatility index (PI). Color and spectral Doppler waveforms were analyzed for the main renal artery, intra-renal arteries, and renal vein. Complications were categorized based on the time of onset as immediate (within the first week), early (1–4 weeks), or late (beyond four weeks). Data were analyzed using MS Office tools, and findings were compared with established diagnostic criteria for renal allograft function and complications.

Result

A total of 43 renal transplant recipients were evaluated in this study. The mean age of the patients was 42.6 ± 9.8 years, with a male predominance (67.4% males, 32.6% females). The most common cause of end-stage renal disease (ESRD) leading to transplantation was chronic glomerulonephritis (37.2%), followed by diabetic nephropathy (27.9%) and hypertensive nephrosclerosis (16.3%). On B-mode ultrasound, the mean graft size was

11.8 ± 1.4 cm, and increased cortical echogenicity was noted in 27.9% of cases. Corticomedullary differentiation was well-preserved in 74.4% of patients, whereas 25.6% had poor differentiation, suggestive of rejection or tubular injury. Doppler ultrasound showed a mean peak systolic velocity (PSV) of 95.2 ± 18.3 cm/sec and a mean resistive index (RI) of 0.67 ± 0.08. Increased RI (>0.7), indicative of graft dysfunction, was observed in 30.2% of patients. Complications were categorized based on the time of onset. Immediate complications included acute tubular necrosis (18.6%), renal artery thrombosis (4.7%), and renal vein thrombosis (2.3%). Early complications included acute rejection (20.9%) and urinary fistulae (4.7%). Late complications were observed in 32.6% of cases, including renal artery stenosis (11.6%) and recurrent native kidney disease (9.3%). Doppler ultrasound effectively detected various graft complications, with acute rejection (20.9%) and renal artery stenosis (11.6%) being the most common. Patients with increased resistive index (RI > 0.7) had a significantly higher risk of graft dysfunction.

Table 1. *Baseline characteristics of study participants*

Parameter	Value (n = 43)
Mean Age (years)	42.6 ±9.8
Male (%)	67.4%
Female (%)	32.6%
Cause of ESRD	
Chronic glomerulonephritis	37.2%
Diabetic nephropathy	27.9%
Hypertensive nephrosclerosis	16.3%
Others	18.6%

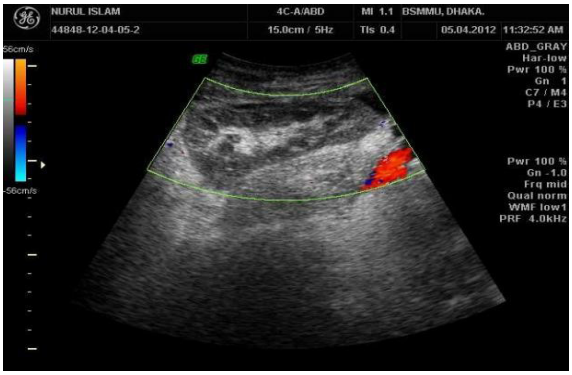

Figure 1. *Cortex of allograft appears more echogenic than that of a normotopic kidney because of lack of ultrasound attenuation by overlying structures (normal cortical echogenicity with echogenic sinus)*

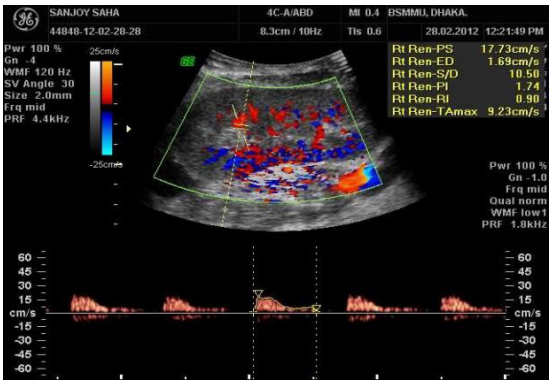

Figure 2. *Renal artery of allograft showing normal Peak Systolic Velocity, 78.2 cm/sec*

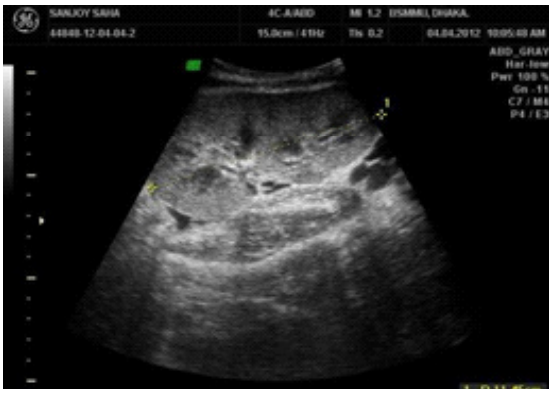

Figure 3. *Increased cortical echogenicity and decreased echogenicity of the renal sinus may suggest acute rejection of renal allograft*

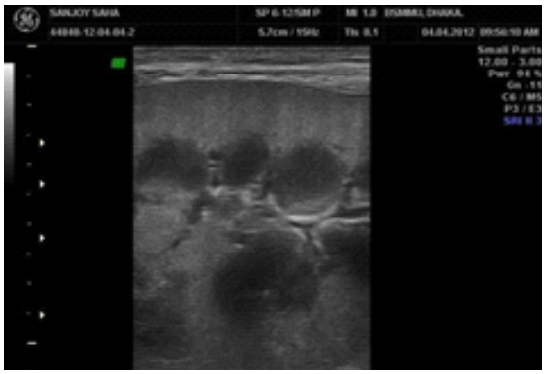

Figure 4. *Increased prominence of renal pyramids in the allograft may suggest acute rejection*

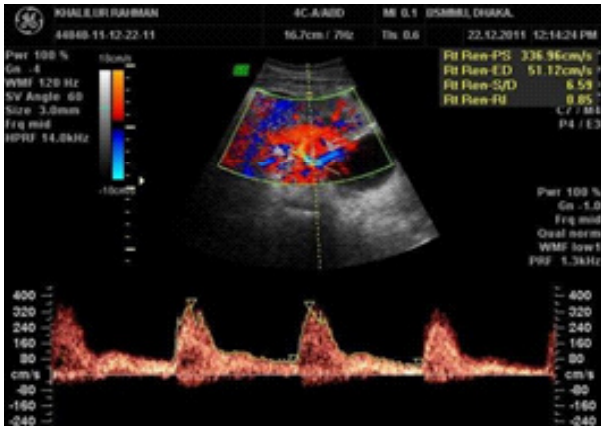

Figure 5. *>50% stenosis of anastomotic site of renal artery, Peak systolic velocity: 336 .9 cm/sec and systolic velocity ratio 6.59*

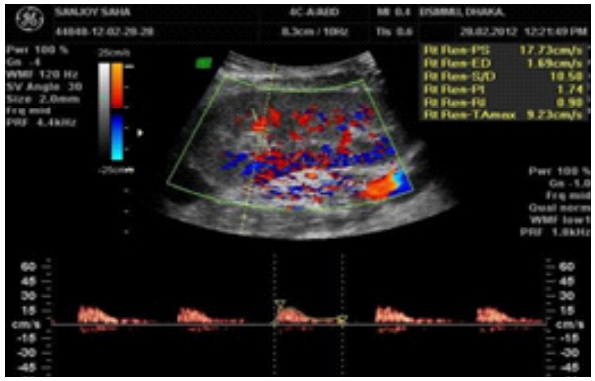

Figure 6. *High- resistance waveform appearance of intra-renal arteries, Resistive Index: 0.9 with absent diastolic flow*

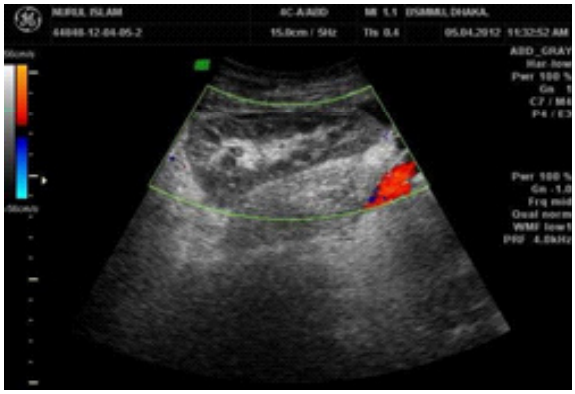

Figure 7. *Color Doppler showing absent arterial and venous flow in the allograft due to arterial thrombosis*

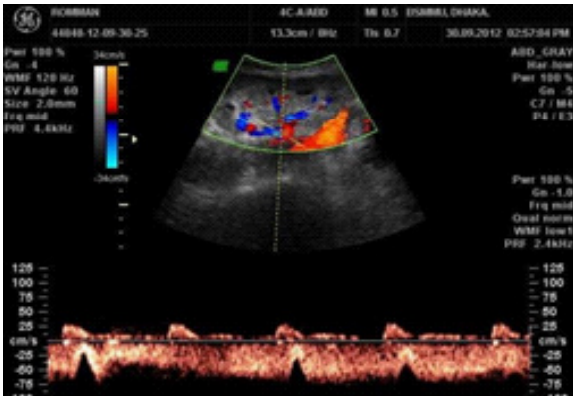

Figure 8. *Color and spectral Doppler of allograft showing pseudoaneurysm (to-and-fro waveform forward and reversed flow) which is confirmed by MRA.*

Table 2. *Doppler parameters of renal allografts*

Parameter	Mean ±SD	Abnormal cases (%)
GS (cm)	11.8 ±1.4	25.6% (Enlarged)
CE	-	27.9% (Increased)
CD	-	25.6% (Poor)
PSV (cm/sec)	95.2 ±18.3	16.3% (>120)
RI	0.67 ±0.08	30.2% (>0.7)

GS: Graft size CE: Cortical echogenicity, CD: Corticomedullary differentiation, PSV: Peak systolic velocity, RI: Resistive index

Table 3. *Complications detected by doppler ultrasound*

Complication	%
Immediate (≤1 week)	
Acute tubular necrosis (ATN)	18.6%
Renal artery thrombosis	4.7%
Renal vein thrombosis	2.3%
Early (1-4 weeks)	
Acute rejection	20.9%
Urinary fistulae	4.7%
Ureteral obstruction	7.0%
Late (>4 weeks)	
Renal artery stenosis	11.6%
Recurrent native kidney disease	9.3%
Hypertension (Cs-A toxicity)	11.6%

Discussion

Doppler ultrasound is a widely accepted, non-invasive imaging modality for evaluating renal allografts, providing crucial insights into graft morphology, vascularity, and function. In this study, we assessed renal transplant recipients using B-mode and Doppler ultrasound to detect potential graft dysfunction and complications. The findings reinforce the role of Doppler ultrasound as the first-line tool for renal allograft evaluation, in agreement with previous studies [16,17]. The mean graft size in our study was 11.8 ± 1.4 cm, which aligns with the normal expected range for renal allografts. Increased cortical echogenicity was observed in 27.9% of cases, which has been correlated with acute rejection and chronic graft dysfunction in earlier studies [18]. Poor corticomedullary differentiation was noted in 25.6% of patients, a significant indicator of graft dysfunction [19]. These findings highlight the importance of grayscale sonography in the early detection of graft

complications. Doppler ultrasound parameters are essential in predicting renal allograft viability. The mean resistive index (RI) in our study was 0.67

± 0.08, with 30.2% of cases exhibiting an RI > 0.7, which is indicative of increased vascular resistance and possible

graft dysfunction. Prior studies have shown that an RI greater than 0.7 is associated with acute rejection, renal artery stenosis, or cyclosporine toxicity [20]. Furthermore, the mean peak systolic velocity (PSV) was 95.2 ± 18.3 cm/sec, with 16.3% of patients exhibiting a PSV > 120 cm/sec, suggesting possible arterial stenosis. These results are consistent with findings from similar research on transplant patients [21]. Complications following renal transplantation can be categorized based on their onset. Acute tubular necrosis (ATN) was observed in 18.6% of cases, making it the most common immediate complication. ATN is a frequent post-transplant condition that occurs due to ischemic injury and is best evaluated using Doppler ultrasound to assess perfusion changes [22]. Acute rejection was detected in 20.9% of patients, with sonographic findings of increased graft size, poor corticomedullary differentiation, and increased vascular resistance (RI > 0.7). This aligns with previous research highlighting these as hallmark features of rejection [23]. Late complications included renal artery stenosis in 11.6% of cases, identified by an increased PSV (>190 cm/sec) and a velocity ratio >3. This is a well-documented complication that can lead to graft loss if undiagnosed [24]. Recurrent native kidney disease (9.3%) was also observed, further emphasizing the need for continuous graft monitoring [25].

Limitations

The findings of this study reinforce the value of Doppler ultrasound in post-transplant surveillance. It serves as an early warning tool for detecting complications, enabling timely intervention. However, limitations exist, including the inability of ultrasound to differentiate between ATN, acute rejection, and immunosuppressive drug toxicity solely based on imaging findings. In such cases, histopathological correlation through biopsy remains the gold standard.

Conclusion

Doppler ultrasound remains an essential tool for evaluating renal allografts, allowing for early identification of complications such as ATN, rejection, thrombosis, and arterial stenosis. The findings of this study corroborate previous literature, demonstrating that increased RI and PSV are significant markers of graft dysfunction. Future studies should focus on integrating Doppler ultrasound findings with emerging imaging modalities such as contrast-enhanced ultrasound to improve diagnostic accuracy.

Recommendation

Doppler ultrasound should be routinely utilized for post-transplant surveillance to detect early graft dysfunction. Standardized Doppler parameters, including resistive index and peak systolic velocity, should be incorporated into clinical protocols. Further studies integrating contrast-enhanced ultrasound and histopathological correlation are recommended for improved diagnostic accuracy.

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