Evaluation of potential live kidney donors using 64-slice multidetector CT

Poster No.: C-1360
Congress: ECR 2010
Type: Educational Exhibit
Topic: Genitourinary
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Keywords: living donor, Kidney, multidetector CT
DOI: 10.1594/ecr2010/C-1360

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Learning objectives

* Describe the 64-slice multidetector CT (MDCT) scanning protocol for preoperative evaluation in patients considering donor nephrectomy.

* Comprehensive illustration of the angiographic appearance of surgically relevant arterial, venous and parenchymal variants.

* Split renal function evaluation by promising cortical perfusion technique.

Background

- Kidney transplantation is considered the treatment modality of choice for the majority of patients with end stage renal disease. Living donor renal transplantation has better renal survival rate than cadaveric graft survival rate.

- 64-rows MDCT systems offers shorter image acquisition time, narrow collimation, improved temporal & spatial resolution and near isotropic data acquisition which is advantageous for two- and three-dimensional imaging.

- CT angiography is becoming an important non invasive means that have significant impact on surgical planning. The exclusion criteria for donation e.g. horseshoe kidney, multiple renal arteries, urolithiasis, complex venous anatomy, renal neoplasm can be evaluated accurately. The modality provides a comprehensive examinations that answers a number of specific questions including numbers, course and caliber of the arteries. Numbers of renal veins and its variants. The status of renal parenchyma and functional evaluation.

**Technique :-**

* No evidence of established technique proved to be optimal as the optimal delay time for each imaging phase depends on multiple variables with the section
thickness option, the number of phases, the volume, the concentration, rate of contrast administration and the subjects cardiac output.

* The formal phases include noncontrast, arterial, venous and excretory phases.

*The examination is obtained using 64-rows Multidetector CT scanner. No oral contrast medium is given. Unenhanced CT scan is obtained from the 11th thoracic vertebral body to iliac crest. This scan is used to localize the kidneys and to provide diagnostic information (e.g., show renal calculi and provide baseline attenuation measurements of renal masses or other unexpected findings). These data were used to assess any renal calcification or obvious abnormality that would preclude nephrectomy and to identify the scanning range for contrast enhanced images. The contrast enhanced scans were obtained from the level of celiac axis to 2 cm below the aortic bifurcation. Nonionic contrast medium containing 350mg iodine per milliliter is injected at 4 mL/s via an 20-gauge peripheral line in an antecubital vein. The estimated dose is determined on the basis of patient body weight as 2ml per kilogram. The start time of arterial phase scanning is determined using automatic bolus tracking (Smart Prepare). For the arterial phase, scanning was initiated approximately 20 seconds after bolus injection, and the area of coverage included from T11 to the S2 level to allow coverage of the common iliac artery bifurcation. For the nephrographic phase, scanning begins 80 seconds after the end of the arterial phase with the same scanning parameters. For the excretory phase, scanning begin 5 minutes after the nephrographic phase. The area scanned ranged from above the kidneys to the bladder base.

**Post processing of CT Data :-**

The active role of the radiologist is creation of the image analysis by the data transferred to freestanding workstation. For each CT examination, the radiologist studies the source axial images, which are supplemented by multiplanar reformations (MPRs), volume rendering (VR), and maximum intensity projections (MIPs) as necessary. The radiologists edits CT volume data sets to create optimal 3D angiography and urography images. Coronal, sagittal, and curved MPR images is used to evaluate vascular anatomy.
- Normally the right renal artery orifice is more superior than the left and arising from the anterolateral aspect of the aorta.

- The left renal vein receives the left adrenal, gonadal and lumbar veins and then passes between and anterior to the aorta and posterior to the superior mesenteric artery to enter the medial side of inferior vena cava. The right renal vein is shorter than the left and receives no tributaries (fig1) on page ______.

**Fig.**: Fig 1: Enhanced axial image shows the right renal artery arises from the anterolateral aspect of the aorta, the left one arises from its lateral aspect(a). The
main renal artery divides into anterior and posterior branches(b). 3D VR image shows bilateral single renal arteries(c).

References: H. F. Refaie; Radiology, Urology & Nephrology Center, Mansoura, EGYPT

- Accessory renal arteries are the most common variant & are seen in about one third of population, 23% had double renal arteries, 4% triple renal arteries, 1% quadruple renal arteries. Bilateral multiple renal arteries in 10-13% of the population (Fig 2 on page 21 & 3 on page 22).

Fig.: Fig 2. Coronal VR images show bilateral renal arteries with low position accessory right lower polar artery and left high position one(a) bilateral low position lower polar arteries(b).

References: H. F. Refaie; Radiology, Urology & Nephrology Center, Mansoura, EGYPT
Fig.: Fig 3. Coronal maximum intensity projection (MIP) image shows triple left renal arteries arising from different levels of the aorta.

References: H. F. Refaie; Radiology, Urology & Nephrology Center, Mansoura, EGYPT

- The origin of the accessory renal arteries may be a high or low position of the abdominal aorta. The accessory renal arteries are categorized according to their course as either polar (piercing the upper or lower pole of the kidney) or hilar (entering the kidney at the hilum). The polar accessory renal arteries are usually smaller, but hilar accessory arteries are not always smaller than the principal arteries (Fig 4 on page 23 & 5 on page _).
Fig.: Fig 4. Coronal MIP image shows left low position polar artery originating from the aorta near its bifurcation.

References: H. F. Refaie; Radiology, Urology & Nephrology Center, Mansoura, EGYPT
Fig.: Fig 5. Coronal MIP image shows right accessory right accessory artery piercing the upper pole and giving an origin of accessory phrenic artery.

References: H. F. Refaie; Radiology, Urology& Nephrology Center, Mansoura, EGYPT

-Prehilar branching is a variant in which the renal artery branches before it reaches the renal hilum. It is important to detect any prehilar branching that occurs within 2cm of the renal artery from the aorta because most surgeons require at least 2cm length of renal artery to ensure adequate anastomosis (Fig 6) on page .
Fig.: Fig 6. Coronal MIP images shows "short neck" right renal arteries (a,b).

References: H. F. Refaie; Radiology, Urology & Nephrology Center, Mansoura, EGYPT

Variations of renal venous anatomy is less common than arteries. Multiple renal veins are the most common variant seen in about 15-30% of the population and more seen on the right side (Fig 7) on page 24.
Fig.: Fig7. Coronal MIP images show double right renal arteries with double renal veins (a) VR images show conjoint two renal veins entering the renal hilum (b&c). Coronal MIP image show dilated gonadal vein draining into the left renal vein(d).

References: H. F. Refaie; Radiology, Urology& Nephrology Center, Mansoura, EGYPT

-The most common anomaly of the left renal vein is the circumaortic left renal vein. In circumaortic renal vein the left renal veins divided into ventral and dorsal limbs that encircle the abdominal aorta. The gonadal vein enters into the retroaortic limb inferiorly (Fig 8) on page 25. Retroaortic renal veins is also seen in 2%-3% of population (Fig 9) on page 25.
**Fig.**: Fig.(8): Coronal oblique MIP images show circumaortic left renal vein (a), with accessory left renal artery enter the hilum (b), a lumbar vein draining into the retroaortic component (c), VR image shows the preaortic and retroaortic component of the left renal vein (d).

**References**: H. F. Refaie; Radiology, Urology& Nephrology Center, Mansoura, EGYPT
Fig.: Fig 9. Coronal (a) and axial (b) VR images show retroaortic left renal vein. Enhanced axial CT image shows left retroaortic vein (c) that runs caudally in coronal images(d).

References: H. F. Refaie; Radiology, Urology& Nephrology Center, Mansoura, EGYPT

- The late venous confluence is another venous variant which is diagnosed on the left side (Fig 10) on page .
Fig.: Fig 10. Oblique MIP image shows late confluence of the left renal vein. There are two hilar origins join to becomes a single vein draining into I.V.C.

References: H. F. Refaie; Radiology, Urology& Nephrology Center, Mansoura, EGYPT

- IVC anomalies reflect abnormal regression or persistence of venous embryonic veins. Double IVC (right & left) has prevalence of 1% - 3% which results from persistence of both the right and left supracardinal veins (Fig 11) on page 26.
Fig.: Fig 11. Axial and MIP coronal images show right and left infrarenal I.V.C, the right renal vein drain into right I.V.C. (a) The left I.V.C. drain into the left renal vein which join the right one. (b) Coronal VR image shows double I.V.C. (c).

References: H. F. Refaie; Radiology, Urology & Nephrology Center, Mansoura, EGYPT

- Renal parenchymal evaluation may reveal incidental findings such as nonobstructing 3-mm-or-less stones (Fig 12) on page , tiny nonenhancing lesions such as cysts (Fig 13) on page , and cortical irregularity may be considered in kidney selection because the less normal appearing kidney is selected for harvest, thus the donor retains the more normal kidney (Fig 14 on page & 15 on page ). In general, the presence of congenital pelvicalyceal anomalies (fig 16) on page 27 or solid (angiomyolipoma or renal cell carcinoma) renal lesions (Fig 17) on page precludes a subject from donation.
**Fig.**: Fig 12. Unenhanced axial image shows left minute stone.

*References:* H. F. Refaie; Radiology, Urology & Nephrology Center, Mansoura, EGYPT
**Fig.**: Fig 13. Enhanced axial image shows small posterior left subcapsular non enhancing parenchymal cyst.

*References*: H. F. Refaie; Radiology, Urology & Nephrology Center, Mansoura, EGYPT
**Fig.**: Fig 14. Coronal non contrast image show significant disparity of the kidney size(a), coronal CT urography show perfect excretory function of the small sized kidney with smooth outline and regular interpapillary line(b).

**References:** H. F. Refaie; Radiology, Urology& Nephrology Center, Mansoura, EGYPT
**Fig.**: Fig 15. Enhanced axial CT image on the nephrographic phase shows persistent fetal lobulation and accessory retroaortic renal vein.

*References:* H. F. Refaie; Radiology, Urology & Nephrology Center, Mansoura, EGYPT
Fig.: Fig 16.3D VR image show normal configuration of the pelvicalyceal systems, normal course and caliber of both ureters (a), coronal MIP image show bilateral bifid pelvicalyceal system (B) coronal MIP image show right infundibulo-pelvic stenosis (c) excretory CT urography show right renal pelvis non obstructed fullness(d).

References: H. F. Refaie; Radiology, Urology& Nephrology Center, Mansoura, EGYPT
Fig.: Fig 17. Axial unenhanced image shows focal lower polar contour bulge (a). Axial and coronal nephrographic phase shows an enhancing small cortical mass confined to the renal capsule which proved histopathologically as RCC (b,c).

References: H. F. Refaie; Radiology, Urology & Nephrology Center, Mansoura, EGYPT

- Functional evaluation can be done using CT cortical perfusion technique. The image data acquired from perfusion scan analyzed by perfusion window which generates reference image and time Maximum Intensity Projection image (tMIP image). The reference image used to select the arterial input ROIs and serve as an anatomical reference for the functional images. While the tMIP image used for tissue ROIs insertion. A tissue-time intensity curve and quantitative report will be displayed automatically (fig18) on page 28.
Fig.: Fig 18. tMIP image shows arterial ROI( of the aorta), cortical tissue ROI at the right kidney (T1), the left kidney (T2 )(a). Color map image shows normal cortical color perfusion of both kidneys(b). Time Attenuation Curve of both kidneys(c). Quantitative report shows the perfusion values and peak arterial enhancement(d).

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Images for this section:
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Conclusion

-64-Slice multidetector CT can provide accurate anatomical details, regarding the anatomy of the urinary tract and renal vasculature. It can detect renal and vascular abnormalities that might be surgically relevant and potentially significant for safe renal donation.

-In addition, perfusion CT can give an idea about the split kidney function, but still isotope renography is considered the gold standard for functional evaluation.

-So, a single MDCT examination of the donors allowing the proper selection of the kidney for nephrectomy based on both anatomical and functional assessment.

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