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ANATOMICAL VARIATIONS IN THE ANTERIOR AND POSTERIOR DIVISIONS OF THE RENAL ARTERY: A CADAVERIC, CORROSION CAST, AND RADIOLOGICAL STUDY

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ABSTRACT

Background: Knowledge of renal arterial segmentation is crucial for nephron-sparing surgeries, renal transplantation, and endourological interventions. Despite classical descriptions, variations in anterior and posterior divisions of the renal artery remain clinically significant.
Objective: To classify and document the variations in the anterior and posterior divisions of the renal artery in 60 adult human kidneys using dissection, corrosion cast, and radiological methods.
Methods: Sixty kidneys (40 cadaveric, 10 corrosion cast, 10 radiological) were studied. The branching pattern of the anterior and posterior divisions of the renal artery was examined. Variations were classified according to established systems (Graves, Kher, Verma) and quantified. Comparative analysis with existing literature was performed.
Results: Eight types of anterior division were identified. The most common was Type VII (20%), where anterior division terminated in combinations of segmental arteries. Type IV (16.6%) and Type III (13.3%) were also frequent. Type I (10%) and Type VIII (6.6%) were least common. Posterior division showed four types: Type II (bifurcation/trifurcation) was the most common (51.6%), followed by Type I (28.3%), Type III (16.6%), and Type IV (3.3%). The findings demonstrate significant anatomical variability compared with classical descriptions.
Conclusion: Variations in the anterior and posterior divisions of the renal artery are common and have direct implications for nephron-sparing surgery, renal transplantation, and interventional radiology. Preoperative imaging should aim to identify these patterns to minimize complications.

Keywords: Renal artery; anterior division; posterior division; anatomical variations; cadaveric study.

INTRODUCTION

Renal vascular anatomy plays a pivotal role in surgical planning for nephrectomy, renal transplantation, and interventional urology. John Hunter first described the segmental anatomy of the kidney in 1794[1], but detailed classification was provided by Graves (1954)[2], who described five segmental arteries with minimal anastomosis. Later studies by Kher et al.[3]and Verma et al.[4] further expanded classifications to include additional variations. Anterior and posterior divisions of the renal

artery are critical landmarks. Knowledge of their variability is essential to avoid inadvertent ischemia, excessive bleeding, and unnecessary removal of functional renal parenchyma during surgery. The present study aims to document the variations of anterior and posterior divisions of the renal artery in Indian cadaveric kidneys and compare them with classical literature.

MATERIALS AND METHODS

Sample: 60 human kidneys (40 cadaveric from dissection, 10 corrosion cast, 10 radiological injection studies).
Study centre: Department of Anatomy, Index Medical College Hospital & Research Centre, Indore (Malwanchal University)
Study Duration: June 2023 to March 2025
Inclusion criteria: Adult kidneys with intact renal vasculature.
Exclusion criteria: Damaged or pathological kidneys.

Methods:

- **Dissection method (40 specimens):** Segmental arteries were traced and documented.
- **Corrosion cast method (10 specimens):** Silicon injection followed by acid corrosion to isolate arterial casts.
- **Radiological method (10 specimens):** Barium sulphate injection followed by radiography.

Classification: Variations were classified using modified systems of Graves, Kher, and Verma.
Analysis: Data were tabulated, and frequencies were calculated.

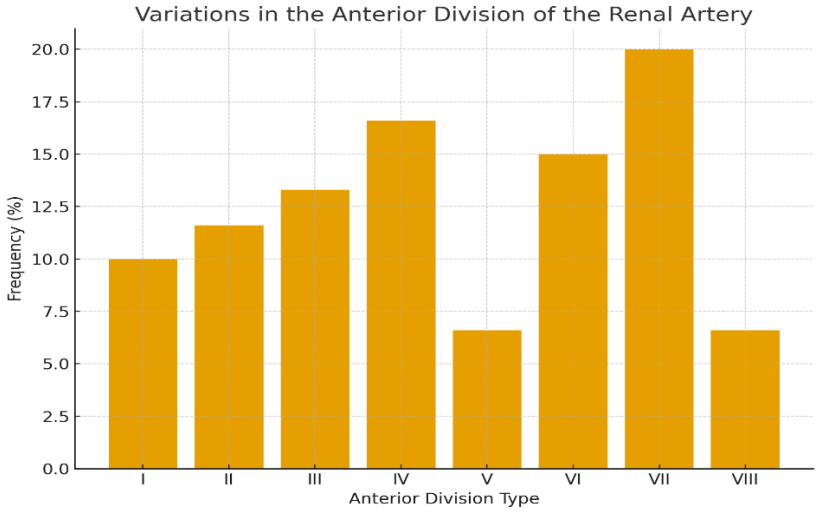
RESULT

A total of 60 kidneys were analysed for branching variations of the renal artery. The anterior division showed considerable variability in its branching pattern, with eight distinct types identified. The posterior division showed comparatively fewer variations, with four main types documented. Anterior Division: The anterior division exhibited eight morphological types. Type VII pattern, in which the anterior division terminated in combinations of segmental arteries, was the most common (20%). Type IV (16.6%) and Type III (13.3%) were also relatively frequent. The classical Type I pattern described by Graves, where the anterior division bifurcates into upper and middle arteries after giving off the lower, was observed in only 10% of specimens. Type VIII, characterized by an accessory artery arising directly from the aorta and supplying the anterior division, was rare (6.6%).

Table 1. Variations in the anterior division of the renal artery (n=60)

Type	Description	Frequency (%)
I	Terminates as upper + middle after giving off lower	10
II	Terminates as middle + lower after giving off upper	11.6
III	Gives rise to apical, then upper + middle + lower	13.3
IV	Gives off apical + upper + middle after lower	16.6
V	Runs in front of pelvis, giving rise to all four	6.6
VI	Divides into 4 segmental arteries before hilum	15
VII	Termination with combinations of segmental arteries	20
VIII	Arises directly from aorta (accessory)	6.6

Figure 1. Distribution of anterior division types of the renal artery.



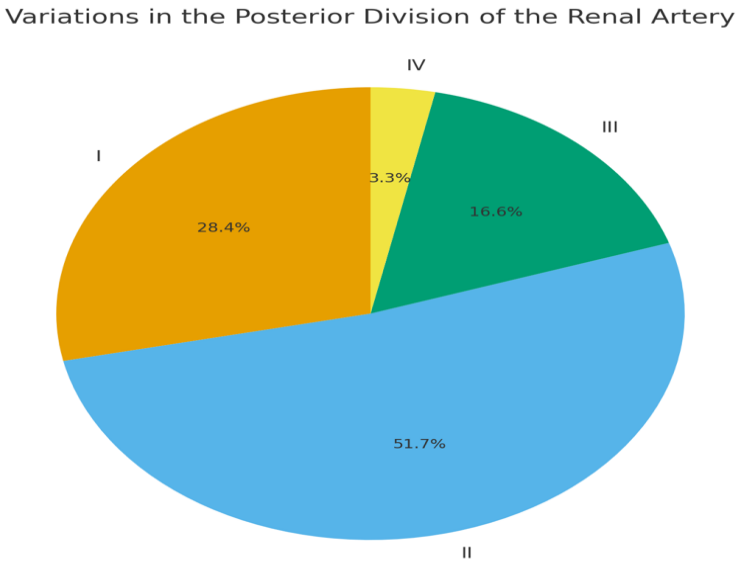
The results indicate that the anterior division often diverges from the classical descriptions provided by Graves. In particular, a significant proportion of kidneys demonstrated additional complexity, with multiple segmental arteries arising directly from the anterior division before entering the hilum.

Posterior Division: The posterior division demonstrated fewer variations, classified into four major types. Type II, characterized by bifurcation or trifurcation, was the most common (51.6%). Type I, where the posterior division descended behind the renal pelvis and gave multiple branches, was seen in 28.3% of kidneys. Type III, with posterior supply arising after giving off apical, middle, or lower segmental arteries, was observed in 16.6%. Type IV, where an accessory posterior branch arose directly from the aorta, was least frequent (3.3%).

Table 2. Variations in the posterior division of the renal artery (n=60)

Type	Description	Frequency (%)
I	Runs down behind pelvis, giving multiple branches	28.3
II	Bifurcation/trifurcation supplying posterior segment	51.6
III	Gives off apical/middle/lower before supplying posterior	16.6
IV	Arises directly from aorta (accessory)	3.3

Figure 2. Distribution of posterior division types of the renal artery.



Comparative Observations:
- In most specimens, the anterior division showed greater variability than the posterior division, suggesting a higher degree of anatomical complexity in anterior vascular supply.
- The predominance of Type VII in the anterior division and Type II in the posterior division indicates a departure from the classical models described in standard anatomical literature.
- Accessory contributions from the aorta to both anterior and posterior divisions were rare but clinically significant, as they may complicate surgical approaches and vascular reconstruction.

Overall Findings:
- The study demonstrated that classical patterns described by Graves (2) were not the most common in this series.
- Approximately one-fifth of kidneys showed a highly variable anterior branching pattern (Type VII).
- More than half of the specimens exhibited posterior division bifurcation/trifurcation (Type II).
- Rare but important variations, such as accessory arteries arising directly from the aorta, were documented in both divisions.

These results provide critical baseline data for understanding renal arterial anatomy in the studied population and highlight the importance of preoperative vascular mapping.

DISCUSSION

The study confirms that anterior and posterior divisions of the renal artery show diverse branching patterns. Type VII anterior division (20%) was the most frequent in this series, unlike Graves' description of Type I predominance[2]. Posterior division most commonly showed bifurcation/trifurcation (Type II, 51.6%), consistent with the venous-type branching noted by Sykes[5].

The presence of these variations has significant surgical relevance:
- **Partial nephrectomy:** Accurate identification of segmental arteries prevents unnecessary loss of parenchyma.
- **Renal transplantation:** Knowledge of division patterns assists in vascular anastomosis.
- **Endourology:** Avoids arterial injury during percutaneous procedures.

Comparison with previous Indian studies[3,4,8] indicates a higher frequency of complex branching in this study population. Global studies[6,7] also emphasize variability, but regional differences in incidence highlight the need for population-specific anatomical data.

CONCLUSION

Anterior and posterior divisions of the renal artery show wide variations. Type VII anterior division and Type II posterior division were most common in this study. Such knowledge is crucial for surgical, radiological, and transplant planning. Preoperative imaging must evaluate renal arterial branching patterns to reduce morbidity.

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