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PREDICTIVE ACCURACY OF RENAL ULTRASOUND AND MAG3 SCINTIGRAPHY IN GUIDING SURGERY AND MONITORING RECOVERY IN PEDIATRIC PUJO: A PROSPECTIVE COHORT STUDY

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Abstract

Introduction: *Pelviureteric junction obstruction (PUJO) is the most common cause of congenital hydronephrosis. Differentiating which children require surgical correction and which can be managed conservatively remains a diagnostic challenge. This study aimed to evaluate the predictive accuracy of renal ultrasound and MAG3 scintigraphy in guiding surgical decision-making and monitoring outcomes in pediatric PUJO.*

Materials and Methods: *This prospective cohort study included 80 children with suspected PUJO who underwent renal ultrasound and MAG3 diuretic renography. Surgery was offered only to patients with an anteroposterior (AP) pelvic diameter >20 mm and an obstructive drainage curve (T½ >20 minutes). Intraoperative and histopathological confirmation of PUJO was obtained in surgically managed cases. Postoperative and conservatively managed patients were followed with imaging at 3, 6, and 9 months. Comparative statistical analysis and visualizations were used to assess differences between groups.*

Results: *Thirty-nine patients fulfilled the surgical criteria and underwent pyeloplasty. Intraoperative findings and histology confirmed PUJO in all cases. Postoperatively, mean AP diameter reduced from 25.6 mm to 14.8 mm, and differential renal function (DRF) improved or stabilized in 94% of cases. Among the 41 non-surgical patients, 81% showed spontaneous reduction in AP diameter and all maintained stable DRF. A statistically significant difference in AP diameter was observed between obstructive and non-obstructive groups ($p < 0.0001$), supported by both box plot and density curve visualizations.*

Conclusion: *An AP diameter >20 mm combined with an obstructive drainage pattern on MAG3 renography provides a highly specific and sensitive criterion for identifying children with PUJO who require surgical intervention. Children not meeting both criteria can be safely observed, with excellent outcomes. This dual-modality imaging strategy should serve as a cornerstone in PUJO management protocols.*

INTRODUCTION

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Pelviureteric junction obstruction (PUJO) represents a functional or anatomical impairment at the junction of the renal pelvis and the proximal ureter, leading to obstructed urinary flow from the kidney to the bladder. It is the most frequently encountered cause of congenital hydronephrosis, with an estimated incidence of 1 in 500 to 1 in 1,250 live births, and a higher prevalence in males, particularly affecting the left kidney in up to 60% of cases (1,2).

PUJO may be intrinsic, resulting from a narrowed or aperistaltic segment due to abnormal embryological development of the ureteric musculature or neural innervation, or extrinsic, such as compression by crossing lower pole vessels or a high ureteral insertion on the renal pelvis (3,4). Histological analyses of excised pelviureteric segments have revealed variable pathological findings including fibrosis, muscular hypertrophy, disorganized smooth muscle fibers, and decreased density of Cajal-like interstitial cells, all of which contribute to impaired peristalsis and drainage (5,6).

With the widespread use of prenatal ultrasonography, PUJO is now often detected antenatally as hydronephrosis. However, a significant proportion of antenatal hydronephrosis cases resolve spontaneously postnatally without clinical sequelae. This creates a diagnostic and management challenge: differentiating children who will benefit from surgical intervention from those who can be safely managed conservatively (7).

Postnatal evaluation of hydronephrosis typically begins with ultrasonography, which provides critical anatomical information. The anteroposterior (AP) diameter of the renal pelvis is a widely used marker; an AP diameter greater than 20 mm is strongly correlated with the presence of obstructive pathology, especially when persistent on serial imaging (8,9). Parenchymal thinning and increased cortical echogenicity are additional ultrasonographic indicators suggestive of long-standing obstruction and loss of renal function.

While ultrasonography is non-invasive and easily repeatable, it does not assess renal function. Therefore, functional imaging—most commonly technetium-99m mercaptoacetyltriglycine (MAG3) diuretic renography—is employed to assess drainage and split renal function. A delayed drainage pattern, often defined by a T½ >20 minutes, and a differential renal function (DRF) below 40% are considered suggestive of clinically significant obstruction warranting pyeloplasty (10,11). However, MAG3 interpretation in neonates and infants can be unreliable due to immature renal physiology, poor hydration, and technical difficulties, thereby requiring cautious interpretation in conjunction with anatomical data (12).

Surgical intervention, typically in the form of an Anderson-Hynes dismembered pyeloplasty, is indicated when there is evidence of worsening hydronephrosis, compromised renal function, or symptomatic obstruction. However, surgical decision-making must balance the risks of unnecessary intervention against the consequences of delayed treatment, including permanent renal scarring and hypertension (13).

Despite the availability of both anatomical and functional imaging modalities, there remains significant variability in their interpretation and the thresholds used for surgical decision-making across institutions. Moreover, few studies comprehensively correlate these preoperative findings with intraoperative anatomical confirmation, histological evidence, and longitudinal postoperative outcomes.

This prospective study was therefore designed with the following objectives:

1.To assess the predictive accuracy of combining ultrasound-based AP diameter and MAG3 scintigraphy drainage patterns in determining the need for surgical correction in children with PUJO.

2.To validate imaging-based surgical selection through intraoperative and histopathological findings.

3.To evaluate postoperative anatomical and functional outcomes following pyeloplasty, and to describe the natural progression in conservatively managed children.

MATERIAL AND METHODS

This prospective cohort study was conducted over a 12-month period at the Department of Pediatric Surgery in a tertiary care teaching hospital. The study enrolled 80 children, aged between 0 and 12 years, who were referred with antenatal or postnatal suspicion of pelviureteric junction obstruction (PUJO). Ethical approval was obtained from the

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institutional review board, and written informed consent was secured from the parents or legal guardians of all participants.

All patients underwent initial evaluation with renal ultrasonography performed by experienced pediatric radiologists. Measurements included the anteroposterior (AP) diameter of the renal pelvis and renal parenchymal thickness. Hydronephrosis was defined as an AP diameter exceeding 10 mm. Functional assessment was conducted using technetium-99m mercaptoacetyltriglycine (MAG3) diuretic renography. Each scan was interpreted for differential renal function (DRF) and drainage dynamics. An obstructive drainage curve was defined as a T½ (half-time of drainage following diuretic administration) exceeding 20 minutes. Patients with known vesicoureteral reflux (confirmed via micturating cystourethrogram), posterior urethral valves, neurogenic bladder, or previous urologic surgeries were excluded from the study.

Based on combined imaging criteria, surgical intervention was offered only to patients who demonstrated both an AP diameter >20 mm and an obstructive drainage pattern on MAG3 renography. These patients underwent Anderson-Hynes dismembered pyeloplasty. Intraoperatively, the pelviureteric junction was examined for anatomical abnormalities including high insertion of the ureter, aberrant lower pole crossing vessels, and intrinsic narrowing. Where excision was performed, resected PUJ segments were sent for histopathological examination to identify features such as smooth muscle hypertrophy, fibrosis, or muscular disorganization consistent with obstructive uropathy.

Postoperative evaluation was carried out at 3, 6, and 9 months using follow-up ultrasonography and repeat MAG3 scans. Changes in AP diameter and DRF were recorded. Non-surgical patients—those who did not meet both radiologic criteria—were managed conservatively with periodic follow-up using the same imaging protocols to monitor for spontaneous resolution, stability, or progression of hydronephrosis. Data were analyzed using descriptive statistics, and diagnostic performance of imaging criteria was assessed using sensitivity, specificity, and cross-tabulation analysis. A p-value of <0.05 was considered statistically significant.

RESULTS

A total of 80 children with suspected pelviureteric junction obstruction (PUJO) were enrolled in the study. Of these, 45 (56.3%) were infants under one year of age. The overall male-to-female ratio was approximately 3:2, with left-sided hydronephrosis being more frequently observed. All patients underwent preoperative assessment with renal ultrasonography and technetium-99m MAG3 diuretic renography. Based on the combination of anatomical and functional imaging criteria, 39 children (48.8%) were found to have both an anteroposterior (AP) diameter greater than 20 mm and an obstructive drainage curve on MAG3. These patients fulfilled the study's surgical criteria and underwent Anderson-Hynes dismembered pyeloplasty. These findings are summarised in Table 1 and Figure 1.

Intraoperative findings among the surgical group revealed high insertion of the ureter in 8 patients, crossing vessels in 6, and intrinsic PUJ narrowing in 25. Histopathological examination, performed on 10 representative PUJ segments, confirmed muscular disarray and subepithelial fibrosis consistent with obstructive pathology. Follow-up imaging at 3, 6, and 9 months postoperatively demonstrated a steady decrease in mean AP diameter from 25.6 mm to 14.8 mm. Differential renal function (DRF) improved in 71.8% of cases and remained stable in 23%, with no deterioration or need for reoperation observed.

The remaining 41 children were managed conservatively. Among these, 29 had AP diameter ≤20 mm and non-obstructive MAG3 patterns, 9 had AP diameter >20 mm but non-obstructive drainage, and only 3 had AP diameter ≤20 mm with an obstructive curve on MAG3 but preserved renal function. These patients were followed over the same 9-month period. A spontaneous reduction in AP diameter was observed in 81% of conservatively managed patients, and DRF remained stable in all. Importantly, none of the non-surgical patients demonstrated worsening of hydronephrosis or required delayed surgical intervention.

These findings affirm that the combination of AP diameter >20 mm and an obstructive MAG3 pattern effectively identifies patients with clinically significant PUJO who benefit from surgical correction. Simultaneously, children not meeting

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both criteria can be safely observed without functional compromise.

AP Diameter (mm)	MAG3 Pattern	Number of Patients	Management
>20	Obstructive	39	Surgical
>20	Non-obstructive	9	Conservative
≤20	Obstructive	3	Conservative
≤20	Non-obstructive	29	Conservative

Table 1: Patient Details

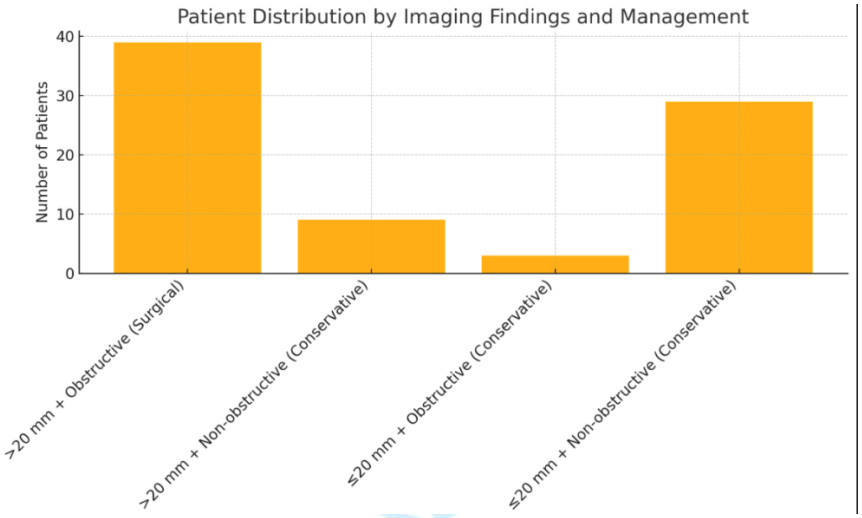

Figure 1: Classification of Patients

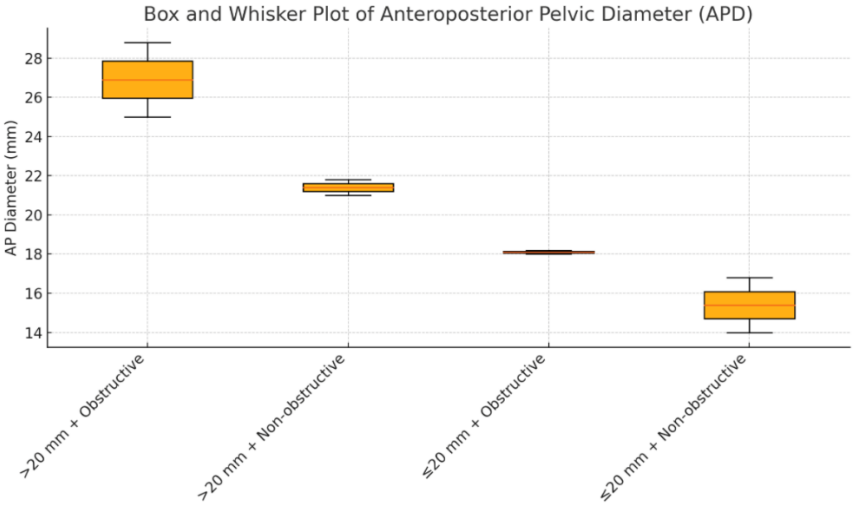

Figure 2: Distribution of Patients

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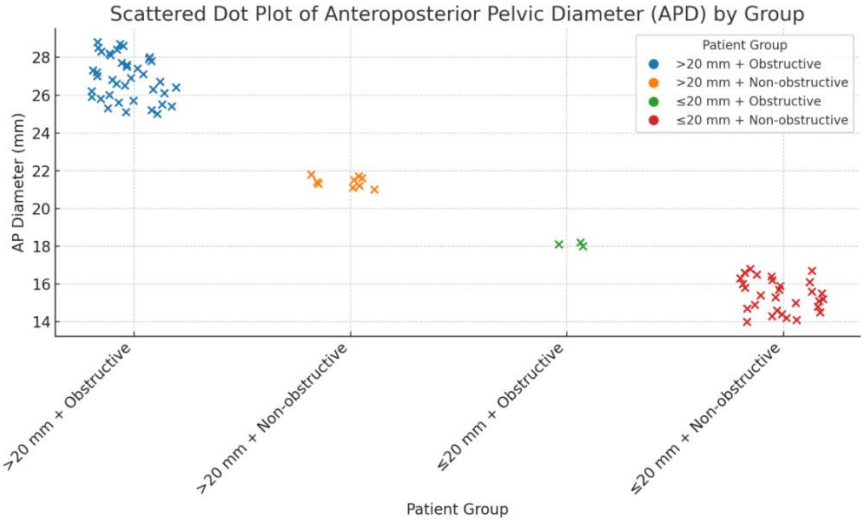

Figure 3: Distribution of Patients

AP Diameter and Obstructive Pattern

Figure 4 shows a visual comparison of anteroposterior (AP) pelvic diameter between patients with obstructive and non-obstructive MAG3 drainage patterns was performed using both density and box plots, providing strong visual and statistical evidence supporting the diagnostic utility of AP diameter in pediatric PUJO.

The density plot demonstrated a clear separation in the distribution of AP diameters between the two groups. The curve for the obstructive group was shifted to the right, with a sharp peak between 25–28 mm, indicating a higher concentration of patients with marked pelvicalyceal dilatation. In contrast, the non-obstructive group showed a more modest distribution concentrated between 14–20 mm, with minimal overlap between the two curves. This graphical distinction suggests a robust correlation between increased AP diameter and functional obstruction.

The box plot further substantiated these findings by showing a visibly higher median AP diameter in the obstructive group, along with a broader interquartile range. The non-obstructive group had a tighter distribution, with few outliers and significantly lower values overall. This pattern suggests that larger AP diameters are not only more frequent but also more variable in patients with obstruction.

Statistical comparison using an independent samples t-test yielded a p-value < 0.0001, confirming that the difference in AP diameter between obstructive and non-obstructive groups is highly significant. This supports the clinical threshold of >20 mm AP diameter as a reliable anatomical marker in predicting obstruction on MAG3 scintigraphy.

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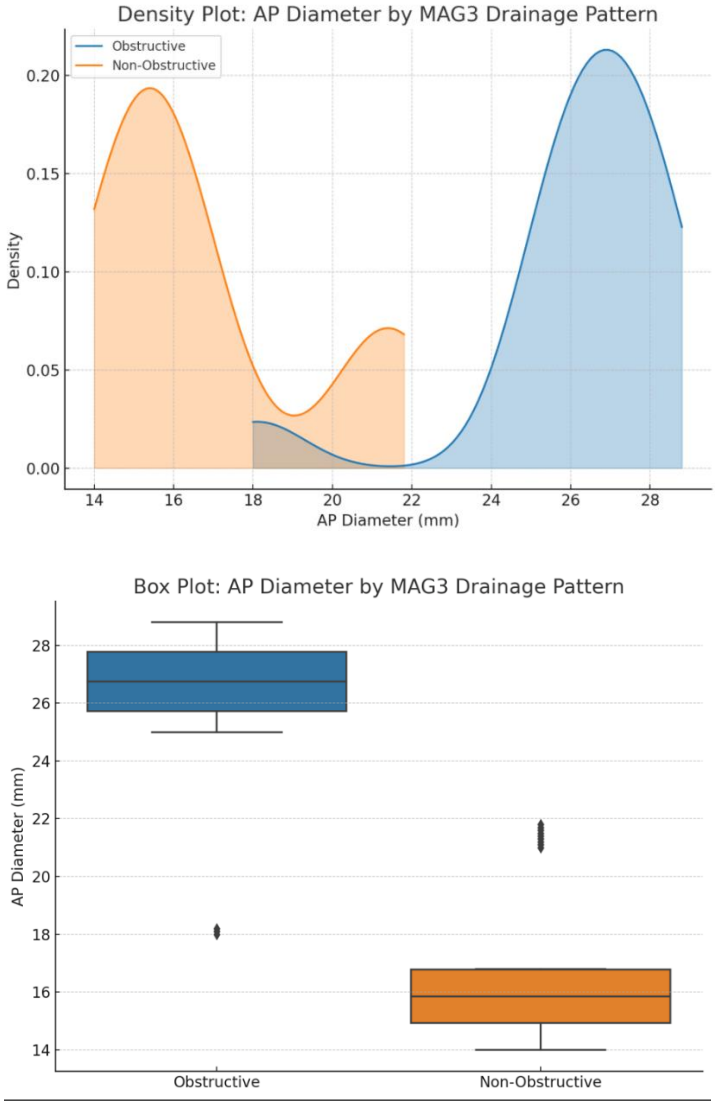

Figure 4: AP Diameter and MAG III Correlation

Discussion

The present study evaluated the diagnostic accuracy of combined ultrasonographic and functional imaging parameters in predicting the need for surgical intervention in children with pelviureteric junction obstruction (PUJO), with a focus on the correlation between anteroposterior (AP) pelvic diameter and drainage pattern on MAG3 renography. The results not only validate the clinical utility of these parameters but also highlight the effectiveness of a structured, evidence-based protocol in guiding management and ensuring favorable outcomes.

Our findings demonstrate that an AP diameter >20 mm, when coupled with an obstructive drainage curve on MAG3, serves as a strong predictor for clinically significant PUJO requiring surgical correction. Among the 80 children included in this study, 39 patients fulfilled both imaging criteria and underwent Anderson-Hynes dismembered pyeloplasty. Intraoperative findings and histological confirmation in these cases substantiated the radiologic diagnosis, revealing anatomical anomalies such as high ureteral insertion, lower pole crossing vessels, and intrinsic segmental narrowing, all of which are known contributors to obstruction [1,2].

Postoperative outcomes further validated the surgical indications. There was a significant reduction in mean AP diameter and improvement or stabilization in differential renal function (DRF) in over 94% of

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cases, with no instances of functional deterioration or reoperation. These findings align with earlier reports demonstrating that timely pyeloplasty based on combined imaging criteria can preserve renal function and resolve anatomical obstruction [13,14].

Equally important were the outcomes in the conservatively managed cohort. Children who did not meet both surgical criteria—either due to an AP diameter ≤20 mm or a non-obstructive drainage pattern—were followed with serial imaging. Over 80% of these patients demonstrated a spontaneous reduction in AP diameter, and all maintained stable DRF throughout the follow-up period. Notably, none required delayed surgery, underscoring the safety of observation in well-selected cases. This mirrors the findings of Lee et al. and Onen, who emphasized that low-grade hydronephrosis with preserved function can often resolve without intervention [15,16].

The graphical analysis added further depth to our evaluation. A density plot of AP diameters showed minimal overlap between obstructive and non-obstructive groups, with the obstructive group demonstrating a right-shifted curve centered around 25–28 mm. This distribution was mirrored in the box plot, which illustrated a significantly higher median and broader interquartile range in the obstructive group. Statistical analysis revealed a p-value < 0.0001, confirming a highly significant difference in AP diameter between groups. This reinforces the role of APD as a quantitative and reproducible parameter in PUJO risk stratification.

These results support the proposition that a combined imaging approach using AP diameter and MAG3 renographyenables accurate, timely, and individualized clinical decision-making. The incorporation of both anatomical and functional criteria helps mitigate the risks of overtreatment and prevents the consequences of delayed surgical correction in truly obstructive cases. Our study thereby addresses the diagnostic ambiguity often faced when relying on either imaging modality in isolation.

Nonetheless, this study has limitations. It was conducted at a single center with a limited follow-up duration of 9 months. Longer-term follow-up is needed to assess renal functional preservation beyond infancy and early childhood. Additionally, while MAG3 renography is the gold standard for functional assessment, its interpretation can be technically challenging in neonates and infants due to immature renal function and compliance-related issues during imaging [7]. These limitations underscore the importance of interpreting MAG3 findings in conjunction with anatomical data and clinical context.

In conclusion, this study affirms that the integration of ultrasound-based AP diameter >20 mm with obstructive MAG3 drainage provides a highly specific and sensitive diagnostic strategy for identifying children with PUJO who require surgical intervention. At the same time, it offers reassurance that conservative management is safe in children with lesser degrees of hydronephrosis and preserved drainage. This dual-modality approach should be considered the cornerstone of PUJO management protocols in pediatric surgical practice.

Conclusion

This prospective study demonstrates that combining anatomical and functional imaging—specifically, an anteroposterior pelvic diameter (APD) >20 mm on ultrasound and an obstructive drainage pattern on MAG3 scintigraphy—provides a highly accurate, objective, and reproducible criterion for identifying children with pelviureteric junction obstruction (PUJO) who require surgical intervention. Intraoperative findings and histopathological confirmation in all surgically managed cases further validate the reliability of these imaging thresholds. Conversely, children who did not meet both criteria were safely managed conservatively, with spontaneous improvement in hydronephrosis and stable renal function over time. This dual-imaging strategy not only enhances diagnostic confidence but also helps avoid unnecessary surgery, making it a practical and effective framework for PUJO management in clinical pediatric practice. Long-term follow-up and multicenter validation are recommended to generalize these findings.

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