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Original article

Precaval Right Renal Artery: Is It More Common?

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ABSTRACT

Background: Thorough knowledge of renal vascular variations has major clinical implications as it contributes to the safe performance of surgical and interventional procedures and proper interpretation of radiological images. Though much attention has been paid to evaluate the numerical variations and prehilar branching pattern of renal arteries, the anomalous course of the right renal artery especially has drawn less attention. **Aim:** To study the prevalence of right renal artery passing anterior to inferior vena cava (Precaval right renal artery) instead of its normal posterior course. **Materials and Methods:** We evaluated contrast-enhanced Multi Detector row Computed Tomography (MDCT) angiography scans of 225 patients (123 males and 102 females) to determine the prevalence of precaval right renal artery. **Results:**21precaval right renal arteries were observed in 20 cases (13 males and 7 females) with a prevalence of 8.88 %. Out of 21 precaval right renal arteries, 1 was main,17 inferior polar and 3 accessory hilar arteries. **Conclusion:** Most commonly, the inferior polar arteries have a precaval course. A higher incidence is also observed in males. There was a single case of main right renal artery having a precaval course which is a rare occurrence. This study suggests that the occurrence of precaval right renal artery may be more common than reported.

KEYWORDS: MDCT Angiography, Precaval, Right renal artery

INTRODUCTION

A thorough knowledge of vascular variations is important while performing surgical, interventional and endovascular procedures and for accurate interpretation of radiological images of abdomen. Right renal artery (RRA) passing anterior to inferior vena cava (Precaval RRA), though rare, is a variant of renal vascular anatomy and so identifying this variant increases the safe performance of minimally invasive renal surgery [1] The advent of interventional radiological procedures, endovascular and laparoscopic renal transplantation surgeries makes the evaluation of vascular variants more so important clinically [2].

Normally the right renal artery reaches the renal hilum passing posterior to the inferior vena cava (IVC). Precaval RRA is defined as a tubular structure with attenuations similar to that of and arising from the aorta or iliac artery that passes anterior to the IVC and terminates in the right kidney [3]. When multiple arteries supply a kidney, the artery with the largest diameter that extends to a given kidney is defined as the main and dominant renal artery and all other renal arteries are considered as additional. Additional renal arteries entering the hilum were designated as accessory hilar and those entering the poles were called as polar. The reported incidence of precaval RRA in existing literature is very variable ranging from 0.6% to 9.17% and in an earlier report we found an incidence of 5.48 % which was higher than that reported in most of the earlier reports. [4] Some reports have suggested that the precaval RRA could produce ureteropelvic junction (UPJ) obstruction [3,5,6]. So we undertook the present study specifically to evaluate the prevalence of precaval right renal artery.

MATERIALS AND METHODS

The present study was done at a single center in Meerut. Written consent was obtained from all the patients before undergoing contrast enhanced multidetector-row computed tomography (MDCT) angiographic evaluation. During the period from February to September, 2013, 253 patients with suspected abdominal pathologies were referred to the imaging center for MDCT angiographic evaluation. Scans of 26 patients were excluded from the study because of poor quality of scans, aortic and renal vascular pathologies, renal masses, prior nephrectomy and other retroperitoneal mass lesions. Out of 227 patients, one male patient had right renal ectopia with the main RRA in a precaval position and another male patient had horseshoe kidney with accessory RRA in a precaval position. Because of the presence of associated renal anomalies these two cases were also not included, thus making the total number of 225 patients included in the study. The study group included 123 males (mean age 51.85; range 18 – 80 years) and 102 females (mean age 51.0; range 25 – 73 years). All 225 patients underwent contrast enhanced angiographic evaluation by a 64 channel CT scanner (GE Optima 660) and received 85 - 100 ml of contrast (Omnipaque) intravenously at the rate of 5 ml/sec. Scans were obtained from diaphragm to pubic symphysis and 0.625 mm thick sections were obtained. Scans were analyzed in a work station (GE- AW Volume share 4.5) and volume rendered (VR) and maximum intensity projections (MIP) of axial and coronal scans were studied specifically for the presence of precaval right renal arteries.

RESULTS

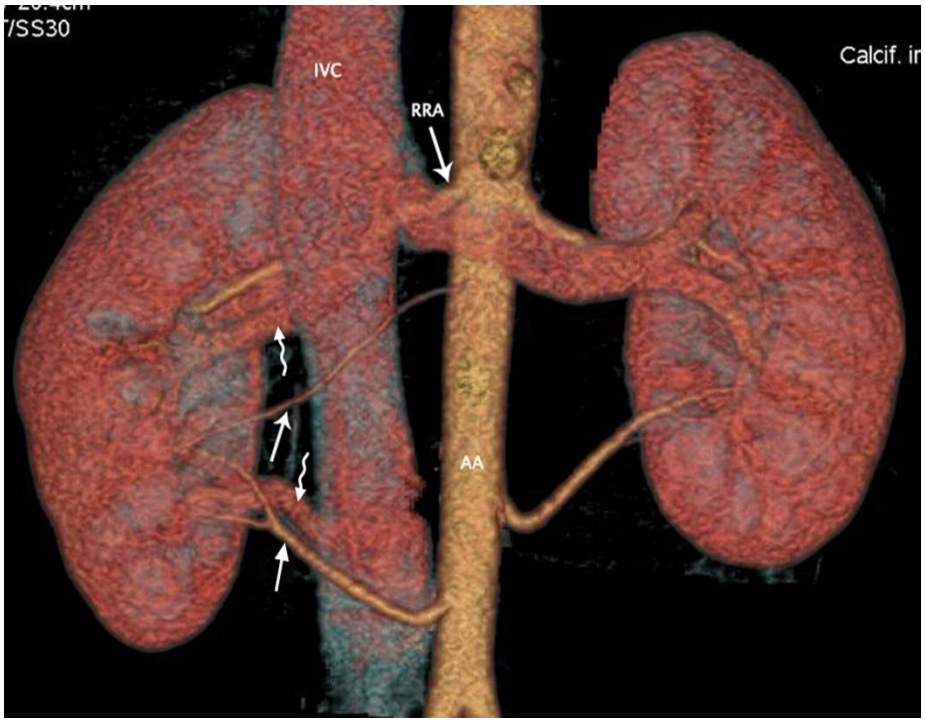
20 patients (13 males and 7 females) showed the presence of a total of 21 precaval right renal arteries (one male patient had double precaval arteries) with a prevalence of 8.88 %. Out of 21 precaval right renal arteries, 1 was main,(Fig -1) 17 inferior polar (Fig- 2,3,4) and 3 accessory hilar arteries (Fig 1, 2). The prevalence is more common in males (13/123 cases; 10.56%) in comparison to females (7/102 cases; 6.86%). Right renal artery was single in 1 case, double in 14 cases, triple in 4 cases and quadruple in 1 case. Left renal artery was single in 12 cases, double in 5 cases and triple in 3 cases. Right hepatic artery originating from the superior mesenteric artery was observed in 3 patients as an additional vascular anomaly (Fig 3A, 3B), in one case retroaortic left renal vein was observed (Fig 3C,3D) and in 2 cases the left gastric artery arose directly from aorta. None of the cases exhibited clinical symptoms of ureteropelvic junction (UPJ) obstruction caused by the presence of precaval RRA. The demographic profile of the cases showing the precaval RRA is summarized in Table-1.

Two more cases having precaval RRA were excluded from the study because of their association with renal positional (renal ectopia) and fusion anomalies (Horseshoe kidney), because such renal anomalies are always associated with other vascular anomalies.

Figure :1 Axial MIP image (A) Coronal MIP image (B) of a 54 year old female showing the main right renal artery in the precaval position (Arrow). VR (C) and Axial MIP (D) images of a 50 year old male showing precaval course of accessory hilar RRA (Arrow).

*****AA- abdominal aorta; IVC- inferior vena cava; LRA – Left renal artery; RRA – right renal artery.

Figure :2 VR image of a 28 year old male showing double precaval right renal arteries- inferior polar and accessory hilar (straight arrows).



AA – abdominal aorta; IVC- inferior vena cava; RRA – Main Right renal artery. Note the presence of double right renal veins (curved arrows).

Figure 3. Axial MIP (A) and VR (B) images of a 49 year old male showing inferior polar RRA (Arrow) having a precaval course. Note also the presence of replaced right hepatic artery originating from the superior mesenteric artery (curved arrow in B). Axial MIP (C) and VR (D) images of a 38 year old male showing precaval course of inferior polar RRA (Arrow). Note the presence of retroaortic left renal vein. (curved arrow in C ,D). IVC- inferior vena cava

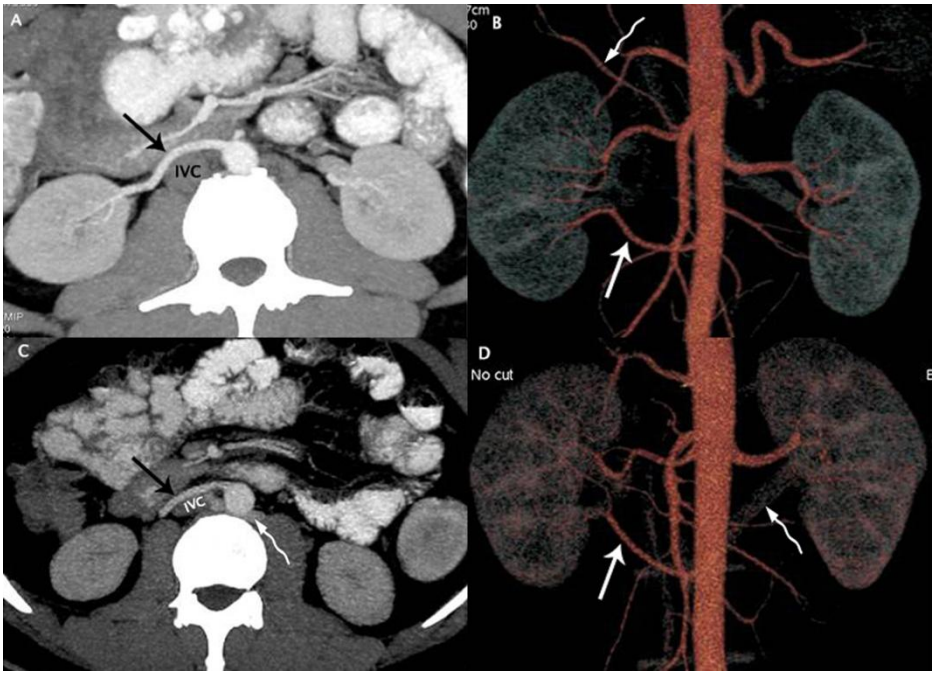


Figure 4. Axial MIP (A) and VR (B) images of a 50 year old female showing precaval course of inferior polar RRA (Arrow). Axial MIP (C) and VR (D) images of a 73 year old female showing precaval course of inferior polar RRA (Arrow). AA- abdominal aorta; IVC- inferior vena cava.

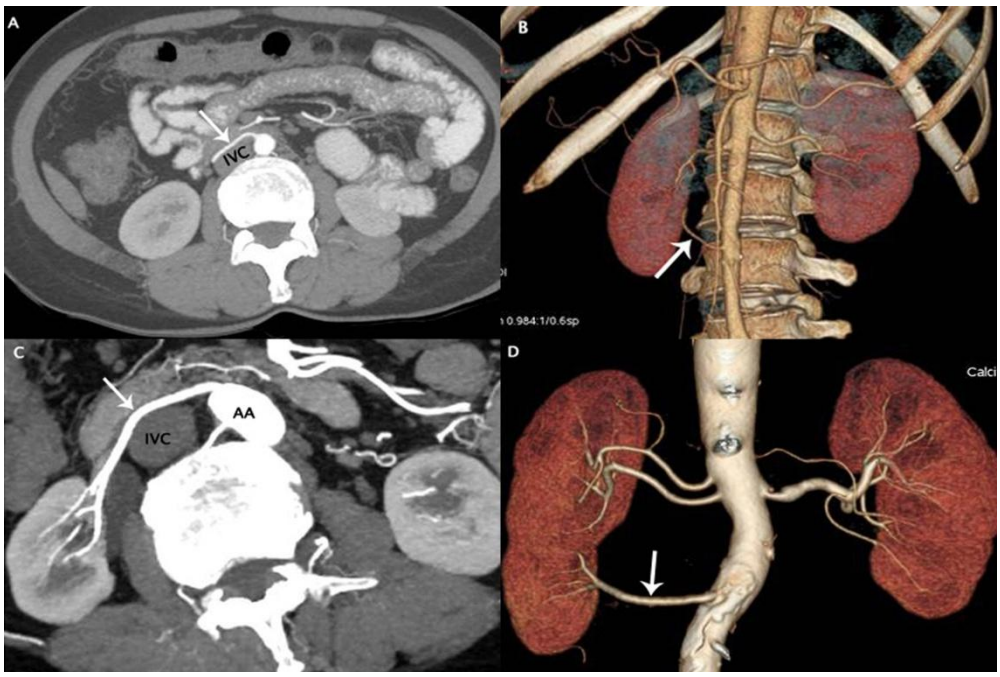


Table : 1 Demographic profile of the cases showing precaval RRA.

S.No.	Gender	Age	No. of Right Renal Arteries.(RRA)	Nature of Precaval RRA	No. of Left Renal Arteries (LRA)	Any other associated variation.
1	M	48	2	Inferior polar	2	
2	M	56	3	Inferior polar	3	
3	M	70	2	Accessory hilar	1	RHA from SMA
4	M	69	4	Inferior polar	3	
5	M	32	2	Inferior polar	1	
6	M	50	2	Accessory hilar	1	
7	M	18	3	Inferior polar	3	
8	M	49	2	Inferior polar	2	RHA from SMA
9	M	38	2	Inferior polar	1	Retroaortic Left Renal vein
10	M	28	3	Accessory Hilar Inferior polar	2	2 right renal veins.
11	M	80	2	Inferior polar	1	
12	M	65	2	Inferior polar	1	
13	M	55	2	Inferior polar	1	
14	F	43	2	Inferior polar	1	
15	F	27	2	Inferior polar	1	LGA from aorta
16	F	50	2	Inferior polar	1	
17	F	54	1	Main	1	
18	F	25	2	Inferior polar	1	
19	F	45	2	Inferior polar	2	
20	F	73	3	Inferior polar	2	RHA from SMA, LGA from aorta

DISCUSSION

Renal vascular anomalies are not uncommon and an exhaustive literature is available on the level of origin, numerical variation and extrahilar branching pattern of renal arteries and anomalies of left renal vein but less attention has been paid especially to the anomalous course of right renal artery. Right renal artery passing anterior to inferior vena cava (Precaval position) has seldom attracted the attention and is sporadically mentioned in the earlier literature. In a study of renal vascular pedicle Pick and Anson [7] described precaval course of two right renal arteries, one hilar and one inferior polar, in a case with four right renal arteries and this case was illustrated by Bergman et al [8].

Hollinshead [9] has stated that unlike the right renal arteries arising at a higher level, the arteries having a lower level of origin more likely pass anterior to IVC instead of posterior to it. He suggested that because of the development of infrarenal inferior vena cava from the supracardinal system (dorsally placed system) the right renal arteries arising at a lower level have a precaval course before reaching the right kidney. In contrast the right renal artery arising at a higher level pass posterior to IVC because the IVC at the level of the kidney develops from the subcardinal system (a ventral system).

Petit et al in 1997 drew the attention to this variant, posing a question "Precaval right renal artery: have you seen this?" and reported an incidence of 0.8 % [10]. The reported prevalence of precaval right renal artery varied from 0.6 % to 9.17 % [11,12] and the features of this variant was recently reviewed by Srivastava et al [4]. An incidence of 1.44 % was reported in an intraoperative observation of 278 patients with testicular germ cell tumors.[13]. In a study of 30 cadavers, precaval right renal artery was observed in one cadaver (3.3 %) [14]. The incidence of precaval right renal artery reported by various authors is summarized in Table-2. A number of single case reports, mostly cadaveric studies, have also appeared sporadically in the literature and are summarized in Table-3.

Table: 2 Prevalence and nature of precaval right renal artery (RRA)

S.No.	Name of Author & Year	Modality of study	Total No. of cases studied	No. of cases & prevalence	Nature of Precaval RRAs
1.	Petit et al (1997) [10]	CECT / USG	380	3 cases (0.8 %)	All dominant single RAs.
2.	Meng et al (2002)[22]	Intraoperative / CT	500	3 cases (0.6 %)	Lower pole RAs.
3	Yeh et al (2004)[3]	Spiral CT	186(retrospective) 3200(Prospecive)	9 cases (5.0%) 39 cases (1.2%)	A total of 52 Precaval RRAs. in 48 cases.- 4 dominant RRAs & 48 Accessory RRAs.
4.	Holden et al (2005) [19]	MDCT Live donors	100	1 case (1.0%)	Single main RRA
5.	Holt et al (2006) [13]	Intraoperative	278 (patients with testicular germ cell tumours.)	4 cases (1.4 %)	Not available. All patients underwent retroperitoneal lymph node dissection.
6.	Chai et al (2008) [11]	Intraoperative Live donors	153	1 case (0.6 %)	Not available
7.	Gupta et al (2011) [20]	Cadaveric	50 cadavers	3 cases (6.0%)	2 dominant & 2 accessory. One case with single dominant RRA.
8.	Apisarntharanak et al (2011) [18]	CTA Renal donors	65	3 cases (4.6 %)	1 case single dominant and 2 cases accessory
9.	Bouali et al (2012) [12]	Spiral CT	120	11 cases (9.17%)	1 case both dominant & accessory; 10 cases accessory lower polar.
10.	Srivastava et al (2013) [4]	MDCT	73	4 cases (5.48%)	1case single dominant; 1 case both dominant & accessory; 2 cases lower polar
11.	VijayKumar & Mane (2013) [14]	Cadaveric	30 cadavers	1 case (3.3%)	4 RRAs all precaval supplying right ectopic kidney.
12.	**Present study**	**MDCT**	**225**	**20 cases (8.8%)**	**1 Main, 17 inferior polar, 3 accessory hilar.**

Table: 3 Single case reports of precaval right renal artery

S. No.	Name of Author & year	Modality of Study	Gender	Nature of precaval artery	Associated variations / conditions.
1	Singh et al. 1998 [15]	Cadaver	Female	Accessory RRA	Gives origin to Ovarian artery & cross in front of right ureter.
2	Madhyastha et al 2001 [23]	Cadaver	Male	4 RRAs (1 main + 3 accessory)	Double ureter, 3 right renal veins.
3	Kurtoglu et al 2004 [16]	Cadaver	Female	Accessory RRA	Gives origin to Right ovarian A.
4.	Lee et al 2005 [1]	CECT	---	Single main RRA	
5	Corey et al. 2005 [5]	MDCT	Female	Inferior polar RRA	UPJ obstruction
6	Radolinski et al 2006 [21]	Operative	----	Single main RRA	Donor nephrectomy
7	Yun et al 2007 [6]	---	---	Inferior polar RRA	Hydronephrosis
8	Raheem et al 2008 [24]	Cadaver	Male	Main & Inferior polar	
9	Nayak 2008 [17]	Cadaver	Female	Accessory RRA	Gives origin to Right ovarian A.
10	Patasi & Boozary, 2009 [25]	Cadaver	Male	Accessory RRA	Cross right ureter anteriorly
11	Gupta et al 2011 [26]	Cadaver	Male	Main & Accessory RRA	
12	Wadhwa & Soni, 2012[27]	Cadaver	Male	Main & Accessory RRA	4 LRAs.
13	Tulunay et al 2012 [28]	Intra operative	Female	3 precaval RRAs	Ptotic right kidney. Middle RRA from a common stem with LRA from anterior aspect of aorta
14	Kanaskar et al. 2012 *[29]	Cadaver	Male	Inferior polar	Cross right ureter anteriorly
15	RameshBabu &Gupta (2012) [30]	MDCT	Male	1 Accessory hilar 1 Inferior polar	3 RRAs and 4 LRAs. Both kidneys malrotated with hilum facing anteriorly.
16	Parimala, 2013 *[31]	Cadaver	Male	Inferior polar	Pass posterior to right ureter.
17	Krishnaveni & Kulkarni,2013 * [32]	Cadaver	Male	5 precaval RRAs.	Ectopic right kidney
18	Uzmansel et al 2013 [33]	Cadaver	Male	Accessory RRA	Pass posterior to right testicular vessels & right ureter
19	Thakuria et al 2013 [34]	Cadaver	Male	Accessory hilar & Inferior polar	Inferior polar pass behind right ureter. 4 RRAs & 5 LRAs.

*Authors did not mention the precaval course of the right renal artery as a variant, though present.

Our study suggests that the precaval right renal artery is more common in males as compared to females (13 males versus 7 females) and this observation is also supported by the single case reports (11 males versus 5 females) (Table-3). Bouali et al [12] also found the prevalence more common in males (8 males versus 3 females) in their retrospective review of 120 patients. In a prospective study of 3200 patients, precaval RRAs were found in 39 patients (23 males; 16 females) [3]. It is also observed that the precaval accessory right renal arteries in females give origin to right ovarian artery [15,16,17]. Such an origin of ovarian artery from the precaval accessory right renal artery was not seen in our cases.

Our study indicates that the majority of the precaval RRAs are inferior polar arteries (17 out of 21) having a lower level of origin from the aorta. Out of 13 precaval RRAs described by Bouali et al 12 were lower pole arteries [12]. Yeh et al found 48 accessory and 4 main precaval right renal arteries but did not distinguish the accessory arteries as hilar or polar [3]. Because of their lower level of origin, the right renal arteries reaching the lower pole are more likely to have a precaval course [9]. Though Bouali et al [12] did not find a case of a single and main RRA in a precaval position, we found one case with a single main RRA having a precaval course which was also described by others [1, 3 , 4, 10 and 18 - 21]. In all the published reports so far there was no case of superior polar RRA having a precaval course.

Some reports have suggested that the precaval RRA could produce UPJ obstruction [3,5,6]. It was also suggested that up to 6% patients having precaval RRAs may develop symptomatic UPJ obstruction [3]. But none of our patients having precaval RRAs showed clinical symptoms of UPJ obstruction.

During development a series lateral segmental (splanchnic) arteries from aorta supply the nephrogenic cord. When the metanephric kidney ascends from its pelvic position, it receives arterial supply from these successive lateral splanchnic arteries. The final position and number of renal arteries is determined by the final position of the kidneys. Complete reduction of the primitive arterial supply results in a single renal artery and incomplete reduction leads to supernumerary renal arteries. Meng et al suggested that the precaval lower pole renal artery develops and persists after

the posterior cardinal vein has become the IVC but before the descent of the gonad. [22]. Disturbances of the complex process of ascent of kidney through a narrow window may affect the development of renal vasculature resulting in precaval right renal artery [22]. It is also suggested that the persistence of some of the caudal lateral splanchnic arteries in a precaval position is due to the development of infrarenal segment of the IVC from the supracardinal vein.[9].

CONCLUSION

The present study suggests that the prevalence of the precaval right renal artery might be more common than reported by most earlier studies because the variant does not cause any clinical symptoms and some studies even failed to report it due to lack of awareness. It is more common in males and in majority of cases the precaval RRA enter the inferior pole. The surgical importance of the precaval RRA lies in the fact that it may be injured during endopyelotomy, cause UPJ obstruction, confused with other vessels and misinterpreted as gonadal or mesenteric arteries. The safety and success of interventional procedures and minimally invasive renal and retroperitoneal surgeries depend upon the familiarity of the anatomic variations and their associations.

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