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Original Research Article

Overview of Anatomical Variations in the Vasculature of Suprarenal Gland and Its Applied Surgical Importance

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ABSTRACT

Background: The suprarenal gland (SrG) presents a substantial circulatory supply compared to its size. The superior, middle, and inferior suprarenal arteries (SrA) have one or more duplicate major branches, which supply each gland. this study aimed to observe the variable arteries and veins of the SrG. As the vessels of SrG are forming extensive network, they may get damaged during different surgical procedures like adrenalectomy, renal transplant surgeries

Methods: Present study conducted with Twenty five cadavers embalmed in 10% formalin. The inclusion criteria for study were intact blood vessels along with SrGs and the exclusion criteria included the damaged blood vessels and SrGs. Dissection was carried out as per standard dissection protocol.

Results: Origin of right superior suprarenal artery from inferior phrenic artery and superior mesenteric artery, Origin of right superior suprarenal artery from aorta and some other findings were noted.

Conclusions: This study highlights the critical importance of understanding the anatomical variations in the vasculature of the SrG, particularly in the context of surgical interventions such as adrenalectomy and renal transplantation. The intricate and variable nature of the blood supply to the SrG, including the SrA, as well as their venous drainage, presents significant challenges during surgery.

KEY WORDS: Suprarenal Gland, Suprarenal Artery, Suprarenal Vein, Phrenic Vessels.

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INTRODUCTION

The suprarenal gland (SrG) presents a substantial circulatory supply compared to its size. The superior, middle, and inferior suprarenal arteries (SrA) have one or more duplicate major branches, which supply each gland [1]. A deep plexus in the zona reticularis is reached by fenestrated sinusoids passing through a subcapsular plexus formed by them, which increase over the capsule before entering the gland and passing between columns in the zona fasciculata and around clustered glomerulosal cells. Venules exiting this plexus travel between medullary cells of chromaffin and into veins in medulla, which are situated between noticeable smooth muscle fibre bundles. A small number of comparatively large arteries go straight to the medulla instead of this diversion. While the arteries are rarely visible during surgery, the veins need special attention [2,3].

A branch of the abdominal aorta (AA), the inferior phrenic artery (IPA) gives rise to the superior SrA, which is typically small or

non-existent. The AA gives rise to the middle (SrA) laterally near the superior mesenteric artery (SMA). Aorta gradually ascends and passes through the diaphragm's crura before connecting with the renal artery (RA) and the IPA near the SrG. Numerous branches often emerge from the middle SrA of the right side. This artery traverse behind the inferior vena cava (IVC) and in near proximity to the right coeliac ganglion. Similarly, the middle SrA of the left side is located near the splenic artery, left coeliac ganglion, and pancreatic upper border. The inferior SrA arise from branches of the RA, but they primarily originate from the main RA [4,5].

An often solitary suprarenal vein (SrV) is formed when medullary veins emerge from the hilum. Being fairly short, the right vein enters the posterior segment of the IVC straight and horizontally. Occasionally, an accessory vein can be seen running from the hilum superior and medially to the IVC over the right SrV. The shortened path makes right arteries of both sides vulnerable to the damage or possible avulsion from the IVC during surgery if an excessive tension is used, resulting in a hole on the side of the cava side. In order to reach the left coeliac ganglion, the SrV of the left side traverse down medially, anteriorly, and laterally. Draining into the left renal vein, it travels posterior to the pancreatic body. Because each gland typically drains its blood via a single vein, damage to a SrV is more likely to result in gland infraction than damage to one of the SrA [6-8].

Thus, this study aimed to observe the variable arteries and veins of the SrG. As the vessels of SrG are forming extensive network, they may get damaged during different surgical procedures like adrenalectomy, renal transplant surgeries. Due to the location of SrG in close morphological proximity to the IVC, aorta, and its numerous branches, anatomical issues may arise during liver or renal transplant procedures. The accurate identification of the SrG several artery sources is necessary for surgery, as the gland is surrounded by arteries that originate from the AA as well as its branches, and does not have an arterial hiatus of its own. It is important to take into account that the branches of the AA that supply

the gland should be avoided for any potential injury during the surgical procedures [9].

METHODS

Twenty five cadavers embalmed in 10% formalin were procured. The inclusion criteria for study were intact blood vessels along with SrGs and the exclusion criteria included the damaged blood vessels and SrGs. Dissection was carried out as per steps given in Cunningham dissecting manual [10].

As dissection of abdominal cavity was already done by undergraduate students, skin was reflected and anterior abdominal wall was removed and parts of gastro-intestinal tract in front of kidneys and SrGs were removed. During further dissection, arteries as well as veins were identified and traced of the SrG. All the variations in the blood vessels of SrG were noted down and photographs were taken.

RESULTS

After dissecting 50 SrGs, following variations were found in the vascular pattern. Both the left and right sides presented distinct patterns which are as follows.

4(8%) cases demonstrated that the superior phrenic artery was the origin for the right superior SrA. However, 4 (8%) cases presented that the SMA was the origin to the right sided superior SrA (figure 1).

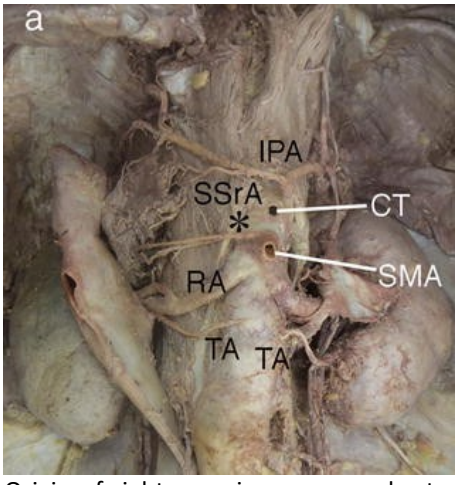

Fig. 1: Origin of right superior suprarenal artery from inferior phrenic artery and superior mesenteric artery. **Legends:** IPA-inferior phrenic artery, CT-common trunk, SMA-superior mesenteric artery, TA-testicular artery, RA-renal artery, SSrA-superior suprarenal artery.

'Also, the superior SrA of the right side was arising from aorta and found in 6 (12%) cases (figure 2).

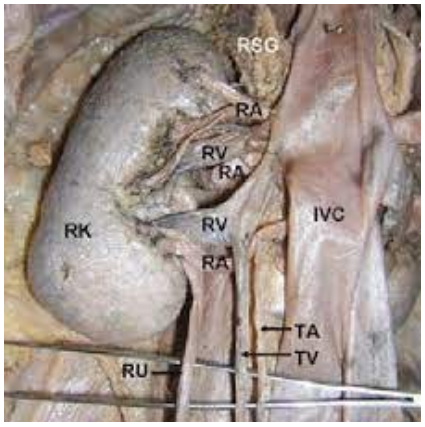

Fig. 2: Origin of right superior suprarenal artery from aorta.
Legends: RSG-right suprarenal gland, RA-renal artery, RV-renal vein, IVC-inferior vena cava, RK-right kidney, TA-testicular artery, TV-testicular vein, RU-right ureter

In 4 (8%) cases, the aorta served as origin for the left superior SrA. Right superior SrA was found to be originating from the ARA in 4 (8%) cases (figure 3)

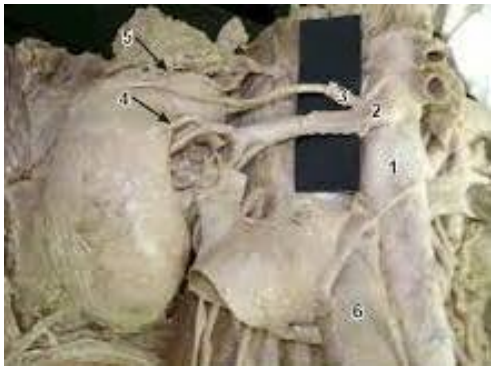

Fig. 3: Origin of right superior suprarenal artery from the accessory renal artery.

Legends: 1-abdominal aorta,2-renal artery,3-accessory renal artery,4-branch of accessory renal artery for upper pole, 5- superior suprarenal artery,6-inferior vena cava.

Middle SrA was absent in 5 (10%) cases, however, it was originating from ARA in 6 (12%) cases and from IPA in 2 (4%) cases (figure 4)

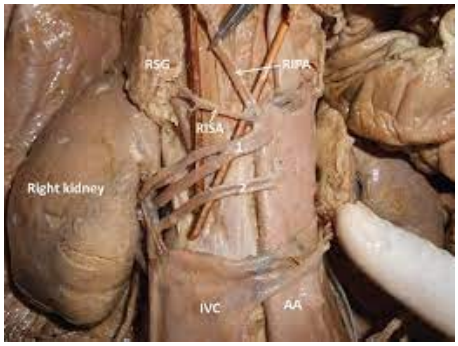

Fig. 4: Origins of the middle suprarenal artery.
Legends: RIPA-right inferior phrenic artery, RMSA-right middle suprarenal artery, RSG-right suprarenal gland, IVC-inferior vena cava, AA-abdominal aorta.

The left inferior SrA and the left testicular arteries presented a common trunk in 8(16%) cases (figure 5)

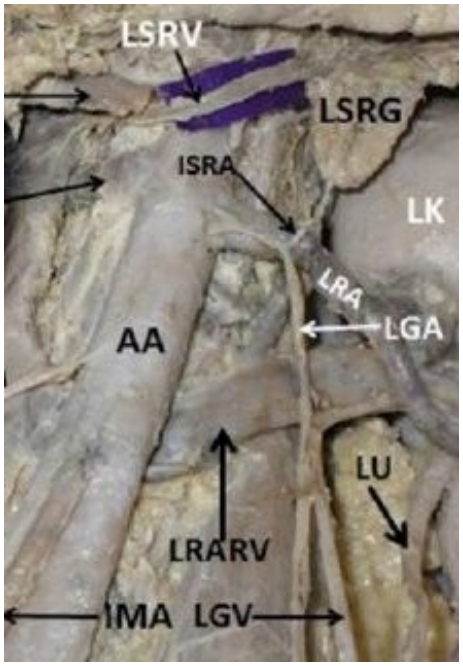

Fig. 5: Origins of inferior suprarenal artery.
Legends: LRA-left renal artery, LGA-left gonadal artery, ISRA-inferior suprarenal artery, LSRG-left suprarenal gland, LU-left ureter, LRARV-left renal artery renal vein , MA-inferior mesenteric artery, LGV-left gonadal vein, AA-abdominal aorta, LSRV-left suprarenal vein.

The AA was the origin of the inferior SrA of the right side in 5(10%) cases and from the aorta in 2(4%) cases. Left inferior SrA was arising from aorta in 4 (8%) cases. In 4(8%) cases, the inferior SrA was arising from the ARA.

DISCUSSION

Vascular variations in the SrGs are a significant concern during surgical interventions such as adrenalectomy, renal transplantation, and vascular surgeries involving the aorta or RA. Detailed knowledge of the blood supply and variations in the blood vessels would present a stable foundation for the specified angiographic technological advances as well as for surgical approach

M. Venkateshwara Reddy et al [11] classified the arteries into four categories that supply the SrG. The IPA on the left side and the superior along with the middle SrA on the right side arose from 35 of the 36 cases (97%) of all three types. Hebel and Stromberg [12] reported the AA as the origin for the superior SrA, however, in the current study, similar

variance was reported in six cases. The middle SrA was characterised as originating from either the AA or the IPA. In one-third of the cases analysed, the inferior SrA emerged from either the IPA, the RA, or the AA. Instead of the IPA, which is located to the extreme left of the caudal segment of the SrG, the inferior SrA may have its origin in a neighbouring artery, such as the RA or AA. This could account for the more frequent alterations in the left SrA pattern compared to the right. The present study highlights anatomical distinctions in the SrA, such as changes in origin, number, as well as distinctive properties of right and left sides. These variations are highly instructive for various surgical and radiological techniques.

According to Sushma R. et al. [13], the SrG exhibits diversity in the origin and position of its arterial supply as well as complexity in its blood supply. Aortic lateral splanchnic branches produce the rete arteriosum urogenitale supplying blood to the kidneys, gonads, and SrGs. The left gastric artery and SMA are the additional sources of the origin of arteries to the SrG. Usually, the Inferior Phernic Artery (IPA), which serves as a branch of the AA, originates the superior SrA.

Toni et al. [14] noted that the middle SrA on the right side was a branch of the AA in 91% of instances or from the coeliac trunk in 4% of cases. It originated from the IPA in 3% of patients and from the RA in 2% of cases, which was an unusual pattern. In 99% of cases on the left side, it originated from the AA, while in 1% of cases from the coeliac trunk. The inferior SrA originated from the RA in the majority of cases, although it was also infrequently formed from the coeliac trunk, the AA, and the ARA.

Bordei et al [15] reported three inferior SrAs in 6.6% of the total cases. According to Rossi et al (16), the arteriograms of the inferior SrA are significant in the explanation of SrG tumours. However, the SrG arteriography is more challenging due to its the concept of complicity, dimensions, and uncertainty.

K Naga Vidya Lakshmi et al [17] in their study observed 60% variations in arterial supply and venous drainage was 0% in adults. The current work is centred around with the origin, route, number, and site of entry of branches into the suprarenal gland. Supernumerary arteries are approximately twice as prevalent as supernumerary veins, which often develop at the renal level. The persistence of some of the mesonephric arteries accounts for the variability of origin of the adult segmental arteries from the aorta [18]. An inferior SrA can occasionally be supplied by a branch of the testicular artery. The current investigation showed no evidence of such variance. Often, the gonadal or ureteric arteries deliver one or more twigs to the gland. ARAs can give rise to inferior SrA.

Merklin and Michel [19] investigations have established that the superior SrA originates straight from the aorta, coeliac trunk, and superior polar artery. According to Merklin and Michels, the inferior SrA could emerge from the aorta just below or above the origin of the RA. The inferior SrA can emerge from either the external RA or the aorta.

The intricate structure of the vascular supply to the SrGs was emphasised for clinical implication by Priya et al. [20]. The study reported that the inferior SrA to shown variations more commonly followed by the middle SrA with the least distinction in superior SrA. Kumar et al. [21] reported that the inferior SrA possess numerous variations in its origin. In some cases, it arose from an ARA, particularly in individuals with RA duplication.

Gagnon et al. [22] conducted a review describing the embryological origins of SrA and their relationships. The findings highlighted that the superior SrA originates from the proximal section of the IPA, whereas the middle SrA originates from the superior polar artery. The middle SRA is often solitary in origin. This study also provided developmental perspective, explaining the embryological remains contributing to the substantial heterogeneity observed in adrenal vasculature in the adult population.

Cunningham [10] found that the middle SrA is missing in some individuals. It is also lacking in five of the cases in current study. The anteromedial surface of the gland receives blood from the middle SrA, which is often a single branch. It can sometimes originate from

the first segment of the kidney or the proximal segment of the IPA. In other cases, the artery is duplicated however, in some cases, it is absent. At the level of the SrG and kidney, supernumerary veins are equally prevalent as supernumerary arteries due to the development of subcardinal, supracardinal, and azygos venous lines and their interactions with the posterior cardinal vein and each other. As a result, variations emerge as embryonic vasculature survive and regress. The SrG is drained by a single, large central vein that emerges through the hilus. The left side of the vein receives the inferior phrenic vein (IPV) before entering the left renal vein behind the pancreas, while the right side joins the IVC after a relatively short course. This description is also consistent with the description provided in Gray's Anatomy 2005 [8]. The solitary central vein that emerges via the hilus is described in the Anatomy for Surgeons by Hollinshed [23]. The IVC, the junction of IVC and the right renal vein, and infrequently the right renal vein itself are the sites where the right vein goes medially to open. The left vein descends and unites with the IPV and becomes accessible to the left renal vein.

CONCLUSION

This study highlights the critical importance of understanding the anatomical variations in the vasculature of the SrG, particularly in the context of surgical interventions such as adrenalectomy and renal transplantation. The intricate and variable nature of the blood supply to the SrG, including the SrA, as well as their venous drainage, presents significant challenges during surgery. These anatomical variations, especially the unpredictable origin and branching patterns of the arteries, must be thoroughly understood to prevent intraoperative complications such as haemorrhage, vascular injury, and suprarenal infarction.

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ABBREVIATIONS

SrG- Suprarenal Gland
SrA- Suprarenal Artery
IVC- Inferior Vena Cava
IPV- Inferior Phrenic Vein
IPA- Inferior Phrenic Artery
ARA- Accessory Renal Artery
RA- Renal Artery
AA- Abdominal Aorta

Author Contributions

Both the authors have made substantial contributions to conception and design, acquisition of data, analysis and interpretation of data. Both were involved in drafting the manuscript or revising it critically for important intellectual content. Both have given final approval of the version to be published.

Conflicts of Interests: None

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