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Anatomical Investigation of the Vascular Supply of the Suprarenal Glands in Fetuses

Investigación Anatómica del Suministro Vascular de las Glándulas Suprarrenales en los Fetos

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SUMMARY: The suprarenal glands are bilaterally supplied by three suprarenal arteries and drained by a single suprarenal vein. Variable vascular origins of the fetal suprarenal gland have been documented in different population groups viz. Indian, Polish and Argentinian. However, there is lack of a detailed description regarding the course, relations, number of branches and vertebral levels of the origins of the vasculature of the suprarenal glands in fetuses. This study aimed to identify and document the vascular supply of the suprarenal glands in fetuses in a South African setting. Fifty fetal specimens (26 males; 24 females) with a gestational age ranging between 12 and 20 weeks, were bilaterally micro-dissected (n=100) using a Zeiss Stemi DV4 microscope. Data was recorded and the frequencies of the origin, course, relations, number of branches and vertebral levels of the suprarenal vascular supply were determined. Arterial supply: Origin: (i) The superior suprarenal artery (SSA) bilaterally arose from the inferior phrenic arteries in 98 % of the fetuses; (ii) the middle suprarenal artery (MSA) frequently arose from the renal artery (RA) on the right side (46 %) and the abdominal aorta on the left side (34 %); while (iii) the inferior suprarenal artery (ISA) predominantly arose from the RA in 91 % of the specimens, bilaterally. Course and relations: The suprarenal arteries followed a superior, inferior, lateral, supero-lateral and infero-lateral course to the gland. These arteries were closely related to the crura of the diaphragm, the inferior vena cava, the left inferior phrenic vein and the pancreas. Number of branches: The branches ranged from one to seven for the SSA, one to four for the MSA and one to three for the ISA. Vertebral levels: The SSA predominantly arose from the first lumbar (L1) vertebral body (32 %), the MSA arose from the middle third of the intervertebral disc between the L1 and the second lumbar (L2) vertebrae (19 %) and the ISA arose from the L2 vertebral body (28 %). Venous drainage: In 1 % of the specimens, an additional right suprarenal vein (ARSV) was observed. This ARSV followed a supero-medial course into the inferior vena cava, just below the entrance of the main right suprarenal vein. The arteries supplying the suprarenal gland presented varying origins and number of branches, corroborating with the reviewed literature and standard anatomical textbooks. The findings of this study may aid pediatric surgeons in understanding the vascular morphology (and the variations thereof) of the suprarenal gland, when performing adrenelectomy surgery in neonates.

KEY WORDS: Suprarenal gland; Artery; Vein; Fetus; Variations.

INTRODUCTION

The vascular architecture of the suprarenal glands includes three suprarenal arteries and a single suprarenal vein on each side (Moore *et al*., 2014). An extensive description of the origin of the suprarenal vasculature, as well as the abundant variability among these vessels has been documented in adults (Manso & DiDio, 2000; Bordei *et al*., 2003; Dutta, 2010; Reddy *et al*., 2014). However, there is limited literature on the suprarenal vasculature in fetuses (Merklin, 1962; Bianchi & Ferrari, 1991; Pitynski *et al*., 1998). Although Bianchi & Ferrari and Pitynski *et al*. described the origin and variations of the suprarenal vasculature in fetal specimens, there is a paucity of literature in relation to the course, relations, number of branches and the vertebral levels. In addition, the literature reviewed documented that there are fetal variations amongst different population groups, viz. Indian, Polish and Argentinian (Bianchi & Ferrari; Pitynski *et al*.; Reddy *et al*.). It is apparent that such studies in a South African setting have not been undertaken.

The superior suprarenal artery (SSA) originated from the inferior phrenic artery (IPA), while the celiac trunk (CT) and abdominal aorta (AA) may also present a few SSA in fetuses (Bianchi & Ferrari; Reddy *et al*.). The IPA, CT and

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AA were also common origins for the middle suprarenal artery (MSA) in fetuses (Bianchi & Ferrari; Pitynski *et al*.). The inferior suprarenal artery (ISA) arose predominantly from the renal artery (RA), however variable origins of the ISA also included the gonadal artery (GO); the superior polar renal artery (SPRA) and the aorto-renal area in fetal specimens (Bianchi & Ferrari; Pitynski *et al*.; Ahmed *et al*., 2015).

Standring (2016) described the right suprarenal vein (RSV) draining into the postero-lateral aspect of the inferior vena cava (IVC), while the longer, left suprarenal vein (LSV) drained into the left renal vein (LRV) in adult cadavers. Pitynski *et al*. stated that the fetal suprarenal veins were single vessels with no variations. Additionally, it is evident that there is an incomplete description of the course and relations of the venous vasculature of the suprarenal glands in fetuses.

A lack of detailed description of the vertebral levels of the fetal suprarenal arteries also exists. Therefore, this study documented the vascular supply of the suprarenal glands in fetuses according to the origin, course, relations, number of branches and the vertebral levels.

MATERIAL AND METHOD

Fifty fetuses (males: 26; females: 24) (n=100) were obtained from the Clinical Anatomy, University of KwaZulu-Natal (Westville Campus). Ethical Clearance was obtained from the University's Biomedical Research Ethics Committee (No: BE 390/15). Gestational ages (12 to 20 weeks) were determined as per Pandey *et al*. (2016) method. All specimens were bilaterally micro-dissected to expose the vascular supply of the suprarenal glands utilizing a standard Carl Zeiss Stemi DV4 stereo-microscope. Micro-photographs were taken with a Zeiss Axio Vision ICc3 microscopic camera. The intervertebral (IV) discs of the vertebral column were divided into upper, middle and lower third divisions, while the vertebral bodies also acted as vertebral levels, since the growth of the IV discs exceeds the growth of the vertebral bodies in fetuses (Taylor, 1974).

RESULTS

A] Arterial supply

I) The superior suprarenal artery (SSA)

The SSA was present in 98 % (98/100) and absent in 2 % (2/100) of the fetal specimens.

Origin. The SSA arose from the ipsilateral IPA in 98 % (98/100) [right: 98 % (49/50); left: 98 % (49/50)] of the fetal specimens (Fig. 1).

Course and relations. The numerous, small SSA branches pierced through retroperitoneal fat towards the suprarenal glands, following an infero-laterally and inferiorly course towards the anterior and posterior surfaces of the superior aspect of the suprarenal glands in 98 % (98/100) of the specimens, bilaterally. The SSA was related to the following structures: (a) antero-inferiorly to the crura of the diaphragm in 86 % (43/50) on the right and in 92 % (46/50) on the left side; (b) posterior to the RSV and the liver in 12 % (6/50) on the right side only; and (c) posterior to the head of the pancreas and the duodenum in 6 % (3/50) on the left side.

Number of branches. The SSA presented as single branches, as it emerged from the IPA in its course towards the diaphragm. Therefore, these SSA branches always continued as singular vessels towards the medial, anterior, posterior and lateral aspects of the superior surfaces of the suprarenal glands in 98 % (98/100) of the specimens. Furthermore, the SSA arose from the IPA and branched into one to seven arteries in the fetal specimens. The SSA presented as: (a) one branch in 15 % (15/100) of the specimens; (b) two branches in 28 % (28/100) of the fetuses; (c) three branches in 24 % (24/100) of the specimens; (d) four branches in 18 % (18/100) of the specimens; (e) five SSA branches in 9 % (9/100) of the specimens; (f) six branches in 2 % (2/100) of the fetuses; and (g) seven branches in 2 % (2/100) of the specimens.

Vertebral levels. The vertebral levels of the first SSA branching from the IPA were located at the following levels in all specimens (Fig. 2): (a) first lumbar (L1) vertebral body in 32 % (32/100); (b) lower one-third IV disc between the twelfth thoracic (T12) and the L1 vertebrae in 24 % (24/100); (c) T12 vertebral body in 17 % (17/100); (d) middle one-third of the T12-L1 IV disc in 12 % (12/100); (e) upper one-third of the IV disc between the L1 and second lumbar (L2) vertebrae in 7 % (7/100); (f) upper one-third of the T12-L1 disc in 4 % (4/100); and (g) lower one-third of the L1-L2 IV disc in 2 % (2/100).

II) The middle suprarenal artery (MSA)

The MSA was present in 80 % (40/50) and 60 % (30/50) of the specimens on the right and left sides, respectively. The MSA was absent in 20 % (10/50) on the right side and in 40 % (20/50) on the left side of the specimens.

Origin. On the right side, the MSA arose from: (a) the AA in 18 % (9/50); (b) the right RA in 46 % (23/50); and (c) the

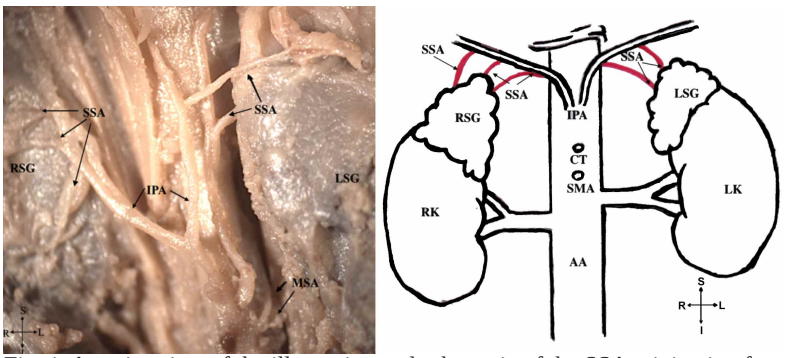

Fig. 1. Anterior view of the illustration and schematic of the SSA originating from the IPA, bilaterally. AA – abdominal aorta, CT – celiac trunk, I – inferior, IPA – inferior phrenic artery, L – left, LK – left kidney, LSG – left suprarenal gland, MSA – middle suprarenal artery, R – right, RK – right kidney, RSG – right suprarenal gland, S – superior, SSA – superior suprarenal artery, SMA – superior mesenteric artery.

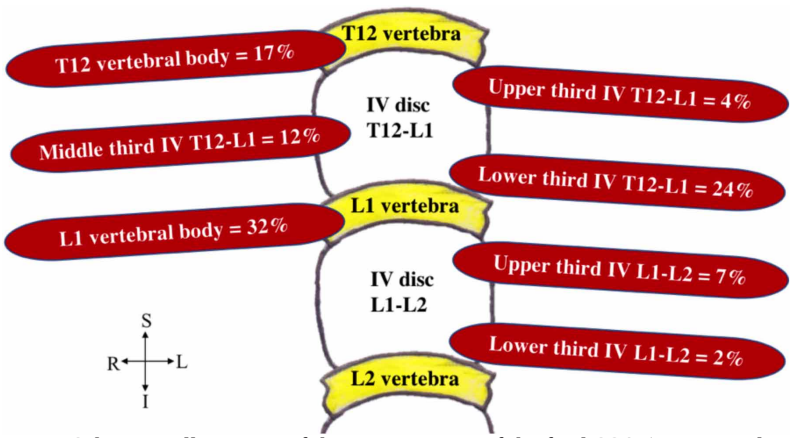

Fig. 2. Schematic illustration of the anterior view of the fetal SSA (represented as red rounded rectangles) and frequencies of their respective vertebral levels. I – inferior, IV – intervertebral, L – left, L1 – first lumbar, L2 – second lumbar, R – right, S – superior, T12 – twelve thoracic.

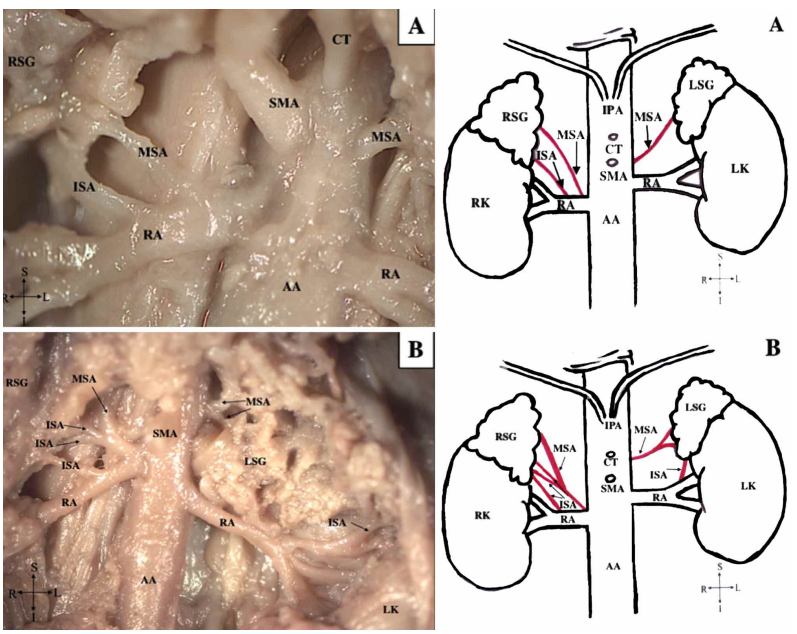

Fig. 3. Anterior view of the illustration and schematic of the MSA arising from the RA on the right side and from the AA on the left side (A); Anterior view of the illustration and schematic of the MSA and ISA sharing a trunk from the aorto-renal area on the right side, and double MSA arising from the AA on the left side (B). AA – abdominal aorta, CT – celiac trunk, I – inferior, IPA – inferior phrenic artery, ISA – inferior suprarenal artery, L – left, LK – left kidney, LSG – left suprarenal gland, MSA – middle suprarenal artery, R – right, RA – renal artery, RK – right kidney, RSG – right suprarenal gland, S – superior, SMA – superior mesenteric artery.

aorto-renal area in 16 % (8/50) in all specimens, respectively. On the left side, the MSA arose from: (a) the AA in 34 % (17/50); (b) the left RA in 16 % (8/50); and (c) the aorto-renal area in 10 % (5/50) in all specimens, respectively (Fig. 3).

Course and relations. The course of the MSA was: (a) supero-lateral from the AA and the aorto-renal area to the medial aspect of the gland in 46 % (23/50) and 35 % (17/50) on the right and left sides, respectively; (b) lateral from the AA to the anterior and posterior surfaces of the medial aspect of the gland in 16 % (8/50) on the right side and 10 % (5/50) on the left side of the specimens; (c) a superior course from the RA to the infero-medial aspect of the gland in 16 % (8/50) and 10 % (5/50) on the right and left sides of the specimens, respectively; and (d) infero-lateral course from the AA to the infero-medial aspect of the gland in 2 % (1/50) on the right side and 6 % (3/50) on the left side in all specimens. The MSA was related to the following structures: (a) posterior to the IVC in 80 % (40/50) of the specimens on the right side; (b) posterior to the pancreas and the left inferior phrenic vein (IPV) in 60 % (30/50) of the specimens on the left side.

Number of branches. The MSA presented as: (a) single branches in 46 % (46/100) of the specimens; (b) double branches in 18 % (18/100) of the fetuses; (c) triple branches in 4 % (4/100) of the specimens; and (d) quadruple branches in 2 % (2/100) of the specimens (Fig. 4).

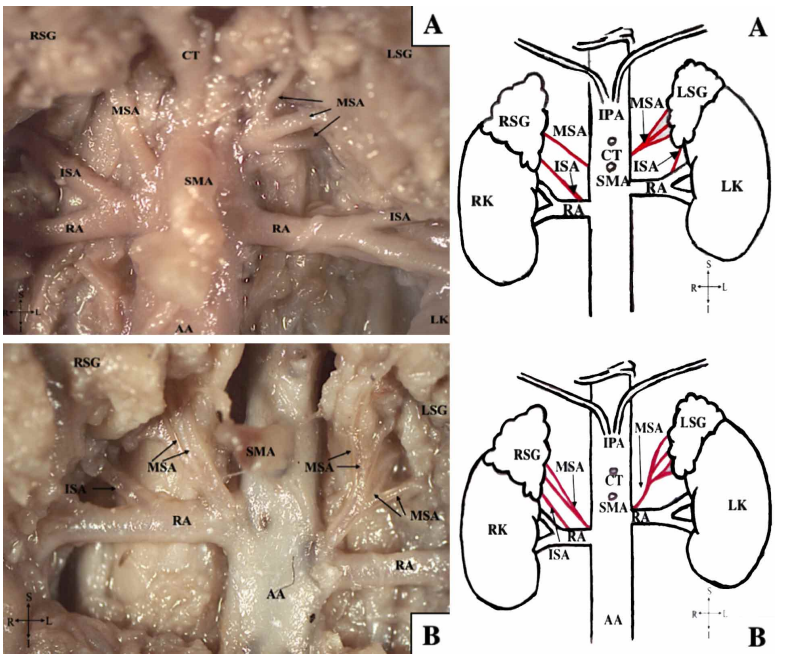

Fig. 4. Anterior view of the illustration and schematic of the single and triple MSA branches from the AA (A); Double and quadruple MSA branches from the RA and aorto-renal area, respectively (B) AA – abdominal aorta, CT – celiac trunk, I – inferior, IPA – inferior phrenic artery, ISA - inferior suprarenal artery, L – left, LK – left kidney, LSG – left suprarenal gland, MSA – middle suprarenal artery, R – right, RA – renal artery, RK – right kidney, RSG – right suprarenal gland, S – superior, SMA – superior mesenteric artery.

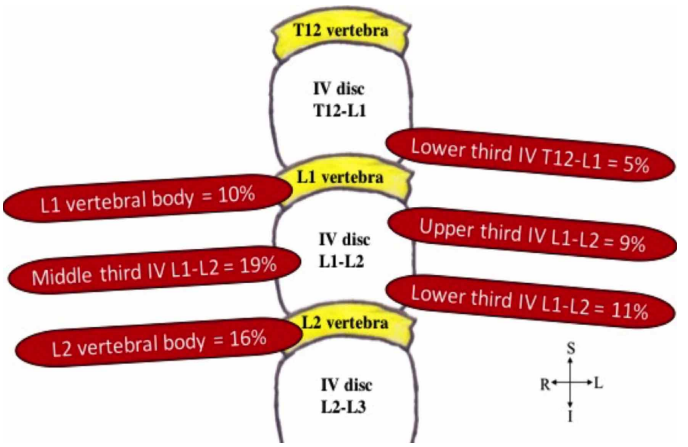

Fig. 5. Schematic illustration of the anterior view of the fetal MSA (represented as red rounded rectangles) and frequencies of their respective vertebral levels. I – inferior, IV – intervertebral, L – left, L1 – first lumbar, L2 – second lumbar, L3 – third lumbar, R – right, S – superior, T12 – twelfth thoracic.

Vertebral levels. The origin of the MSA was located at different vertebral levels in all specimens (Fig. 5) viz. (a) the middle one-third of the L1-L2 IV disc in 19 % (19/100); (b) the L2 vertebral body in 16 % (16/100); (c) the lower one-third of the L1-L2 IV disc in 11 % (11/100); (d) the L1 vertebral body in 10 % (10/100); (e) the upper one-third of L1-L2 IV disc in 9 % (9/100); and (f) the lower one-third of the T12-L1 IV disc in 5 % (5/100) of the fetuses, respectively.

III) The inferior suprarenal artery (ISA). The ISA was present in 100 % (50/50) of the fetuses, bilaterally.

Origin. On the right side, the ISA originated from: (a) the right RA in 90 % (45/50) of the specimens; (b) the AA in 4 % (2/50) of the specimens; and (c) the aorto-renal area in 6 % (3/50) of the specimens. On the left side, the ISA arose from: (a) the left RA in 92 % (46/50) of the fetuses; (b) the AA in 2 % (1/50) of the fetuses; (c) an additional renal artery (ARA) in one fetal specimen (2 %, 1/50); and (d) the aorto-renal area in 4 % (2/50) of the fetuses (Fig. 6).

Course and relations. The ISA had varying courses: (a) supero-lateral from the RA, the AA and the aorto-renal area to the suprarenal gland in 88 % (44/50) on the right and 90 % (45/50) on the left sides in the specimens; (b) an infero-lateral direction from the AA to the inferior aspect of the gland in 2 % (1/50) solely on the right side; (c) ascended superiorly from the RA and the ARA to the suprarenal gland in 8 % (4/50) on the right and in 8 % (4/50) on the left side of the specimens; and (d) turned lateral to the suprarenal glands from the AA in 2 % (1/50) on the right side and in 2 % (1/50) on the left side of the specimens, respectively. In addition, the relations of the ISA were: (a) posterior to the IVC in 100 % (50/50) of the specimens on the right side; (b) posterior to the neck of the pancreas in 100 % (50/50) of the specimens on the left side; (c) the left ISA was also postero-medial to the IPV in 92 % (46/50) of the specimens; and (d) the left ISA was also postero-lateral to the IPV in 8 % (4/50) of the specimens.

Number of branches. The number of ISA branches recorded were: (a) single in 84 % (84/100); (b) double in 14 % (14/100); (c) triple in 2 % (2/100) of the specimens, respectively (Fig. 7).

Vertebral levels. The vertebral levels of the ISA were documented as: (a) the L2 vertebral body in 28 % (28/100); (b) the middle one-third of the L1-L2 IV disc in 24 % (24/100); (c) the lower one-third of the L1-L2 IV disc in 19 % (19/100); (d) the upper one-third of the L1-L2 IV disc in 15 % (15/100); (e) the L1 vertebral body in 12 % (12/100); and (f) the

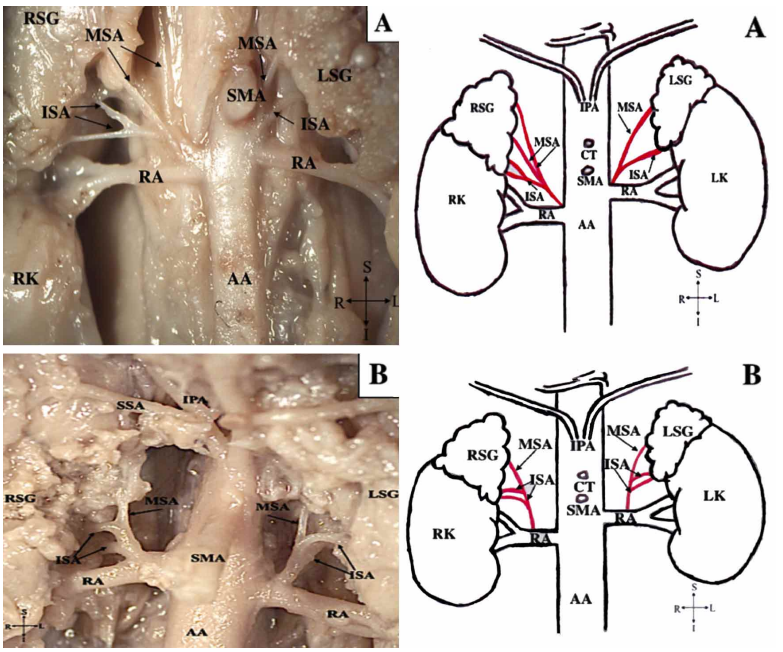

Fig. 6. Anterior view of the illustration and schematic of the ISA sharing a trunk with the MSA from the aorto-renal area, bilaterally (A); Anterior view of the illustration and schematic of the ISA sharing a trunk with the MSA from the RA, bilaterally (B). AA – abdominal aorta, CT – celiac trunk, I – inferior, IPA – inferior phrenic artery, ISA - inferior suprarenal artery, L – left, LK – left kidney, LSG – left suprarenal gland, MSA – middle suprarenal artery, R – right, RA – renal artery, RK – right kidney, RSG – right suprarenal gland, S – superior, SMA – superior mesenteric artery, SSA – superior suprarenal artery.

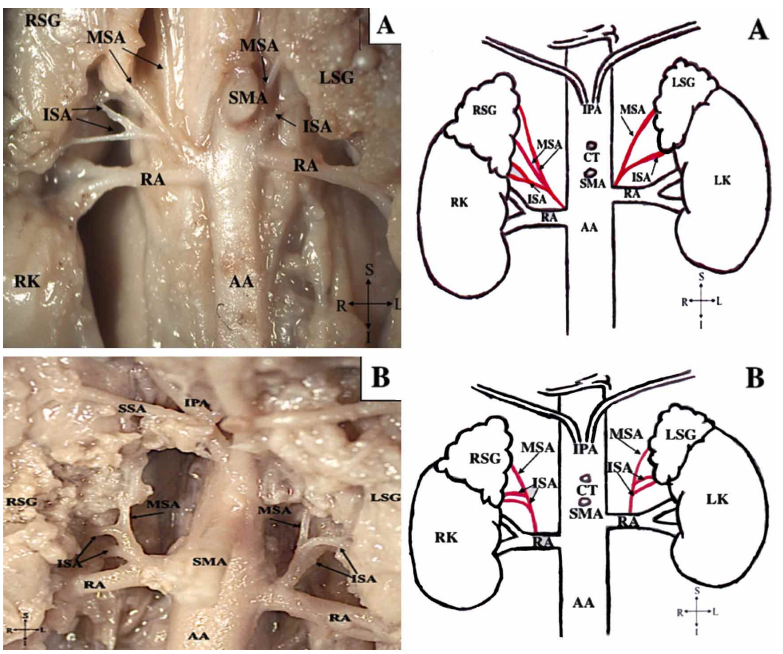

Fig. 7. Anterior view of the illustration and schematic of double ISA from the RA on the right side and single ISA from the RA on the left side (A); Anterior view of the illustration and schematic of single ISA arising from the AA on the right side and triplicated ISA from the RA on the left side (B). AA – abdominal aorta; CT – celiac trunk, I – inferior; IPA – inferior phrenic artery, ISA – inferior suprarenal artery; L – left; LK – left kidney, LSG – left suprarenal gland; MSA – middle suprarenal artery; R – right; RA – renal artery; RK – right kidney, RSG – right suprarenal gland, S – superior; SMA – superior mesenteric artery.

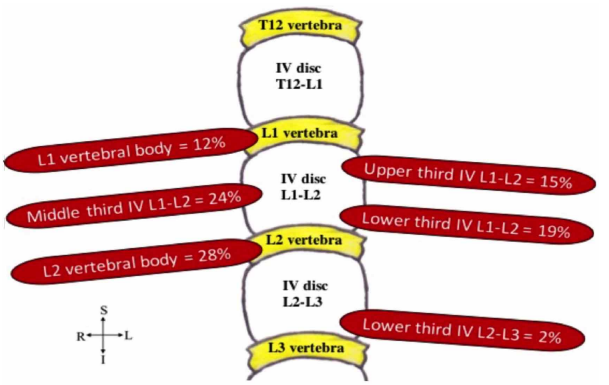

Fig. 8. Schematic illustration of the anterior view of the fetal ISA (represented as red rounded rectangles) and frequencies of their respective vertebral levels. I – inferior, IV – intervertebral, L – left, L1 – first lumbar, L2 – second lumbar, L3 – third lumbar, R – right, S – superior, T12 – twelfth thoracic.

lower one-third of the IV disc between L2 and third lumbar (L3) in 2 % (2/100) of the specimens, respectively (Fig. 8).

B] Venous drainage: The suprarenal veins. The RSV and the LSV were present in all the fetal specimens. The RSV drained into the IVC in 100 % (50/50) of the fetal specimens, while the LSV drained into the LRV in 100 % (50/50) of the specimens.

Course and relations. The course of the RSV was: (a) postero-medial from the central aspect of the gland to the IVC in 78 % (39/50) of the fetuses; (b) an antero-medial course from the central aspect of the gland in 16 % (8/50) of the fetuses; and (c) a medial course from the middle aspect of the gland in 6 % (3/50) of the fetuses. The course of the LSV was: (a) infero-medial towards the LRV in in 94 % (47/50) of the fetuses; and (b) inferior direction into the LRV in 6 % (3/50) of the fetal specimens. A single RSV was present in 98 % (49/50) of the fetuses. However, in one specimen (2 %, 1/50) an additional right suprarenal vein (ARSV) was observed. This vessel followed a supero-medial course to enter the IVC from a posterior aspect, just below the entrance of the main RSV. A single LSV was present in 100 % (50/50) of the specimens. The relations of the suprarenal veins were: (a) medial to the IVC on the right side in 100 % (50/50) of the specimens; (b) lateral to the left inferior phrenic vein (IPV) on the left side in 84 % (42/50) of the specimens; and (c) lateral to the AA, with an absent IPV on the left side, in 16 % (8/50) of the specimens.

DISCUSSION

The arteries supplying the suprarenal gland had varying origins. The suprarenal arteries were divided into superior, middle and inferior branches, based on the criteria reported in previous literature (Anson & Cauldwell, 1940; Gagnon, 1956; Pitynski *et al*.; Standring). The main source of the SSA, MSA and ISA was the IPA, AA and RA, respectively. The origin and number of branches of the SSA, MSA and ISA were compared with previously reported literature on the fetuses.

The superior suprarenal arteries

Origin, course and relations. The origins of the SSA was the ipsilateral IPA. This was similar to reports made by other authors who reported the IPA as the main origin of the SSA, above 90 % of the fetuses on the right side and above 80 % of the fetal on the left side (Bianchi & Ferrari; Pitynski *et al*.). However, this study differed with the same authors as they reported the AA and the CT as additional sources of the SSA, which was not documented in the present study (Bianchi & Ferrari; Pitynski *et al*.).

Table I. Summary of the reviewed literature of the fetal superior suprarenal arteries in fetuses.

Author	Sample Size	Population Group	RSSA	RSSA branches	LSSA	LSSA branches
Bianchi and Ferrari (1991)	50 Fetuses (n=100)	Argentinian	IPA – 100%	-	IPA – 96% CT – 4%	-
Pitynski *et al.* (1998)	40 Fetuses (n=80)	Polish	Ipsilateral IPA – 92.5% Ipsilateral IPA + opposite IPA – 7/5%	One: 10% Two: 5% Three: 5 % Four: 12.5% Five: 20% Six to ten: 25% Eleven to thirteen: 12.5% Fourteen to seventeen: 10%	Ipsilateral IPA – 82.5% Ipsilateral IPA + opposite IPA - 12.5% IPA + AA – 5%	One: 7.5% Two: 7.5% Three: 12% Four: 10% Five: 15% Six to ten: 17.5% Eleven to thirteen: 10% Fourteen to seventeen: 12.5% Eighteen to twenty-two: 7.5%
PRESENT STUDY	50 Fetuses (n = 100)	South African	Ipsilateral IPA – 98% Absent – 2%	One: 16% Two: 32% Three: 20% Four: 20% Five: 8% Seven: 2% Absent: 2%	Ipsilateral IPA – 98% Absent – 2%	One: 14% Two: 24% Three: 28% Four: 16% Five: 10% Six: 4% Seven: 2% Absent: 2%

AA – abdominal aorta, CT – celiac trunk, IPA – inferior phrenic artery. LSSA – left superior suprarenal artery, RSSA – right superior suprarenal artery.

The SSA in the present study followed an inferolateral or inferior course towards the superior surface of the gland. According to Pitynski *et al*., the SSA are the arteries that reach the anterior and posterior surfaces of the superior aspect of the gland; however, the course or related structures were not described entirely.

The variations of the SSA in the present study included the absence of the SSA in two fetuses, which has not previously been documented in the literature.

Number of branches. The branches of the SSA ranged from one to seven branches, bilaterally. However, this did not corroborate with other fetal studies (Table I).

Vertebral levels. The first SSA branching from the IPA were predominantly found at the level of the vertebral body of the L1 vertebra in the fetuses.

II) The middle suprarenal arteries

Origin, course and relations. The origins of the MSA documented in this study corroborated with the findings reported by previous authors (Bianchi & Ferrari; Pitynski *et al*.). They reported the MSA to branch from the AA or the RA. Furthermore, Bianchi & Ferrari and Pitynski *et al*. reported that the MSA also arose from the CT, the IPA, the SSA and the left gastric artery (LGA); however, this was not observed in the present study. Pitynski *et al*. reported that MSA coursed in the direction of the anterior groove of the suprarenal gland and towards the suprarenal vein in this area in all fetal specimens. This was also observed in the present study, where the MSA coursed towards the middle portion of the gland to supply the anterior and posterior parts of the middle and medial aspects of the gland. The MSA was closely related posteriorly to the IVC, the LRV and left IPV. However, the relations have not been described in detail in the literature reviewed.

Variations of the MSA in the present study included: (a) a higher incidence of the MSA origin from the RA (31 %); (b) the absence of MSA (30 %) overall; and (c) MSA arose from the aorto-renal area. This was compared to the fetal study conducted by Pitynski *et al*., who reported only 12 % of the MSA originating from the RA and no absent MSA in their study. Reddy *et al*. also reported the MSA branching from the area between the AA and the RA.

Number of branches. The number of branches of the MSA were found to range between single and quadruple branches in the present study (Table II). This finding corroborated with the findings by Bianchi & Ferrari, who reported that in fifty fresh fetuses, the MSA was predominantly a single branch. This study also agreed with the study conducted by Pitynski *et al*. who found a variable quadruple MSA branch entering the glands. In the cases where the MSA were absent, the SSA and the ISA replaced the function of the MSA (Gagnon; Merklin; Bergman *et al*., 2006). This was also observed in the present study, since the ISA presented multiple branches when the MSA was absent.

Table II. Summary of the reviewed literature of the middle suprarenal arteries in fetuses.

Author	Sample Size	Population Group	RMSA	RMSA branches	LMSA	LMSA branches
Bianchi and Ferrari (1991)	50 Fetuses (n=100)	Argentinian	AA – 68% IPA – 32%	One: 48% Two: 29% Three: 18%	AA – 68% IPA – 20% CT – 12%	One: 53% Two: 29% Three: 18%
Pitynski *et al.* (1998)	40 Fetuses (n=80)	Polish	AA – 32.5% IPA – 27.5% IPA + AA – 15% RA – 17.5 % LGA – 7.5% Absent 0%	One: 57.5% Two: 35% Three: 7.5% Absent: 0%	AA – 47.5% IPA – 17.5% IPA + AA – 22.5% AA + SSA – 2.5% RA – 7.5 % LGA – 2.5% Absent 0%	One: 67.5% Two: 22.5% Three: 7.5% Four: 2.5% Absent 0%
PRESENT STUDY	50 Fetuses (n = 100)	South African	AA – 18% RA – 46% Aorto-renal area – 16% Absent – 20%	One: 48% Two: 22% Three: 6% Four: 4% Absent: 20%	AA – 34% RA – 16% Aorto-renal area – 10% Absent – 40%	One: 44% Two: 14% Three: 2% Absent: 40%

AA – abdominal aorta, CT – celiac trunk, IPA – inferior phrenic artery, LGA – left gastric artery, LMSA – left middle suprarenal artery, RA – renal artery, RMSA – right middle suprarenal artery, SSA – superior suprarenal artery.

Vertebral levels. The MSA predominantly originated from the middle one-third of the IV disc between the L1-L2 vertebrae. The vertebral levels of the MSA was reported by Moore *et al*. and Standring who stated that it arose at the level of the superior mesenteric artery (SMA). Consequently, the same authors report that the SMA is located at the L1 or L2 vertebral levels, but does not state the precise division of the vertebrae.

III) The inferior suprarenal arteries

Origin, course and relations. The ISA predominantly arose from the RA, which concurred with previous studies (Bianchi & Ferrari; Pitynski *et al*.). Variations of the ISA included: (a) the ISA arose from the AA and the aorto-renal area; and (b) triple ISA branches were documented. Bianchi & Ferrari, Bordei *et al*. and Ciçekcibasi *et al*. (2005) reported that the ISA frequently arose from the AA. A variable origin was documented in the present study i.e. an area between bifurcation of the AA and the RA, the aorto-renal area; nonetheless, this was not observed by previous authors in fetuses. Bianchi & Ferrari and Pitynski *et al*. were the only authors who reported that the ISA originated from a combination of sources involving the GO and SPRA. However, the afore-mentioned origins were not present in this study. The ISA vessels either followed a superior, supero-lateral or lateral course into the inferior aspect of the glands. This finding was also reported by Pitynski *et al*., who stated that the ISA are the arteries reaching the renal surface and the inferior part of the anterior and posterior surface of the suprarenal gland.

Number of branches. The number of branches of the ISA ranged between one and three, with single branches being the most prevalent in the present study. However, the number of ISA branches have been reported to vary between one and five (Pitynski *et al*.) (Table III).

Vertebral levels. The ISA was located predominantly at the level of the L2 vertebral body in the specimens. However, the vertebral level of the origin of the ISA has not been reported in the literature reviewed.

Table III. Summary of the reviewed literature of the inferior suprarenal arteries in fetuses.

Author	Sample Size	Population Group	RISA	RISA branches	LISA	LISA branches
Bianchi and Ferrari (1991)	50 Fetuses (n=100)	Argentinian	RA – 60 % RA + GO – 12 % SPRA – 4 % AA – 4 % GO – 4 % Aberrant GO – 4 %	-	RA – 40 % RA + GO – 8 % RA + SPRA – 4 % SPRA + GO – 4 % AA – 24 % AA + SPRA – 4 % GO – 8 % AA + GO – 4 % Aberrant GO – 4 %	-
Pitynski *et al.* (1998)	40 Fetuses (n=80)	Polish	RA – 55 % RA + AA – 25 % RA + SPRA -5 % RA + AA + SPRA – 2.5 % RA + GO – 7.5 % RA + GO + AA – 2.5 % SMA – 2.5 %	One: 30 % Two: 25 % Three: 20 % Four: 17.5 % Five: 7.5 %	RA – 37.5 % RA + AA – 32.5 % RA + SPRA – 2.5 % RA + GO – 12.5 % RA + GO + AA – 10 % RA + GO + SPRA – 5 %	One: 22.5 % Two: 27.5 % Three: 22.5 % Four: 15 % Five: 12.5 %
Present Study	50 Fetuses (n = 100)	South African	RA – 90 % AA – 4 % Aorto-renal area – 6 %	One: 82 % Two: 16 % Three: 2 %	RA – 92 % AA – 2 % Aorto-renal area – 4 % ARA -2 %	One: 86 % Two: 12 % Three: 2 %

AA – abdominal aorta. ARA - additional renal artery. CT – celiac trunk. GO – gonadal artery,.LISA – left inferior suprarenal artery. RA – renal artery. RISA – right inferior suprarenal artery. SMA – superior mesenteric artery. SPRA – superior polar renal artery

IV) Suprarenal veins. The RSV and LSV drained into the IVC and the LRV, respectively. This was also reported by other authors (Kahn & Angle, 2010; Scholten *et al*., 2013; Cesmebasi *et al*., 2014). The RSV coursed transversely into the postero-lateral aspect of the IVC, while the LSV coursed infero-medially into the superior aspect of the LRV. This corroborated with other authors (Avisse *et al*., 2000; Scholten *et al*.; Tubbs *et al*., 2016). In one specimen in the present study, an ARSV was observed entering the IVC from a postero-lateral aspect just below the entrance of the main (central) RSV. Avisse *et al*. and Scholten *et al*. stated that each suprarenal vein has multiple accessory veins, and not just the main (central) suprarenal vein of each gland.

CONCLUSION

The origin of the vascular supply of the suprarenal glands has been documented in literature. However, there was a requirement for thorough clarification of the suprarenal arteries regarding the course, relations and number of branches in fetal specimens. Although the gross anatomy of the suprarenal arteries and veins documented in this study, conformed to that described in standard anatomical textbooks, multiple variations were found in the origins and number of branches. The SSA arose from the IPA, which agreed with the literature; however absent SSA was also reported. The number of branches of the SSA branches observed were much fewer than reported in previous literature. The AA and the RA were the most common origins for the MSA and not just the AA as previously documented in textbooks. Also, it originated from an aorto-renal area and was frequently absent, bilaterally. The ISA conformed to the standard anatomical descriptions; however, the ISA presented triplicated vessels in the fetuses. The specific divisions of the vertebral levels of the origins of the suprarenal arteries in fetuses have also not been documented in previous literature and is elaborated in the present study. Knowledge of the anatomical variations of the suprarenal vasculature may aid pediatricians during adrenelectomy surgery in neonates.

GREEFF, B.; PILLAY, P.; DE GAMA, B. Z. & SATYAPAL, K. S. Investigación anatómica del suministro vascular de las glándulas suprarrenales en los fetos. *Int. J. Morphol., 37(3)*:1023-1032, 2019.

RESUMEN: Las glándulas suprarrenales son irrigadas bilateralmente por tres arterias suprarrenales y drenadas por una sola vena suprarrenal. Los orígenes vasculares variables de la glándula suprarrenal fetal se han documentado en diferentes grupos de población: indios, polacos y argentinos. Sin embargo, no existe una descripción detallada del curso, las relaciones, el número de ramas y los niveles vertebrales de los orígenes de la vasculatura de las glándulas suprarrenales en los fetos. Este estudio tuvo como objetivo identificar y documentar el suministro vascular de las glándulas suprarrenales en fetos en una población sudafricana. Cincuenta especímenes fetales (26 hombres; 24 mujeres) con una edad gestacional que oscila entre las 12 y las 20 semanas, fueron micro-diseccionados bilateralmente (n = 100) utilizando un microscopio Zeiss Stemi DV4. Se registraron los datos y se determinaron las frecuencias de origen, curso, relaciones, número de ramas y niveles vertebrales del suministro vascular suprarrenal. Suministro arterial: Origen: (i) La arteria suprarrenal superior (SSA) surgió bilateralmente de las arterias frénicas inferiores en el 98 % de los fetos; (ii) la arteria suprarrenal media (MSA) surgió frecuentemente de la arteria renal (AR) en el lado derecho (46 %) y en la parte abdominal de la aorta en el lado izquierdo (34 %); mientras que (iii) la arteria suprarrenal inferior (AIS) surgió predominantemente de la AR en el 91 % de los especímenes, bilateralmente. Curso y relaciones: las arterias suprarrenales seguían un curso superior, inferior, lateral, superolateral e inferolateral hacia la glándula. Estas arterias estaban estrechamente relacionadas con la crura del diafragma, la vena cava inferior, la vena frénica inferior izquierda y el páncreas. Número de ramas: Las ramas variaron de una a siete para la SSA, de una a cuatro para la MSA y de una a tres para la ISA. Niveles vertebrales: la SSA surgió predominantemente del primer cuerpo vertebral lumbar (L1) (32 %), la MSA surgió del tercio medio del disco intervertebral entre la L1 y la segunda vértebra lumbar (L2) (19 %) y la ISA surgió del cuerpo vertebral L2 (28 %). Drenaje venoso: en el 1 % de las muestras, se observó una vena suprarrenal derecha (ARSV) adicional. Este ARSV siguió un curso superomedial hacia la vena cava inferior, justo debajo de la entrada de la vena suprarrenal derecha principal. Las arterias que irrigaban la glándula suprarrenal presentaban diversos orígenes y número de ramas, lo que corrobora la literatura revisada y los libros de texto anatómicos estándar. Los hallazgos de este estudio pueden ayudar a los cirujanos pediátricos a comprender la morfología vascular (y sus variaciones) de la glándula suprarrenal, al realizar una cirugía de adrenelectomía en neonatos.

PALABRAS CLAVE: Glándula suprarrenal; Arterias; Venas; Feto; Variaciones.

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