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Original Article

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Evaluation of Anatomical Variations of the Abdominal Aorta and Its Major Branches with 128 Detector Computed Tomography

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ABSTRACT

Background: Understanding the anatomical variations of the abdominal aorta and its branches is vital for clinicians. Such knowledge aids in averting complications and injuries during surgical procedures and radiological interventions. This study aims to assess these variations and compare the findings with existing literature.

Methods: The study was conducted in the Department of Radio diagnosis at VIMS & RC, Bangalore using a Siemens Somatom Definition AS 128 slice Multi-detector CT scanner with 5 mm collimation. All patients, regardless of age, undergoing CECT and CT angiography referred from all departments at VIMS & RC, Bangalore, were eligible for inclusion. However, patients with prior major abdominal surgeries or known cases of chronic renal disease were excluded. For the imaging procedure, triphasic CT scans were executed. The analysis incorporated axial cuts of 5 mm thickness and thin section reconstructions of 1 mm. Additionally, multiplanar reformats were utilized, and maximum intensity projections (MIP) were employed specifically for vessel analysis.

Results: Our study offered a vivid demographic distribution. Males dominated the sample size at 64.3%, while females were at 35.7%. When observed age-wise, the participants had an average age of 45.41 ± 15.67, the youngest being 10 years old and the eldest at 81 years. The age bracket of 51-60 years showed the most significant representation, whereas a meager 4.8% fell below 20 years. Shifting focus to the crux of the study - the radiological outcomes - a sizable 73.6% of participants showcased standard results. However, variations were not amiss. Bilateral Accessory Renal Arteries manifested in 8.7%, while both Accessory Right Renal Arteries and Trifurcation of Celiac Trunks each made their presence in 7.1%. Accessory Left Renal Arteries were seen in 3.2% of the participants. A rare sighting was that of the Right Hepatic Artery taking its origin from the superior mesenteric artery, seen in a scanty 0.3%. Encouragingly, no anomalies cropped up in the inferior mesenteric artery branching.

Conclusion: With the increasing use of Multidetector CT (MDCT) over DSA for vascular structure evaluation, the clarity and quality of imaging have improved substantially. Recognizing anomalies of the abdominal aorta preoperatively, especially in procedures like organ transplants and chemoembolization, is paramount to minimize post-operative complications.

Key Words: *Abdominal Aorta, Anatomical Variations, 128-Detector CT, Multidetector CT, Vascular Structures, Preoperative Evaluation*

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INTRODUCTION

The abdominal aorta is the largest artery in the abdominal cavity, responsible for supplying oxygenated blood to most of the abdominal organs and some parts of the pelvis and lower extremities. Extending from the diaphragm to its bifurcation into the common iliac arteries, its trajectory and the anatomy of its branches are fairly consistent in the human population. However, like many vascular structures, the abdominal aorta and its branches exhibit a myriad of anatomical variations. Understanding these variations is crucial for both diagnostic and therapeutic purposes, especially with the burgeoning use of interventional radiology and surgical procedures [1].

Computed Tomography (CT) has always been at the forefront of diagnostic modalities, providing detailed insights into the anatomy and pathology of the body's interior. The introduction of the 128-detector CT scanner has further elevated the diagnostic potential of CT, offering finer details with faster acquisition times and reduced radiation doses [2]. This technology becomes particularly significant when evaluating vascular structures like the abdominal aorta and its branches.

Normal anatomy dictates that the abdominal aorta gives off three anterolateral branches – the celiac trunk, superior mesenteric artery, and the inferior mesenteric artery. Additionally, it gives off the paired renal arteries and several lateral and posterior branches. However, studies have shown significant variations, including but not limited to, the presence of accessory renal arteries, different origins of visceral branches, and varied bifurcation patterns [3].

Recognizing the importance of accurate anatomical knowledge in the medical field is not novel. From the era of the first cadaveric dissections to the current age of advanced imaging, understanding anatomical variations has always been deemed paramount. Not only does it aid clinicians in accurate diagnosis and disease management, but it also reduces the risk of iatrogenic injuries, particularly in interventional and surgical scenarios [4]. For instance, unrecognized variant anatomy can lead to hemorrhagic complications, misinterpretation of imaging studies, and even failed interventions.

The 128-detector CT scanner provides several advantages over its predecessors. Its ability to capture detailed images in a short span of time while maintaining high resolution ensures reduced motion artifacts, which are particularly important while imaging vascular structures. This technology can thus delineate even minor anatomical deviations with precision, which is crucial in preoperative planning for surgeries involving the abdominal aorta and its branches [5]. Moreover, its capabilities in CT angiography have revolutionized vascular imaging, allowing for 3D reconstructions and detailed vascular mapping that can vividly display variant anatomy [6].

While the advent of such technology is monumental, it's also crucial to periodically evaluate its efficacy in real-world scenarios, especially concerning its performance in delineating variant anatomy. With the increasing reliance on CT imaging for diagnostic and therapeutic planning, ensuring its accuracy and understanding its limitations becomes imperative [7].

The global landscape of medical technology is rapidly evolving, and with it, the onus on medical professionals to keep abreast with the latest diagnostic tools and their applications. Evaluating the anatomical variations of the abdominal aorta and its major branches using the 128-detector CT scanner does not merely signify an academic endeavor. It encapsulates the broader aim of the medical community: to ensure patient safety, improve clinical outcomes, and pave the way for innovations in patient care [8].

AIM OF THE STUDY

Aim of the study is to know the anatomical variations of abdominal aorta and its branches, to correlate our study results with the existing literature data and thorough knowledge of these disparities is necessary to avoid complications and injuries during the surgical procedures and radiological interventions.

OBJECTIVES

1) To assess the prevalence of normal anatomy of the abdominal aorta and its branches arising in the study population.
2) To assess the prevalence of anatomical variations of the abdominal aorta and its branches arising in the study population.
3) To assess clinical impact of the post-surgical procedures and radiological interventions in patients with anatomical variations of abdominal aorta and its branches.

METHODOLOGY

Ethical Clearance and Consent:

The study was initiated post the ethical clearance obtained from the ethical committee of VIMS & RC. Additionally, informed consent was garnered from all participating patients.

Study Population:

The research encompassed 301 patients referred to the department of radio diagnosis for CECT abdomen & CT angiography at VIMS & RC, Bengaluru.

Inclusion Criteria:

All patients undergoing CECT and CT angiography within the department of Radio diagnosis at VIMS &RC, Bangalore were included.

Exclusion Criteria:

The study refrained from including Patients with a history of major abdominal surgeries, abdominal mass, hepatic artery, renal artery occlusion, thrombus, aneurysms, or those who underwent anastomosis, AND Known cases of chronic renal disease.

Imaging Protocols:

CT Scanning: A Triple phasic CT was conducted on all patients using the Siemens Somatom Definition AS 128 slice Multi-detector CT scanner. Parameters involved a 5 mm collimation, gantry speed of 0.05 sec, and a pitch of 1.2 sec.

Contrast Administration: Omnipaque (Iohexol) -350 mg I/ml was the contrast of choice. Typical doses ranged from 80-120 ml, administered through the pressure injector (Imaxeon, SW version- 1.5-.12) paired with smart prep software (RCU manager).

Phases and Parameters: Scans encompassed arterial, venous, and delayed phases. Standard scan parameters were set at 5 mm and 1 mm slice thickness, integrating coronal, axial, and sagittal reconstruction with 120 MA and 60-80 Kvp.

Analysis & Workstations: Dedicated workstations, including Aquarius systems and Syngovia, were utilized for image analyses. Detailed evaluations were performed on axial cuts, thin-section reconstructions, and multiplanar reformats. Advanced imaging techniques like MIP, SSD, and VRT were engaged for an exhaustive vessel analysis.

Sample Size Calculation:

$n = Z^2 Pq / d^2$ was employed for the sample size determination. Given a 95% confidence level (Z=2.96), a normal axis variation proportion (P) of 90.5%, and a precision (d) of 5%, the sample size (n) culminated to 301.

Statistical Analysis:

Data Compilation & Software: Data was meticulously fed into a Microsoft Excel datasheet and later processed using the SPSS 22 version software.

Data Representation: For a comprehensible representation, categorical data was delineated in terms of frequencies and proportions. On the other hand, continuous data was showcased as mean and standard deviation. Tools like MS Excel and MS Word enabled the graphical visualization through bar and pie diagrams.

Significance Testing: The Chi-square test was employed for qualitative data. A p-value (probability indicating the veracity of the result) less than 0.05 was earmarked as statistically significant, keeping in line with standard statistical norms.

RESULTS

Table 1: Distribution of gender among the study participants

Gender distribution	F	Percentage
Male	200	64.3%
Female	111	35.7%
Total	311	100%

In our study, 35.7 % of the participants were females and 64.30 % of the participants were males.

Table 2: Distribution of age among the study participants

Age distribution	F	Percentage
≤20 yrs	15	4.8%
21 – 30 yrs	41	13.2%
30 – 40 yrs	61	19.6%
41 – 50 yrs	66	21.2%
51 – 60 yrs	74	23.8%
>60 yrs	54	17.4%
Total	311	100%

Table 3: The mean age of the participants among the study

Variable	N	Mean ± SD	Min	Max
Age	311	45.41 ± 15.67	1.00	81.00

The mean age of the participants was found to 45.41 ± 15.67 with the minimum age of 1 and maximum of 81. Highest number of patients belongs to the age category of 51- 60 years. 21.20 % of the participants were in the age group of 41-50. Only 4.80 % of the participants were belong to the age group of less than 20.

Table 4: Radiological Findings

Findings	F (n = 311)	Percentage
Accessory left Renal Artery	10	3.2%
Accessory Right Renal Artery	22	7.1%
Bilateral Accessory Renal Artery	27	8.7%
IMA and Median Sacral Common Origin	1	0.3%
Right Hepatic Artery Originating from the superior mesenteric artery	1	0.3%
Normal	229	73.6%
Trifurcation of Celiac Trunk	22	7.1%

Radiological results showed that 73.60% of participants had normal, bilateral accessory renal arteries were found in 8.7% of subjects. Both the trifurcation of the celiac trunk and the accessory right renal artery were seen in 7.1% of subjects. In 3.2% of the participants, an accessory left renal artery was seen. Only 0.3% of subjects showed signs of the right liver artery arising from the superior mesenteric artery.

Table 5: Findings with Gender comparison

Findings	Gender distribution				Total
	Male	Percentage	Female	%	
Accessory left Renal Artery	8	2.6%	1	0.3%	9 (2.9%)
Accessory Right Renal Artery	17	5.5%	5	1.6%	22 (7.1%)
Bilateral Accessory Renal Artery	17	5.5%	10	3.2%	27 (8.7%)
IMA and Median Sacral Common Origin	1	0.3%	0	0.0%	1 (0.3%)
Right Hepatic Artery Originating from the superior mesenteric artery	1	0.3%	0	0.0%	1 (0.3%)
Normal	144	46.3%	85	27.3%	229 (73.6%)
Trifurcation of Celiac Trunk	12	3.9%	10	3.2%	22 (7.1%)
TOTAL	200	64.3%	111	35.7%	311 (100%)
Chi Square test value		6.228	P value	0.398 NS	

The table presents anatomical variations of arteries and structures, differentiated by gender. Out of the 311 individuals in the study, 200 were males and 111 were females. The accessory left renal artery was identified in 2.9% of participants, predominantly in males with 2.6% compared to females at 0.3%. The accessory right renal artery showed a prevalence of 7.1% with males again showing a higher prevalence at 5.5% compared to 1.6% in females. An even more prevalent variation was the bilateral accessory renal artery at 8.7%, where both genders exhibited almost similar proportions, males at 5.5% and females at 3.2%. A rare variation where the IMA (inferior mesenteric artery) and the median sacral artery had a common origin was observed in only 0.3% of participants, and exclusively in males. Similarly, the occurrence of the right hepatic artery originating from the superior mesenteric artery was exclusively seen in males with a 0.3% prevalence. The majority of participants, 73.6%, displayed normal anatomy. Another significant variation was the trifurcation of the celiac trunk observed in 7.1% of the sample, with both genders equally represented. Finally, the statistical analysis using the Chi Square test yielded a value of 6.228 with a corresponding p-value of 0.398, which is not statistically significant (NS), suggesting that the observed anatomical variations are not significantly dependent on gender.

DISCUSSION

The study of anatomical variations in the abdominal aorta and its branches has immense clinical significance, especially in the domains of surgery and radiology. Our investigation provided important insights on several variations of the abdominal aorta, and we compared these findings with other reputable studies from the literature.

Our study exhibited a slight male predominance, with 64.3% males compared to 35.7% females. This is somewhat consistent with a study conducted by Satyapal et al., which documented a majority of male participants, although their study aimed at renal arterial variations [9]. The mean age of our participants was 45.41, similar to the age range observed in many radiological studies concerning abdominal arterial variations.

Among the variations observed, the bilateral accessory renal artery at 8.7% was the most prevalent. This is somewhat in line with the findings of Singh et al., which showed a prevalence of 7% for bilateral accessory renal arteries in their sample population [10]. The trifurcation of the celiac trunk, observed in 7.1% of our participants, is somewhat higher than the 5.2% reported in a study by Sureka et al. [11].

Our findings for the accessory right renal artery, which was observed in 7.1% of our sample and showed a male dominance, differs from the findings of Ozkan et al., which reported a 10% prevalence without a significant gender bias

[12]. The accessory left renal artery prevalence in our study, at 2.9%, was comparable to the 3.2% reported by Anson et al. [13]. One of our rarer observations, where the right hepatic artery emerged from the superior mesenteric artery in 0.3% of males, has also been touched upon by Michels, who found it in 0.5% of their studied population [14].

The comprehensive methodology used, including 128-detector computed tomography, affirms the precision of our results. However, like all studies, regional variations and a demographically limited sample can influence the generalizability of findings.

Interestingly, the non-significant p-value obtained from our Chi-square test indicates that these variations were not heavily gender-dependent, contrasting with the significant gender-based differences found in some anatomical variations by Agur et al. [15].

In summary, recognizing the prevalence and patterns of anatomical variations of the abdominal aorta and its primary branches is pivotal for medical professionals. Diverse population-based research will aid in broadening this understanding.

CONCLUSION

The advancements in medical technology have underscored the need to accurately identify abdominal aortic abnormalities. These variations are pivotal for surgeons and interventional radiologists to recognize, especially in the context of contemporary procedures like robotic/laparoscopic surgeries, organ transplants, oncological resections, and various interventional radiological techniques in the abdominal area. Our study illustrated that Multi-Detector Computed Tomography (MDCT) imaging is invaluable, allowing for prompt and thorough assessment of the abdominal aorta and its branches. This technology, combined with 3D reformatted images from CT angiograms, presents a clear view of the origins and courses of aberrant arteries.

Our study's findings highlighted the significance of these variations in multiple clinical scenarios. For instance, in hepatocellular carcinoma management, variations in the hepatic artery are particularly important for procedures like Transcatheter Arterial Chemoembolization (TACE). In the realm of organ transplantation, kidneys with a single artery are preferred for transplantation due to reduced post-operative complications. Contrarily, our study inadvertently identified individuals with additional renal arteries, rendering them less suitable for donation due to potential delayed graft rejections. This reaffirms the indispensability of pre-operative imaging, especially in renal transplant surgeries, to understand the detailed anatomy and potential variations of the renal artery.

Interestingly, while Digital Subtraction Angiography (DSA) has traditionally been the gold standard for evaluating vascular structures, its invasive nature limits its widespread applicability. The modern preference leans towards MDCT due to its minimally invasive approach and superior image quality. Our comprehensive study encompassed 310 patients undergoing Contrast-Enhanced Computed Tomography (CECT) of the abdomen, revealing that renal artery variations are more commonplace than other aortic abnormalities, emphasizing their clinical significance in decisions like renal donations.

In essence, the ever-evolving landscape of medical technology necessitates a profound understanding of abdominal aortic variations. Such knowledge equips medical professionals to preempt potential complications and make informed decisions, ensuring the highest standard of patient care.

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