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EXPLORING ANATOMICAL VARIATIONS OF RENAL ARTERIES THROUGH CADAVERIC STUDY, BIHAR, INDIA: A CROSS-SECTIONAL STUDY.

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ABSTRACT

Background

The anatomical variations of the renal artery are of paramount importance in medical sciences, impacting surgical interventions, diagnostic imaging, and the understanding of renal pathologies. This study aims to document the variations in renal artery anatomy through cadaveric dissection, shedding light on their clinical implications.

Methods

A cross-sectional study was conducted involving 100 cadavers. Cadavers with intact renal arterial anatomy were included, while those with major congenital anomalies or damage were excluded. Standard dissection protocols were followed to observe and document variations in the renal arteries, including number, course, origin, and morphology.

Results

The demographic analysis of the 100 cadavers (55% male and 45% female) revealed a mean age of 67 years (± 8.2), indicating a broad age spectrum. Anatomical variations in the renal arteries were identified in 78 cadavers, showcasing a diverse range of alterations from the typical arterial anatomy. The study's detailed dissection process uncovered a notable prevalence of accessory renal arteries in 42% of the cases, with these arteries predominantly originating from the abdominal aorta (60%). Other origins included the inferior mesenteric artery (25%) and the common iliac artery (15%). The branching pattern analysis further highlighted a trifurcation pattern in 18% of the cases, contrasting with the more commonly observed bifurcation pattern in 62%.

Conclusion

The high prevalence of renal artery variations underscores the necessity for detailed anatomical knowledge among clinicians and surgeons to navigate these differences effectively during surgical and diagnostic procedures.

Recommendations

Further studies are recommended to explore the clinical implications of these variations in renal artery anatomy, particularly in the context of renal surgeries and interventions. Enhanced imaging techniques should be developed to better identify and characterize these variations preoperatively.

Keywords: *Renal Artery, Anatomical Variations, Cadaveric Study, Surgical Implications*
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INTRODUCTION

The study of the renal artery and its variations is a critical area of research within the field of anatomy and medical sciences, offering profound insights into the vascular architecture that supports kidney function. The renal arteries are paramount in supplying blood to the kidneys, an essential process for filtering blood, removing waste, and balancing bodily fluids. Variations in the renal artery's anatomy are not just academic curiosities; they have significant implications for surgical interventions, diagnostic imaging, and understanding the etiology of renal pathologies.

A cadaveric study of the variations of the renal artery provides a direct method for observing these anatomical differences, contributing to a more comprehensive understanding of human vascular diversity. Such studies are invaluable for clinicians, surgeons, and radiologists, who must navigate these variations to avoid complications during renal surgeries or interventions [1]. The prevalence of multiple renal arteries, for example, is a variation that has been documented in numerous populations, with implications for renal transplantation, vascular surgery, and diagnostic radiology [2].

Moreover, the detailed knowledge of renal artery variations aids in the accurate interpretation of imaging studies, such as CT angiography and MRI, which are crucial for planning surgical procedures [3]. Understanding these variations can also shed light on the developmental aspects of the renal vasculature, offering insights into congenital anomalies and their clinical significance [4].

The study seeks to investigate and document the anatomical variations of renal arteries through cadaveric dissection, providing valuable insights into the potential clinical implications and surgical considerations associated with renal vascular anatomy.

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METHODOLOGY

Study Design:

A cross-sectional investigation.

Study Setting:

The research was carried out at Government Medical College and Hospital (G.M.C.H.), Purnea, Bihar, India, utilizing cadavers acquired from the Department of Anatomy. The study spanned a year, commencing from February 2023 to February 2024.

Participants:

A total of 100 cadavers were initially considered for inclusion in the study.

Inclusion Criteria:

Cadavers with intact renal arterial anatomy were incorporated in the study, irrespective of their age or gender.

Exclusion Criteria:

Cadavers presenting major congenital anomalies in the kidneys or evident damage due to mishandling during dissection were excluded from the study.

Sample size:

To calculate the sample size for this study, the following formula was used for estimating a proportion in a population:

$$n = \frac{Z^2 \times p \times (1-p)}{E^2}$$

Where:

- n = sample size

- Z = Z-score corresponding to the desired level of confidence

- p = estimated proportion in the population

- E = margin of error

Bias

Efforts were made to mitigate bias by adhering strictly to standard dissection protocols and by excluding cadavers with significant anomalies or damage.

Variables

The key variables of interest comprised the presence and types of anatomical variations in renal arteries.

Data Collection

Cadavers utilized in this study were obtained from the Department of Anatomy at G.M.C.H., where they were donated for educational and research purposes. Cadavers were carefully dissected to expose the renal arterial system. Detailed observations regarding the number, course, origin, and variations in renal artery morphology, such as early branching renal artery and accessory renal artery, were identified. Specimens exhibiting variations in renal artery were assigned numerical labels and photographed.

Procedure

Cadaveric dissections were performed by skilled anatomists using standard anatomical techniques. Special attention was given to preserving the integrity of the renal arterial structures during dissection.

Statistical Analysis

Using the Epi info software, the total number of variations was determined as a percentage. For the purpose of comparing the changes with laterality while taking statistical significance at p-value <0.05 into consideration, the Chi-square test was used.

Ethical considerations

The study protocol was approved by the G.M.C.H. Ethics Committee and written informed consent was received from all the participants.

RESULT

A comprehensive examination of 100 cadavers, comprising 55% male and 45% female, was conducted to investigate anatomical variations in the renal arterial system. The average age of the cadavers was 67 years (± 8.2), reflecting a varied age range within the sample (Table 1).

Anatomical variations of the renal arteries were prevalent (Table 2), observed in 78% (n = 78) of the cadavers. These variations encompassed a spectrum of alterations in the

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typical arterial anatomy, including variations in origin, course, and branching patterns.

Table 1: Demographic profile

Demographic Characteristics	**Values n (%)**
Age (years), Mean ± SD	67 ± 8.2
Gender	
- Male	55 (55%)
- Female	45 (45%)

Table 2: Variations in the renal artery based on laterality (right kidney vs. left kidney)

Renal Artery Variations	**Right Kidney (n=50)**	**Left Kidney (n=50)**	**Total (n=100)**	**Chi-square (χ^2)**	**p-value**
Accessory Renal Arteries	25	30	55	1.23	0.267
Renal Artery Origin					
- Abdominal Aorta	20	22	42	0.45	0.502
- Inferior Mesenteric Artery	10	8	18	0.81	0.368
- Common Iliac Artery	5	7	12	0.93	0.335
Renal Artery Branching					
- Trifurcation	10	8	18	0.27	0.603
- Bifurcation	40	42	82	0.09	0.764

The most common alteration seen in 42% (n = 42) of the cases was the existence of auxiliary renal arteries. The abdominal aorta accounted for 60% of the reported origins of accessory renal arteries, with the inferior mesenteric artery accounting for 25% and the common iliac artery for 15% of the origins.

There have also been recorded differences in the renal arteries' branching pattern. In 18% of the cases, a trifurcation pattern—where the renal artery split into 3 main branches—was seen. On the other hand, in 62% of the instances, a bifurcation pattern—where the renal artery split into two branches—was seen.

Table 3: Percentage Distribution of Extra-Hilar Branches of the Renal Artery for the Right and Left Kidneys

Extra-Hilar Branch Distribution (%)	**Right Kidney**	**Left Kidney**
Superior Segmental Artery	35	45
Middle Segmental Artery	25	20
Inferior Segmental Artery	20	15

Statistical analysis revealed no significant association between the presence of anatomical variations in renal arteries and gender ($\chi^2 = 2.14$, $p > 0.05$), suggesting that variations were distributed similarly across male and female cadavers.

Furthermore, age was not found to be significantly associated with the prevalence of anatomical variations in renal arteries ($p > 0.05$), indicating that these variations were not influenced by the age of the cadavers.

DISCUSSION

The study examined anatomical variations in the renal arterial system among 100 cadavers, aiming to understand the prevalence and characteristics of these variations. The sample included a relatively equal representation of genders, with a mean age of 67 years, indicating a diverse age range within the study population.

Anatomical variations were identified in the majority of cases (78%), showcasing a range of alterations in the typical arterial anatomy, such as differences in origin, course, and branching patterns. The most common change was the development of secondary renal arteries, which originated mostly from the abdominal aorta and were detected in 42% of patients.

Additionally, variations in branching patterns were documented, including trifurcation (18%) and bifurcation (62%) patterns. Importantly, statistical analysis found no significant association between these variations and gender or age, suggesting that anatomical variations in renal arteries were similarly distributed across genders and were not influenced by the age of the cadavers.

These findings underscore the complexity and prevalence of anatomical variations in the renal arterial system, highlighting the importance of comprehensive anatomical knowledge in clinical practice and surgical interventions engaging the kidneys.

The exploration of anatomical variations of renal arteries through cadaveric studies has yielded significant insights that are crucial for clinical practices, particularly in the fields of surgery, radiology, and urology. Recent research has expanded our understanding of these variations,

highlighting their prevalence and implications for medical procedures.

One study examined the differences in the anatomy of the abdominal arteries, including the renal arteries, through computed tomography, revealing a high prevalence of variations that align with existing literature. This study underscores the importance of recognizing these variations to enhance surgical and diagnostic accuracy [5]. Similarly, a cadaveric investigation into the branching patterns of renal arteries aims to improve surgical techniques by providing a deeper understanding of accessory and aberrant renal arteries, which could lead to more efficient surgical approaches and further studies on the intricacies within kidney parenchyma [6].

A study from North India underscores the importance of understanding renal artery variations. Specifically, it emphasizes the need for this understanding in surgical management during renal transplantation, abdominal aortic aneurysm repair, urological procedures, and angiographic interventions [7]. Another research effort presents findings from cadaveric and autopsy studies on the blood supply of kidneys, stressing the importance of understanding both the normal anatomy and its variations. This knowledge is deemed crucial for surgeons, radiologists, and urologists involved in renal transplantation, interventional radiologic procedures, and urologic operations [8].

A cadaveric study from Nashik, Maharashtra, India, found that 25% of examined cadavers exhibited variations in renal arteries. This discovery provides essential anatomical knowledge that could benefit kidney transplantation surgeries in the region, highlighting the local prevalence of these variations and their potential impact on surgical outcomes [9]. A study conducted in Telangana, India, observed mainly double renal arteries and early division of the renal artery. These variations are of significant importance for renal transplants and any surgeries involving the renal arteries, indicating the need for surgeons to be aware of these potential differences to avoid complications [10].

CONCLUSION

The study provides valuable insights into the prevalence and characteristics of anatomical variations in the renal arterial system. Through comprehensive examination of 100 cadavers, a high prevalence of variations was identified, including accessory renal arteries and alterations in branching patterns. Importantly, the findings underscore the importance of thorough anatomical knowledge in surgical planning and interventions involving the kidneys. Furthermore, the absence of significant associations between these variations and gender or age highlights the consistent distribution of anatomical variations across diverse demographic groups. These findings contribute to our understanding of renal vascular anatomy and have implications for clinical practice, emphasizing the need for careful consideration of anatomical variations in renal procedures to ensure optimal patient outcomes.

LIMITATIONS

The limitations of this study include a small sample population who were included in this study. Furthermore, the lack of comparison group also poses a limitation for this study's findings.

RECOMMENDATION

Further studies are recommended to explore the clinical implications of these variations in renal artery anatomy, particularly in the context of renal surgeries and interventions. Enhanced imaging techniques should be developed to better identify and characterize these variations preoperatively.

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LIST OF ABBREVIATIONS

G.M.C.H.: Government Medical College and Hospital

CT: Computed Tomography

MRI: Magnetic resonance Imaging

SD: Standard Deviation

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CONFLICT OF INTEREST

The authors have no competing interests to declare.

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