SCIENTIFIC ARTICLE

Anatomical variations of the renal vasculature and outcome of live donor nephrectomies: experience of a single surgeon

Joel Arudchelvam[1], Waruna Laksiri[2]
[1]Teaching hospital Anuradhapura, Sri Lanka
[2]Base Hospital, Horana, Sri Lanka

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Abstract

Introduction

Renal artery [RA] variations occur in 18 % to 21%. Variations determine the side selection in kidney donors and the outcome of Kidney Transplantation. This series reports the renal vascular anatomy [RVAS] variations and associated complications encountered during live donor nephrectomies [LDN].

Methods

Consecutive LDN done by a single surgeon is included, the patient's demography, LDN side, RVAS variations and complications are recorded. The kidney with worse function and the least number of RA is selected for LDN. The RVAS is assessed by Computed Tomography Angiography and intra-operatively. Single RA and vein with the hilar division are considered normal anatomy.

Results

159 were included with 103 [64.8%] males. The mean age was 38.2 years [23-63]. 106 [66.7%] were left LDN. 136 [85.5%] had single RA of these 34 [21.4%] had early-branching [EB]. 23 [14.5%] had multiple RA [2 in 21 and 3 in 2]. Therefore variations occurred in 35.8 %. In a subgroup analysis of 123 renal veins, only 6 [6.8%] with single RA but 9 [25.7%] out of 35 with multiple arteries or EB arteries had multiple veins. This difference was statistically significant [p-0.004]. 11 [6.9%] had complications [3 renal bed haematoma]. 2 of 3 haematoma patients had EB of RA [5.9% vs. 0.8%] and underwent right LDN [3.8% vs. 0.9% / p>0.05].

Conclusions

RA variations occur in 35.8 %. Multiple arteries and EB is significantly associated with multiple veins. The complication rates in patients with EB appear to be high. However, this was not statistically significant probably due to low numbers.

Introduction

Renal transplantation is a commonly performed surgery. The variations of the renal vasculature in the donor play a major role in the outcome of both the donor and the recipient. The renal arteries [RA] arises at the level of the first lumbar [L1] to the second lumbar [L2] vertebral level from their lateral aspect of the abdominal aorta. RA are about 4 to 6 cms in length. The right RA is longer than the left RA and runs posterior to the inferior vena cava [IVC]. The RA divides into segmental branches at the renal hilum. If the artery divides outside the hilum it is called early-branching [EB]. Additional renal arteries can arise from the aorta and enter the kidney. Additional arteries are either “Hilar arteries” or “Polar arteries”. Hilar arteries arise superior or inferior to the level of the main renal artery and enter the hilum of the kidney. Whereas polar arteries arise from the aorta either superior or inferior to the level of the main renal artery and enter either the upper pole or the lower pole of the kidney outside the hilum. Multiple renal arteries are encountered at a rate of 27.0% - 31.9% [1] [2].

In addition, early branching of the renal artery [Proximal to the renal hilum] is found in 26.7% - 29.1% [1] [2]. The Kidneys are usually drained by a single renal vein [RV]. The left renal vein is about 6 to 7 cms in length and runs anterior to the aorta and drains into the inferior Vena cava [IVC]. The right renal vein is about 3 to 4 cms in length and also drains into the IVC. Both RV drains into IVC at the level of L1 to L2. The left renal vein also has a thicker wall when compared to the right vein. Variations also occur in RV anatomy. For example, multiple renal veins are found in 16.7 % of individuals [3]. The renal vein variations are more common on the right side 16.6% vs. 2.1% [3]. Variations determine the side selection of the donor. Renal vascular variations during donor nephrectomy [DN] is known to increase the surgical time and the complications in the donor [4]. This series reports the renal vascular anatomy [RVAS] variations and associated complications encountered during live donor nephrectomies [LDN].

Correspondence: Joel Arudchelvam
E-mail: joelaru@yahoo.com
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Methods

Consecutive open LDN did by a single surgeon were included. The patient's demography, LDN side, RVAS variations and complications were recorded. The RVAS was assessed by Computed Tomography Angiography [CTA] and intra-operatively. 3D reconstruction of the CTA images was done before interpretation. The CTA was interpreted by both the surgeon and the radiologist. Single RA and RV with hilar division were considered normal anatomy.

A preoperative Tc99m-DTPA [Diethylene Triamine Pent Acetate] scan was done in all donors to assess the relative function of the kidneys. The kidney with the lesser relative function was selected for donor nephrectomy. A split function difference of 45% to 55% was considered normal and acceptable for donation. After the split function determination, the kidney with the least number of arteries and veins was selected for donor nephrectomy. The kidneys with the least number of arteries and veins will make transplantation in the recipient easier. In addition, if there were any other abnormalities in the donor's kidneys [calculi, cysts, hydronephrosis, sluggish emptying of urine as shown in DTPA scan, etc.] the kidney with the abnormality was considered for donor nephrectomy leaving behind the healthy kidney in the donor. If all the above factors were equal in both donor kidneys, the left kidney was preferred. Because the left renal vein is longer and has a strong venous wall. Therefore the anastomosis in the recipient is easier.

Results

159 patients were included. 103 [64.8%] were males. The mean age was 38.2 years [23-63]. 106 [66.7%] were left LDN. 136 [85.5%] had a single RA of these 34 [21.4%] had early branching. 23 [14.5%] had multiple RA [2 arteries in 21[13.2%] and 3 arteries in 2 [1.2%]]. Therefore variations occurred in 35.8 %. In a subgroup analysis of 123 renal veins, only 6 [6.8%] with single RA but 9 [25.7%] out of 35 with multiple arteries or EB arteries had multiple veins. This difference was statistically significant [p-0.004].

Eleven [6.9%] patients developed complications. The complications were; wound infection in 5 [3.1%], sciatica in 2 [1.2%], pneumothorax in 1 [0.6%] and renal bed haematoma in 3 [1.9%]. The patient who developed pneumothorax was a left kidney donor. There was a small pleural tear during the surgery. The pleural tear was repaired. But in the immediate post-operative period, her peripheral SaO2 dropped to 90% to 92% while on oxygen via face mask. The left-sided chest was hyper resonant and breath sounds were reduced on the left side. Chest x-ray confirmed the pneumothorax. An intercostal drainage tube was inserted and connected to a underwater seal.

Three patients developed renal bed hematoma. These patients complained of severe pain over the surgical site. In all patients, the symptoms worsened in 48 hours from the time of surgery and they became haemodynamically unstable. There was a significant drop in haemoglobin in all patients. The hematoma was confirmed with an ultrasound scan. All 3 patients underwent re-exploration and evacuation of a haematoma under general anaesthesia. During the reoperation no particular bleeding sources were identified. Two of 3 patients, who developed a haematoma, had EB of RA [5.9% vs. 0.8%] and underwent right LDN [3.8% vs. 0.9%]. These differences were not statistically significant probably due to the small numbers [p>0.05].

Discussion

During embryonic development, series of arteries develop from the aorta i.e. mesonephric arteries, supplying the developing kidneys. During further development, most of the superior mesonephric arteries regress. The caudal mesonephric arteries [usually one] persist to supply the future metanephric [adult] kidney. The persistence of some of the mesonephric arteries results in multiple renal arteries in adults [5].

This study shows that multiple RA occurs in 14.5% of individuals. Early branching occurs in 21.4% of patients with single RA. Previous studies have shown that multiple renal arteries, multiple renal veins and early branching of the arteries are associated with increased operating time, increased bleeding during surgery, increased warm and cold ischemia times of the kidney and increased postoperative serum creatinine in the donor [6].

This study shows that 25.7% of patients with multiple renal arteries and EB have associated multiple renal veins. Awareness of this fact is important during renal surgeries especially donor nephrectomy to avoid inadvertent damage to the veins and bleeding. Unexpected bleeding during donor nephrectomy results in unexpected damage to the renal artery branches when attempting haemostasis. The complication rates in patients with EB and on the right side appear to be high.

However, this was not statistically significant probably due to low numbers. The probable reason for this is that the right renal vein and its branches are thinly walled. In addition, a significantly large number of patients with early branching of the renal arteries and multiple renal arteries have associated multiple renal veins [25.7%] as demonstrated in the current study. These multiple veins are also very thin-walled. Accidental damage to these veins can result in bleeding and haematoma formation both intraoperatively and postoperatively.

Also in cases of early branching, to get a common renal artery stump on the right side, more dissection needs to be done posterior to the inferior vena cava. This can result in prolongation of the surgery and a higher risk of bleeding.

At present, the available guidelines and consenting forms do not specifically mention the associated higher risk of complications in patients with multiple renal vessels and early branching of renal arteries. This additional risk should be separately explained to the renal donors with multiple renal vessels and early branching of renal arteries.

Small sample size is a limitation of the current study and further studies with larger cohorts are needed before recommendations can be made for donors.

All authors disclose no conflict of interest. The study was conducted in accordance with the ethical standards of the relevant institutional or national ethics committee and the Helsinki Declaration of 1975, as revised in 2000.

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