Preoperative evaluation of laparoscopic living renal donors with computerized tomography and its effect on donor morbidity and graft function

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Objective: *To assess the efficacy of CT angiography (CTA) in evaluating the renovascular anatomy in 50 patients who underwent laparoscopic donor nephrectomy, and to correlate results with donor morbidity and recipient outcome.*

Methods: *Forty-eight patients were evaluated by CTA prior to laparoscopy. Donors with aberrant renovasculature and their respective recipients were divided into: 1) accurate preoperative CTA ("predictive group", PG), 2) inaccurate CTA ("non-predictive group", NPG). Warm ischemia times (WIT), estimated blood loss (EBL), operative time (OT), and the open conversion rate were compared. Recipient creatinine values on post-operative day 1 and 3 months were recorded with the rate of delayed graft function (DGF) and ureteral complication. Statistical significance was calculated using the student's T-test.*

Results: *Among patients with aberrant vasculature (48%, 23/48) at laparoscopy, 14 were accurately predicted by CT angiography (11 arterial, 3 venous). NPG consisted of 5 duplicated arteries, 1 early arterial branching, and 3 anomalous veins. CT accuracy was 85%. The sensitivity and specificity of the arterial imaging were 65% and 100% respectively, while those of venous imaging were 50% and 100%. EBL, WIT, OT, number of open conversions, and ureteral complications were statistically insignificant between groups (p= 0.05, 95% C.I.). The mean decreases in creatinine between NPG and PG on post-operative day 1 and at 3 months were 45.4% and 54.8%, and 71.5% and 79.1% respectively, both statistically insignificant. Two of 8 in the NPG experienced DGF as compared to 1/8 in the PG.*

Conclusions: *Despite the lower sensitivity of this study, the discordance between imaging and laparoscopy did not augment donor morbidity or increase adverse recipient outcomes. This may indicate that regardless of the shortcomings of 2-D CTA for living donors, it represents a safe and effective imaging modality when coupled with meticulous laparoscopic dissection and central intraoperative involvement of the transplant surgeon.*

Key Words: laparoscopy, nephrectomy, living kidney donation, computerized tomography, angiography

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Introduction

In kidney transplants, since the gap between the number of needy recipients and the number of

available cadaveric organs has widened, living donors have been increasingly involved in the procurement of viable organs. Additionally, another compelling reason for the increase in live donors is the relatively superior outcome obtained from living donors as opposed to cadaveric kidneys.[1] Studies have indicated a 1-year graft survival rate of 92%-97% for live donor grafts as compared to 81%-93% for cadaveric kidneys.[2] In the last 10 years, laparoscopic kidney procurement has demonstrated a significant reduction in donor morbidity while maintaining the same recipient outcome as is in the open operation.[3] Therefore, in any center worldwide, laparoscopic live donor nephrectomy has become the modality of choice for kidney procurement.

The success of live donor transplantation is significantly contingent on accurate and reliable depiction of function and anatomy of the donor kidney preoperatively. Anatomical assessment of the donor kidney is performed prior to transplantation to aid in the selection of which kidney to use, to plan the surgical approach as well as to rule-out any disease that would preclude donorship. Candidates for live renal donor procedures undergo extensive preoperative evaluation including extensive medical and family history, laboratory testing and radiographic imaging.[4] In the past, excretory urography (IVP) coupled with conventional angiography were the modalities of choice. The approach was intended to assure the presence of two equally functioning kidneys, as well as the properly discern the renovascular anatomy. Angiography, while being effective,[5] is invasive, and associated with significant complications in 1.73% of cases, including thromboembolism (0.14%), pseudoaneurysm (0.05%), bleeding (0.26%), arteriovenous fistula formation (0.01%), allergic reactions (0.03%), and death due to cardiac event in 0.29 %.[6,36] Also, angiography requires approximately 8 hours of post-procedural observation, representing both an inconvenience to the patients as well a financial burden for transplant programs.

More recently, the utilization of these classic modalities has been challenged by the use of helical CT angiography.[7-10] Recent advances in helical computerized tomography allow for high quality images of renovascular structures and soft tissue anatomy in any plane. Three dimensional imaging is also possible with real time interactive viewing. Data can be edited and reconfigured in any possible projection of renal parenchyma, arterial or venous anatomy or the proximal renal collecting system. A delayed abdominal film may also be taken to further evaluate the collecting systems. CT has the added benefit of creating cross sectional images that could detect pathological conditions that may preclude the patient from kidney donation. Aside from a peripheral intravenous contrast injection, no special preparation is required and the total procedure time is roughly 20-30 minutes (operator dependent). The CT angiography has the potential to become the widespread modality of choice, as it has been used successfully for the last decade for pre-operative assessments of living renal donors. Recently, studies have shown that the accuracy of CT angiography can match that of IVP plus conventional angiography.[11-13]

In our first 48 cases of laparoscopic left kidney harvest, we set out to retrospectively evaluate the accuracy, specificity and sensitivity of CT arteriography in defining and elucidating renal vascular anatomy. During this evaluation period, special emphasis was placed on comparing donor morbidity, and graft function post-transplant, in those patients with both predictive and non-predictive imaging studies.

Patients and methods

One hundred ninety-four patients were evaluated and screened in our transplant center as potential renal donors from January 2002 to January 2004. Candidates underwent concomitant evaluation of blood type and compatibility, as well as numerous standard protocol evaluations were undertaken to exclude candidates with underlying renal dysfunction, hypertension or any condition that could be associated with a predilection for renal disease, including risk factors that would preclude major surgery and general anesthesia. Of those 194 patients, 136 patients were precluded as renal donors due to medical reasons including hypertension and ABO incompatibility. Fifty-eight patients were evaluated as per protocol by CT angiography after having satisfied all other necessary donor criteria, eight of whom were eventually rejected as laparoscopic donors due to CT findings Table 1. The reasons for rejection of these eight patients included one case of a unilateral atrophic kidney, one case of a renal artery aneurysm, two patients with extensive kidney stone disease, and four patients with multiple vessels, which were excluded from laparoscopic harvesting during the first year of our learning curve.[14,15] One of these four patients eventually went on to have an open harvest. Fifty patients who successfully completed the pre-operative workup were scheduled for a laparoscopic donor nephrectomy during this time period. One hundred renal units were evaluated with

TABLE 1. **Abnormal anatomical findings on CT**

Total number of CT studies performed	58
Renovascular anatomy precluding laparoscopy (multiple renal arteries)	4
Nephrolithiasis	2
Unilateral atrophic kidney	1
Renal artery disease	1

CT angiography as per the standard protocol. Forty-eight of the 50 patients underwent a successful laparoscopic donor nephrectomy, as two patients with clearance for laparoscopic harvesting changed their mind prior to surgery.

CT protocol and technique

An identical CT protocol was used in all 48 patients. All scans were performed using a General Electric Lightspeed spiral CT scanner machine (Waukesha, Wisconsin, U.S.A.). The energy parameters utilized were 400 mA at 120kV and the tube rotation time was 0.6 seconds. The configuration of the detector was 16 X 0.625, and the speed and pitch were 9.37 and 0.938 respectfully. Pre-imaging protocol maintained the patients NPO for 4 hours prior to the scan. Initially, a scout film was attained, followed by a non-contrast scan with 5 mm slice collimation and new images reconstructed every 2.5 mm, which allowed for identification of the kidneys and any potential renal or vascular calcification. The patient then had 100 ml of non-ionic contrast administered at a rate of 4 ml/second via a peripheral venous access site, and the scan proceeded with visualization of the region of the diaphragmatic aorta. The slices taken were 1.25 mm per slice at a 0.5 mm interval. Time to peak enhancement of the aorta at the level of the renal arteries was measured, and this time plus 5 seconds was used for optimum visualization of the cortex and renal vein in the next phase of the scan. The vascular phase of the scan was purposely extended inferiorly from the celiac artery to the common iliac arteries to include any potential accessory arteries. Lastly, a delayed abdominal scout film was attained to visualize the ureters and the bladder.

Image analysis

The CT angiograms of all 48 patients were read prospectively by the same attending radiologist (LAS) with expertise in this imaging modality. Renal arterial anatomy was evaluated with special emphasis placed on the number and location of renal arteries, accessory arteries, early branching of the main renal artery (as defined by branching within 1.5 cm of its origin), and the presence of any vascular anomalies such as atherosclerosis or fibro-muscular disease. Venous anatomy was further evaluated in a similar fashion, with special emphasis placed on locating potential early venous tributaries, associated adrenal vasculature, or aberrant anatomy. The imaging was also used to assess non-vascular, parenchymal and collecting system abnormalities.

Surgical method

All laparoscopic donor nephrectomies were performed by the same surgical team. We followed the previously described technique of pure transperitoneal laparoscopic donor nephrectomy.[15] We purposely elected to do only left sided nephrectomies during our initial experience because of the anticipated learning curve.[14,15,37] Three of 48 cases required hand retrieval at the beginning of our experience due to a large perceived size of the harvested kidney, but none were converted to open harvests. During laparoscopy, and then during the ex-vivo bench preparation of the harvested kidney by the transplant surgeons (PM, JT), the number of renal arteries and veins, and the presence of any early vascular branches were noted. Pre-operative CT angiography studies were then correlated with intra-operative findings. Parameters potentially associated with donor morbidity including blood loss, OR time, warm ischemia time, and the need for conversion were recorded, as well as recipient characteristics such as the number of ureteral complications and post-transplant creatinine values were determined at day one and followed regularly for 3 months post-operatively.

Post-transplant renal function

All 48 allograft recipients had daily kidney function tests during the immediate post-operative time period, and routinely in the outpatient transplant clinic. The numbers of patients with delayed graft function (DGF) were noted, as measured by a failure of their serum creatinine to drop 20% by post-operative day 1, or the need for hemodialysis during the first post-operative week. This is a classic definition of DGF by the United States Network for Organ Sharing and is widely utilized in the literature.[8] Patients were maintained on standard immunosuppressive regimens and no significant differences with respect to which agents or dosages they received were measured.

Statistical analysis

The transplant warm ischemia times were statistically compared using the student's T- Test. The mean decreases in the creatinine on post-op day-1 and at 3 months were determined for eight age matched patients from each group, and were compared in a similar fashion ($p < 0.05$, 95% C.I.). Rate of conversion to open surgery, operative time, average blood loss numbers of ureteral complications were directly compared.

Results

CT angiography results in 48 patients

When findings at laparoscopy were used as a reference for determining precise renal artery and venous anatomy, there was an overall 85% agreement between CT and laparoscopic findings in these 48 cases Table 2. CT angiography was both sensitive and specific in delineating renal arterial anatomy, with overall percentages of 65% and 100% respectfully. Arterial renovascular anomalies were identified by CT in 11 patients, whereas 17 were encountered at laparoscopy. Of these 17 patients, 11 had confirmed multiple renal arteries (10 patients with two and one with three renal arteries) and six patients had early arterial branching. The six patients with non predictive CTs were divided into one case of early arterial branching and five cases of multiple arteries. Indeed, two cases reviewed as early branching were in fact distinct arteries.

There were six cases of aberrant venous anatomy found at surgery, and three of these cases were overlooked by CT. The three concordant imaging series revealed two duplicated and one retroaortic renal vein. The discordant studies included one duplicated renal vein as well as two inadequately opacified venous tributaries. The overall sensitivity, specificity and accuracy of CT for venous anatomy in our study were 50%, 100% and 94% respectively.

TABLE 2. **Sensitivity, specificity and accuracy of CT angiography versus operating room findings**

	Overall	Arteries	Veins
Sensitivity (%)	62	65	50
Specificity (%)	100	100	100
Accuracy (%)	85	88	94

Warm ischemia time

The warm ischemia time for the patients with both predictive and non-predictive CTs, as defined as the time from clamping the artery to graft perfusion with preservation solution, were compared and revealed averages of 2.6 and 2.99 minutes respectfully. No statistical significance was detected ($p=0.211$, alpha= 0.05) Table 3.

Blood loss

The mean blood loss (ml) for the study groups (predictive imaging and non-predictive imaging) was documented to be 226 ml and 269 ml respectfully. These values did not display statistical significance ($p=0.435$, alpha= 0.05). Moreover, when mean blood loss was compared between patients with one renal artery and patients with multiple renal arteries (documented at time of laparoscopy), the mean blood losses were 203 ml and 230 ml respectively, and displayed no statististical significance Table 4.

Operative procedure time

The average operative time was 2.5 hours. The

TABLE 3. **Intra-operative factors-donor morbidity**

		Patients with multiple renal arteries/early branching/early venous tributaries (n=22)		
CT angiography	**Overall (n=48)**	**Non-predictive (n=8)**	**Predictive (n=8)**	**P-value alpha=0.05 95% C.I.**
Mean OR time (min)	188	222.5	186.625	0.10
Mean warm ischemia time (min)	2.58	2.6	2.99	0.22
Ureteral complications	3	0	0	-
Patients requiring conversion to open surgery	0	0	0	-

TABLE 4. **Blood loss**

	Patients with one renal artery	**Patients with >1 renal artery**		**P-value (alpha=0.05)**
Mean blood loss (ml)	203	230		0.44
		Predictive CT angiography imaging	Non-predictive CT angiography imaging	
Mean blood loss (ml)		269	226	0.43

average OR time for cases with non predictive imaging was 222.5 minutes, as compared to the lower time of 186.7 minutes for the cases with predictive imaging. Although the trend was for lower OR time for those latter cases, there was still no statistically significant difference in the OR times between the groups (p=0.103, alpha =0.05) Table 3.

Need for conversion to open

There were no conversions to open surgery in n=48 cases. This included all cases in which there were documented and undocumented aberrant renovascular structures in either test group Table 3.

Rate of ureteral complications

There were no reported recipient ureteral complications in either test group despite the presence of one lower pole artery in each group. Table 3.

Recipient outcome

The mean decreases in creatinine for the predictive and the non-predictive groups were 44.4% and 54.8% on post-op day 1, and 86.1% and 83.9% at 3 months respectively, demonstrating no statistical significance (n=8, p=0.05). None of the patients in either group necessitated dialysis during the first post-operative week. However, two patients in the non-predictive group versus one patient in the predictive group failed to have a 20% creatinine drop on post-operative day 1. These cases met criteria for delayed graft function, but their serum creatinine values normalized by post-operative day 2 Table 5.

The overall numbers of patients with one renal artery who experienced DGF delayed graft function post-operatively was 8, as compared to 3 patients with multiple arteries.

Discussion

Laparoscopic donor nephrectomy has been shown by multiple investigators to be safe and effective, providing kidney donor and allograft outcomes comparable to those of open surgery.[1,9,15-17] However, the issue of multiple renal arteries in laparoscopic

TABLE 5. **Comparison of post-operative kidney function**

		Patients with supernumerary vessels confirmed at laparoscopy (n=22)		**P-value (alpha= 0.05)**
CT angiography	**Overall** (n=48)	**Non-predictive** (n=8)	**Predictive** (n=8)	
Mean serum creatinine POD1 (μmol/L)	345	418	319	0.40
Mean decrease in serum creatinine POD1 (%)	40.1	44.4	54.8	0.37
Mean serum creatinine 3 months post-op (μmol/L)	120	110	105	0.72
Mean decreases in serum creatinine 3 month's post-op (%)	79.4	86.1	83.9	0.59
Patients needing dialysis in week 1	5	0	0	-
Patients with delayed graft function	5	2	1	-

donor nephrectomy is substantial as the presence of multiple renal arteries is not an uncommon clinical problem and presents a special challenge in both donor nephrectomy and renal transplantation. The presence of anonomalous vasculature often requires more complex procurement and reconstruction strategies and has a higher risk of longer renal warm ischemia time and less optimal allograft outcome.[18]

In this study we set out to retrospectively assess the accuracy of 2-D CT angiography for pre-operative mapping of vascular anatomy in laparoscopic live renal donors. Our results demonstrate 85% agreement between CT and laparoscopic findings in these 48 cases. The sensitivity and specificity and accuracy of CT angiography for arterial anatomy were 65%, 100% and 88% respectfully, and for venous anatomy were 50%, 100% and 94% respectfully. When we compared the predictive and non-predictive group, neither the donor morbidity nor recipient outcome were compromised.

In our study, three-dimensional volume rendering imaging was not utilized unlike other recently reported series.[8,10] Our CT imaging protocol was two-dimensional and involved slices of 1.25 mm with a 0.5 mm interval. Del-Pizzo et al[8] utilized 1 mm axial slices with maximum intensity projection reconstruction and reported a sensitivity and specificity of 91% and 98% respectfully in detecting vascular anomalies.[8] Likewise, in a recent report of the first 47 laparoscopic donor nephrectomy patients from Kaynan et al, 1.5 mm slices were utilized with delayed 3-D image reconstruction, and the reported arterial sensitivity and specificity were 50% and 100% respectfully.[10] Our results fall between and compare favorably to these two studies, despite the absence of 3-D digital reconstruction. Since our protocol utilized larger slices, this might have contributed to our 65% arterial sensitivity. El-Fattouh and Gill[7] utilized 1.5 mm intervals with a 50% overlap, with a rigid protocol of 4 cc per second of contrast enhancement for a scan time of 30 seconds, more standardized than in our series, producing an arterial sensitivity of 98%. The latter study also employed 3-D digital videotaping which likely contributed to these impressive results.

In the present study, despite using 2-D imaging as well as relatively thicker slices, renovascular structures missed on CT that might have been visualized with 3-D enhancement did not negatively impact donor morbidity nor graft survival. Several factors could explain these results including the care which was taken to methodically identify and preserve arterial structures throughout the laparoscopic dissection. As the transplant surgeon was always present prior to kidney extraction, his opinion was also strongly regarded in the decision-making process, especially when vascular anomalies were encountered. The decision to harvest the kidney was based on the feasibility of the ex-vivo arterial reconstruction, which was frequently necessary in the cases of multiple arteries to optimize reperfusion of the kidney. There were no cases in which the decision was made to halt the laparoscopic harvest.

In the present investigation, the six patients with non-predictive CTs with respect to their arterial anatomy consisted of a single case of non-visualized early arterial branching and five cases of supernumerary arteries. Two of the patients with multiple arteries, including one patient with three arteries who was thought to have two, had vascular structures located anatomically anterior to the main renal artery. This rendered them difficult to visualize with 2-D CT angiography, but might have been visualized in a 3-D coronal views.[19] Additionally, two of the cases initially reviewed as early arterial branching were found to be distinct arteries intraoperatively. Nevertheless, due to the 12 mm of the vessel length being lost due to the endo-stappler application, we expected to deliver two arteries to the transplant surgeon, and thus this non-visualization had little impact on the operative planning. Kavoussi previously described the same technical issue, in which the use of the vascular endo-GIA resulting in a loss of 1.0 cm-1.5 cm of renal artery length impacts the number of arteries delivered to the transplant surgeons, in cases of early arterial branching.[20]

The renal venous system has a potential vast collateral network, including inferior phrenic, adrenal, gonadal and lumbar veins. In addition, multiple renal veins are present in up to 10% of people.[21,22] The decreased sensitivity of CT angiography in visualizing venous anatomy has been previously documented in large series.[8,10] A scan delay, which may allow for clearer delineation of arterial anatomy, will result in poorer CT venous visualization.[23] The optimum delay time for the scan remains the debated variable.[23] In our series, CT angiography was less sensitive than specific in detecting venous anomalies. The overall number of venous anomalies found intraoperatively was 6/48 patients, three of which being not detected pre-operatively by CT angiography. These three non-visualized cases included two cases of a duplicated vein, as well as one accessory early lumbar vein. Nevertheless, the operative procedure in live-donor nephrectomy requires controlling each venous tributary; therefore this large lumbar tributary did not impact on our dissection. The duplicated veins were

handled similarly whether they were expected from CT (two cases) or discovered at the time of laparoscopic dissection (one case): after taking the opinion of the transplant surgeon, the smallest one was secured and transected early in the procedure with the endo-GIA or Hemo-lock 10 mm clip application.

The three cases of anomalous venous anatomy properly identified by CT angiography included two cases of duplicated renal veins and one case of a retroaortic renal vein. In a recent report by Gill et al,[24] the presence of venous anomalies such as retro or circumaortic veins was not seen to be contraindications for laparoscopic surgery. In this latter study, excellent recipient outcomes were observed, with little deleterious effect on blood loss or donor morbidity.[24] Comparatively in the present study, we observed one case of a retroaortic vein that was expected at the time of surgery from CT angiography. We did not encounter any impact on donor morbidity or graft function in this single patient.

With respect our donor morbidity, the average OR times were 186.7 minutes and 222.5 minutes for the predictive and non-predictive groups respectively. Although the trend did show more OR time for the non-predictive CT cases, it was not statistically significant. This compares favorably with the reported results of Bartlett et al,[15] who reported an average operative time of 202.6 minutes (+/- 51.8 minutes) for left sided laparoscopic live-donor nephrectomy.[9] Their series did include patients with one and two renal arteries, 98% of which were visualized with 3-D CT angiography. Similarly, our reported operative times for both the predictive and non-predictive study groups positively compare to the mean OR time of 221 minutes reported by Gill and colleagues.[7]

The average blood loss in the present study was found to be 226 ml for the predictive group and 269 ml for the non-predictive group, a statistically insignificant comparison. Our results again compare favorably to those published by Gill[7] and Bartlett,[15] who reported estimated blood losses of 175 ml and 128 +/- 179 respectively, both for left-sided laparoscopic nephrectomies. In our study, if we compare the patients with single renal arteries to those with multiple renal arteries, the mean blood loss was 203 ml and 230 ml respectively, the difference being not statistically significant. Therefore, based on our preliminary results, we believe that there is no relationship between the blood loss and the number of renal arteries, irrespective of the CT angiography results. Kavoussi[3] also found no relationship between the number of renal arteries and intraoperative blood loss in his series of 353 patients.

Warm ischemia time (WIT) is an important aspect of laparoscopic renal harvesting, as this parameter has the ability to negatively affect graft function immediately and long-term.[25] More specifically, in review of 100 cases of laparoscopic renal harvesting by Bartlett, warm ischemia time was found to be associated with delayed graft function, as measured by a serum creatinine above 2 mg/dl, only when the number was greater than 10 minutes.[17] Additionally, in a recent series by Gill et al,[26] prolonged WIT (less than 10 minutes) was not found to be associated with increased occurrence of delayed graft function. Whether warm ischemia time can be affected by unexpected vascular structures on pre-operative imaging has not been addressed yet in the literature. In the present study, our WIT for the predictive and non-predictive groups was 2.6 and 2.99 minutes respectively, demonstrating statistical insignificance. This again emphasized the need for meticulous laparoscopic procurement and team collaboration with the transplant surgeon. Our results match-up constructively to recent reported studies. Bartlett,[9,15] who reported average WIT of 167.8 +/- 90.9 seconds. Similarly, Gill reported an average WIT of 256.4 seconds (4 minutes, 16.4 seconds) and 3.6 minutes in a subgroup of patients with retro and circumaortic renal veins.[24,26]

The proximal ureters receive substantial vascular collaterals from the inferior suprarenal branches off the main renal artery.[22,27] Often smaller arteries that supply the lower renal pole also give off substantial branches to the proximal ureter, making their preservation during kidney procurement vital, in order to prevent ureteral necrosis.[28] In the present study, there was were no reported cases of post operative recipient ureteral necrosis in either imaging group, despite the presence of one lower pole artery in each group. This is keeping with Kavoussi's results, which demonstrated no post-operative ureteral complications in patients with anomalous renal vasculature.[3] This author's conclusions were similar to those of the present study, in that meticulous procurement techniques are vital to maintain low morbidity, and low rates of post-operative ureteral complications.

The last aspect of donor morbidity that was investigated in the present study was the conversion rate to open surgery. In our 48 patients, no single case required conversion to open surgery. This is in agreement to recent reports indicating that multiple renal arteries are not associated with higher rates of open conversion.[3]

A foremost motivation of the present study was the investigation of impact of pre-operative imaging on allograft function. Our results demonstrate a mean decreases in serum creatinine for the predictive and non-predictive study groups of 44.8% and 54.8% on post operative day one, and 86.1% and 83.9 % at three months respectively. Although the creatinine values tended to trend lower for those patients with predictive angiography, there was no measurable statistical significance between groups at either time period.

Delayed graft function after live-donor nephrectomy affects 5%-10% of patients, regardless of procurement technique (open versus laparoscopic) and may be associated with increased acute rejection and long-term graft failure.[29,32] While there are both numerous medical and surgical factors related to a delayed onset of renal function in the transplant recipient,[30] focus has been placed on technical aspects of laparoscopy that may increase the risk of delayed graft function compared to open surgery.[31] Nevertheless, recent evidence suggests that neither prolonged pneumoperitoneum, nor renal artery length, nor the multiplicity of renal arteries negatively impacts the risk of delayed graft function.[3,26] In the present study, there were two cases of failure of the creatinine to decrease by 20% on postoperative day 1 in the non predictive group versus one in the predictive group. None of the patients in either group required post-operative dialysis. Importantly, all three patients recovered their renal function on post-operative day 2. This relationship was not statistically significant, and as result, we did not see a deleterious impact of multiple arteries on graft function whether expected or not by pre-operative CT, supporting previously published results.[26,34]

Conclusion

In the present study, we have assessed the sensitivity and specificity of 2-D CT angiography for pre-operative mapping of renovascular anatomy in laparoscopic live donor nephrectomy. Moreover, we compared both predictive and non-predictive CT imaging groups with respect to donor morbidity and recipient outcome. Our results indicate no statistical significance in both groups, emphasizing the need for meticulous laparoscopic procurement technique as well as constant interaction with the transplant surgeon. Despite these positive achievements, our ongoing efforts are targeted at refining the CT angiography technique by incorporating three-dimensional reconstruction in order to increase the sensitivity of pre-operative imaging. □

References

1. Nicholson ML, Bradley JA. Renal transplantation from living donors: should be seriously considered to help overcome the shortfall in organs. *British Medical Journal* 1999;318:409-410.
2. 1995 Annual Report: US Scientific Registry of Transplant Recipients and Organ Procurement and Transplantation Network. Transplant Data: 1988-1995. US Department of Health and Human Services, Health Resources and Services Administration, Bureau of Health resources Development, Division of Transplantation. Tables 12, 18, 26-29 and 40. http://www. Unos.org/UNOSar97//frame1.htm.
3. Thomas HS, Hsu LM, Ratner LE, Trock BJ, Kavoussi LR. Impact of Renal Artery Multiplicity on Outcomes of Renal Donors and Recipients In Laparoscopic Donor Nephrectomy. *Urology* 2003;61(2):323.
4. Lowell JA, Taylor RJ. The evaluation of the living renal donor, surgical techniques and results. *Seminars in Urology* 1994;12;102.
5. Derauf B, Goldberg ME. Angiographic assessment of potential renal transplant donors. *Radiology Clinics of North America* 1987;25:261.
6. Hessel SJ, Adams DF, Abrams HL. Complications of angiography. *Radiology* 1981;138:273.
7. Abou El-Fettouh H, Herts BR, Gill IS. Prospective Comparison of 3-Dimensional Volume Rendered Computerized Tomography and Conventional Renal Arteriography for Surgical Planning in Patients Undergoing Laparoscopic Donor Nephrectomy. *The Journal of Urology* 2003;170:57-60.
8. Del Pizzo JL, Sklar GN, Jacobs SC et al. Helical Computerized Tomography Arteriography for Evaluation of Live Renal Donors Undergoing Laprascopic Nephrectomy. *The Journal of Urology* 1999;162:31-34.
9. Jacobs SC, Cho E, Dunkin BJ, Bartlett ST et al. Laprascopic Live Donor Nephrectomy: The University of Maryland 3-Year Experience. *The Journal of Urology* 2000;164(Nov):1494-1499.
10. Kaynan AM, Rosenblit AM, Lerner Se et al. Use of Computerized Tomography in Lieu of Angiography for Preoperative Assessment of living Renal Donors. *The Journal of Urology* 1999;161(June):1769-1775.
11. Bluemke DA, Chambers PT. Spiral CT angiography: an alternative to conventional angiography (Editorial). *Radiology* 1995;195:317.
12. Cochran ST, Kransy RM, Danovitch RM Rosenthal JT et al. Helical CT angiography for examination of living renal donors. *American Journal of Radiology* 1997;168,:1569.
13. Rubin GD, Alfrey EJ, Dake MD, Semba CP, Sommer FG Jeffrey RB et al. Assessment of living renal donors with spiral CT. *Radiology* 1995;195:457.
14. Hollenbeck, BK, Seifman, BD, Wolf Jr JS. Clinical Skills Acquisition for Hand-Assisted Laparoscopic Donor Nephrectomy. *The Journal of Urology* 2004;171(Jan):35-39.
15. Jacobs SC, Cho Eugene, Foster Clarence, Liao Peter, Stephen T Bartlett. Laparoscopic Donor Nephrectomy: The University of Maryland 6-year Experience. *The Journal of Urology* 2004;171:52-57.
16. Flowers JL, Jacobs S, Cho E et al. Comparison of open and laparoscopic live donor nephrectomy. *Annals of Surgery* 1997;226:483.
17. Sasaki, TM, Finelli F, Bugarin E, Fowlkes D, Trollinger J, Barhyte DY et al. Is the laparoscopic donor nephrectomy the new citerion standard? *Archives of Surgery* 2000;135:943.
18. Kou PC, Bartlett ST Shweitzer EJ, Johnson LB, Lim JW and Dafoe DC. A Technique for management of multiple renal arteries after laparoscopic donor nephrectomy. *Transplantation* 1997;64: 779.

19. Moore CJ. Horton KM. Fishman EK. 3D CT angiography of the kidney. *Critical Reviews in Computed Tomography* 2003;4(5):279-304.
20. Ratner LE, Fabrizio M, Chauvin K, Montgomery RA, Mandal AK, Kavoussi LR. Technical considerations in the delivery of the kidney during laparoscopic live-donor nephrectomy. *Journal of the American College of Surgeons* 1999;189:427.
21. Pollack HM. Clinical Urography. Philadelphia: WB Saunders, pg 2084, 1999.
22. Campbell's Urology. Meredith F. Campbell, Alan B. Retik and Patrick C. Walsh, 4th Edition. Section of Renal Anatomy.
23. Rubin GD, Alfey EJ, Dake MD, Semba CP, Sommer FG, Kuo PC, Dafoe DC Waskerwitz JA Bloch DA, Jeffrey RB Jr. Assessment of Living Renal Donors with Spiral CT. Three Dimensional spiral CT angiography. *Radiology* 1995;195:457.
24. Lin CH, Steinberg AP, Ramani AP, Abreu SC, Desai MM, Kaouk J, Goldfard DA, Gill IS. Laparoscopic Live Donor Nephrectomy in the Presence of Circumaortic or Retroaortic Left Renal Vein. *The Journal of Urology* 2004;171(Jan):44-46.
25. Ratner LE, Montgomery RA, Maley WR, Cohen C, Burdick J, Chavin KD et al. Laparoscopic Live Donor Nephrectomy: the recipient. *Transplantation* 2000;69:2319.
26. Abreu SC, Goldgard DA, Derweesh I, Thornton J, Urbain JL, Mascha E, Steinberg AP, Kaouk JH, Flechner S, Modlin C, Krishnamurthi V, Novick AC, Gill IS. Factors related to Delayed Graft Function after Laparoscopic Live Donor Nephrectomy. *The Journal of Urology* 2004;171(Jan):52-57.
27. Gray SW, Skandalakis JE. Embryology for Surgeons, 2nd edition. Baltimore: Williams and Wilkins, chapter 17, 1994.
28. Lind MY, Hazebroek EJ, Kirkels WJ, Hop WC, Weimar W, Ijzermans JN. Laparoscopic versus open donor nephrectomy: ureteral complications in recipients. *Urology* 2004;63(1):36-39; discussion 39-40.
29. Nogueira JM, Cangro CB, Fink JC, Schweitzer E,Wland A, Klassen DK et al. A comparison of Recipient Renal Outcomes with Laparoscopic versus Open Live Donor Nephrectomy. *Transplantation* 1999;67:722.
30. Shoskes D, Holloran PF. Delay Graft Function in Renal Transplantation: etiology, management, and long-term significance. *Journal of Urology* 1996;155:1831.
31. Khauli RB, Hussein M, Shaar A, Madi R, Medawar W, Habbal A, Kazma A, Dagher F. A prospective evaluation of laparoscopic donor nephrectomy versus open donor nephrectomy. *Transplant Proc* 2003;35(7):2552.
32. Boom H, Mallat MJ, de Fijter JW, Zwinederman AH, Paul LC. Delay Graft Function Influences Renal Function, but not survival. *Kidney International* 2000;58:859.
33. Egglin TKP, O'Moore PV, Feinstein AR, Waltman AC. Complications of peripheral arteriography: a new system to identify patients with increased risk. *Journal of Vascular Surgery* 1995;22;787.
34. Nogueira JM, Cangro CB, Fink JC, Schweitzer E, Wiland A, Klassen DK, Gardner J, Flowers J, Jacobs S, Cho E, Philosophe B, Bartlett ST, Weir MR. A comparison of recipient renal outcomes with laparoscopic versus open live donor nephrectomy. Transplantation 2001;72(2):355-356.
35. Cochran ST, Krasny RM, Rosenthal JM et al. Helical CT Angiography for Examination of Living Renal Donors. *American Journal of Radiology* 1997;168:1569.
36. Sussman SK, Weinreth JL, Braun SD, Saeed M., Illescas FF, Cohan RH, Newman GE, perlmutt LM, Dunnick NR. Intravenous Digital Subtraction Angiography in the Evaluation of Potential Renal Donors. *Journal of Urology* 1987;138:28.
37. Walker TG, Geller SC, Delmonico FL, Waltman AC, Athansoulis CA. Donor Renal Angiography: its influence on the decision to use the right or left kidney. *American Journal of Roengentology* 1998;151:1149.