

Peer Reviewed **Article of Interest****A PICTORIAL PRESENTATION OF CT KIDNEY LESIONS IN ADULTS, PARTICULARLY KIDNEY CANCER: PART 4**Joel Harold Bortz¹ MB ChB [Cape Town]; DMRD [London]; FRCR [London]; FFRRCS [Ireland]Riaan van de Venter² DRad, MTech:Rad (research), PDTELeonie Munro³ ND Rad (D), MA, P Grad Dip: Public Admin, Cert for trainers¹LSG Imaging, Los Angeles, California, America²Lecturer, Nelson Mandela University, Port Elizabeth, South Africa³Durban, South Africa**ABSTRACT**

There are many pathologies that affect the kidneys. The focus of this paper is computed tomography of kidney cancer. Other imaging modalities for kidney pathologies are briefly discussed. A few examples of benign tumours and masses are presented. The bulk of the paper is a pictorial presentation of kidney cancer and its spread to other organs and bones. A range of unenhanced and enhanced CT images are included for self-assessment.

Keywords: renal cell carcinoma, lymphadenopathy, oncocytoma, imaging modalities

LAY ABSTRACT

Imaging of the kidneys is done to find out whether a mass in a kidney may be a benign tumour, cyst or cancer. If it is a cancer then it is important to check whether there is spread to other organs. Examples of computed tomography (CT) are used to describe the different patterns of benign and cancer lesions.

11. PICTORIAL PRESENTATION OF ENHANCED CT CASES OF KIDNEY LESIONS AND SPREAD TO OTHER REGIONS

Tips on how to evaluate CT images for cancer of the kidney underpin the pictorial examples of kidney lesions and spread to other regions.

11.1 Tips to evaluate 2D CT images for cancer of the kidney

Care must be taken to methodically evaluate the images obtained of a

patient who (i) is suspected of having cancer of the kidney, (ii) has undergone screening CT colonography, or (iii) has abdominal pain, loss of weight or blood in the urine. Usually a CT examination for these reasons includes the lung bases, and views of the pelvis include the bony pelvis and upper end of both femurs. The protocol for follow-up of a patient who has had a nephrectomy is a full CT scan with contrast media and includes the lungs.

As shown in this article spread of cancer from the kidney may be wide-

spread. It is thus important to perform a careful analysis of each image. There are many ways to evaluate CT scan images. The preference of the main author is to check organ by organ and to check that the base of the lungs, as well as the upper femora, are included in the study. His systematic method to assess each image is presented below. It is important to assess an entire scan (i.e., from left to right) as there may be pathology in more than one organ, bones, and vessels. Examples are presented below.



Figure 11.2a. Unenhanced 2D axial supine scan shows no pathology.



Figure 11.2b. Unenhanced 2D axial prone view of the same patient showing a non-calcified lesion (white arrow) and represents a secondary deposit. Its visualisation is due to greater coverage of the lung fields in the prone position.

11.2 Lungs and ribs

These are a favourite site for metastatic spread of renal cancer. The spread may be in the form of multiple secondary deposits which initially may be small (e.g., 2mm in size). They may over time increase in number and size until quite large and may finally resemble 'cannonball' secondaries. Spread

may affect upper, middle, and lower parts of a lung. Spread is usually bilateral but is not symmetrical. Examine the costo-phrenic angles carefully to see if fluid is present indicating a pleural effusion. Examine the mediastinal area carefully (the space between the right and left lung) to check whether there is a presence of enlarged lymph

nodes. The hilar region is not the only area where glandular spread may occur. Kidney cancer frequently spreads to bone. Look carefully at the ribs for destruction; there is frequently an associated soft tissue mass present. Figures 11.2a and b show the value of two views. Figures 11.2c to j are examples of spread to lungs and ribs.

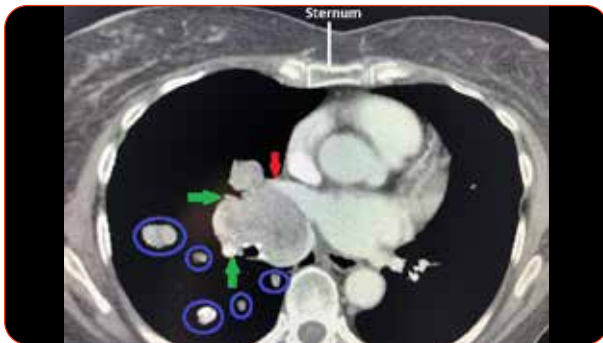


Figure 11.2c. Enhanced axial CT scan showing (i) small secondary deposits (blue circles) in the right lung from a RCC, and (ii) large right hilar lymph node (green arrows) compressing right superior pulmonary vein (red arrow).

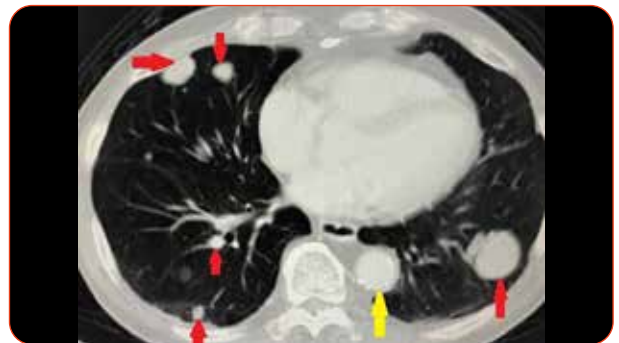


Figure 11.2d. Enhanced axial CT scan showing multiple small secondary deposits (red arrows) in both lung fields. Primary lesion RCC. Descending aorta (yellow arrow).



Figure 11.2e. Enhanced axial CT scan showing (i) secondary deposits (red circles) in the left lung, and (ii) large hilar lymph node mass on the right (green arrow) and on the left (red arrow). Primary lesion RCC.



Figure 11.2f. Enhanced axial CT scan showing post carinal lymph nodes (green arrows) and left hilar lymph nodes (red arrows). Small effusion in left lung (blue arrow). Irregular mass (purple arrow) in left upper lobe. Small amount of air visible (purple circle) suggestive of necrosis. Primary lesion RCC.



Figure 11.2g. Enhanced axial view showing multiple large 'cannonball' secondaries (red circles). Secondary in the left upper lobe (blue hexagon). Enlarged lymph nodes (red and green arrows).



Figure 11.2h. Enhanced axial CT scan showing irregular mass lateral to the left thyroid gland (red circle). This is a proven secondary from a RCC. RC = right clavicle. LC = left clavicle. Trachea (green arrow).

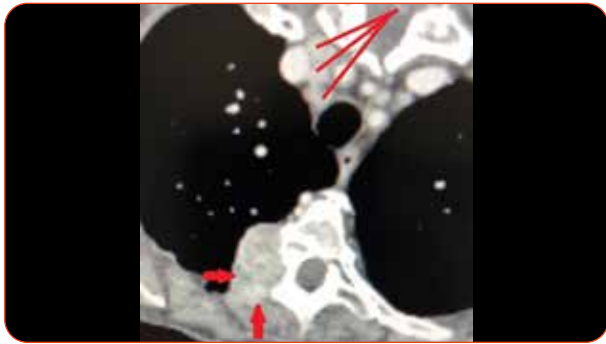


Figure 11.2i. Enhanced axial view showing destruction of right rib with an associated soft tissue mass (red arrows). Additional secondary lymph nodes in the mediastinum (red lines).

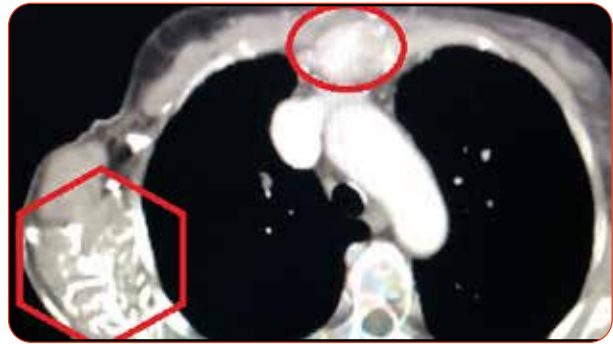


Figure 11.2j. Enhanced axial CT scan showing (i) extensive destruction of right scapula (red hexagon) from spread of RCC, and (ii) destruction of sternum (red circle).

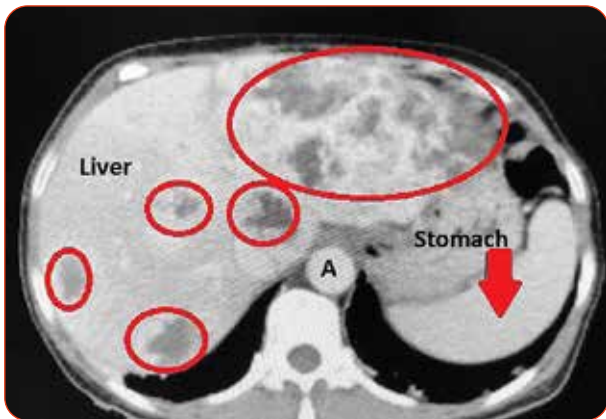


Figure 11.3a. Axial view showing multiple lesions in the liver due to secondary deposits (red circles). Aorta (A). Spleen (red arrow).

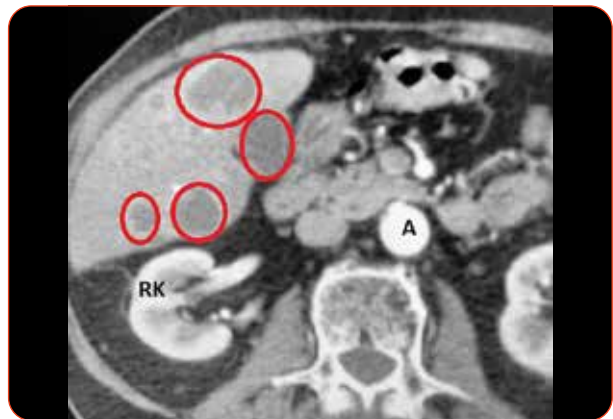


Figure 11.3b. Enhanced axial view showing multiple lesions (red circles) in the liver. Aorta (A). Right kidney (RK).



Figure 11.3c. Enhanced axial view showing multiple lesions (red circles) in the liver. Aorta (A).

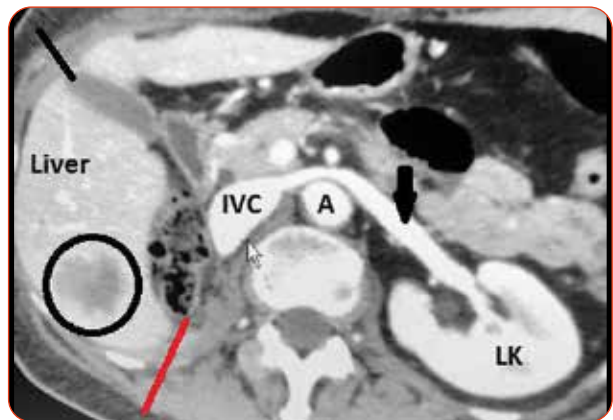


Figure 11.3d. Enhanced axial view showing an irregular lesion in the liver (black circle). Red line = bowel lying in the right renal bed following a right nephrectomy. Black line = gallbladder. Aorta (A). Left kidney (LK). Inferior vena cava (IVC). Black arrow = left renal vein entering the IVC.

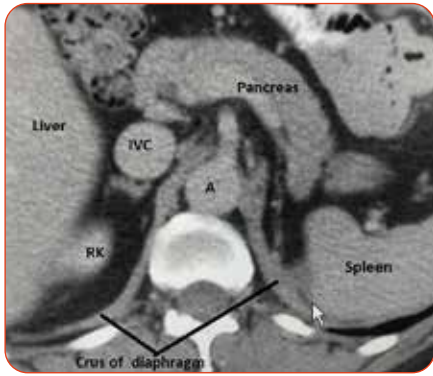


Figure 11.4a. Enhanced axial CT scan showing the position of the spleen and pancreas following a left nephrectomy. IVC = inferior vena cava. A = aorta. RK = right kidney which is just coming into view on this slice.

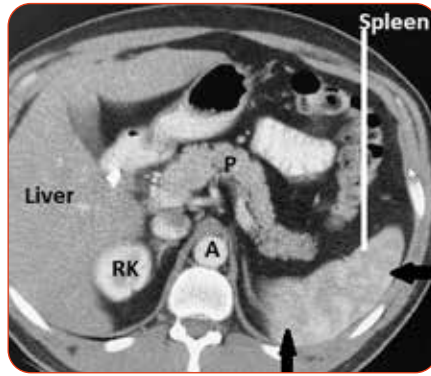


Figure 11.4b. Enhanced axial CT scan showing the spleen lying in the space of the left kidney. Black arrows show areas of hypo and hyper-density in the spleen and are termed 'zebra' spleen. This is a normal finding that is caused by variable flow rates of contrast filled blood through the spleen.^[42] P = pancreas. RK = right kidney. A = aorta.

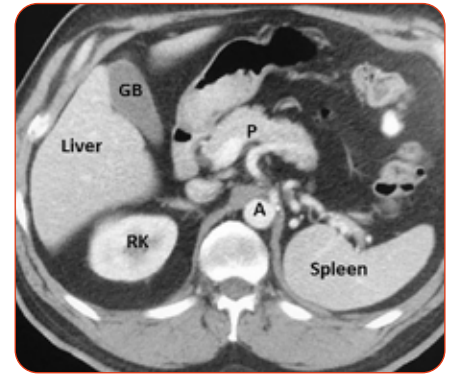


Figure 11.4c. Axial enhanced CT scan showing left nephrectomy. The spleen is lying in the space previously occupied by the left kidney. RK = right kidney. GB = gallbladder. A = aorta. P = pancreas.

11.3 Liver

This organ is a frequent site of secondary spread and may involve either the right or the left lobe or both lobes. A secondary in the liver may be single or multiple. They show up as areas of decreased density and the lesion may be small or big and usually is a little irregular on its edges. If contrast enhanced CT has been performed the secondary deposits will usually enhance. Always check for ascites (fluid) around the liver. Figures 11.3a to d focus on spread into the liver. Other examples of lesions in the liver are also included in our discussions below.

11.4 Spleen and pancreas

Most spleens are in the left upper quadrant (see Figure 2.1) and are not

usually involved in spread of a tumour. A spleen's position does however usually shift in a patient who has had a left nephrectomy. It shifts to the area of the left renal bed where the kidney used to be positioned. Its orientation also changes and it tends to lie in a horizontal position. The position of the pancreas also changes in these patients. Its body and tail tend to dip vertically towards the renal bed. The splenic artery and vein accompany the pancreas in this move. Figures 11.4a to c focus on the position of the spleen and pancreas. There are more examples in 11.10.

11.5 Venous system

Particular attention must be paid to the renal veins in all cancers of the kidney. The renal veins join the inferior

or vena cava (IVC) as shown in Figure 11.5a. Tumour may spread to the IVC and propagate cranially into its hepatic portion, as well as into the right heart. Figures 11.5b and c are examples of the latter spread.

It is important to check the CT scans during the different phases of enhancement of these veins, especially of the renal ones, to see whether the veins are dilated as a result of tumour spread. The latter shows as a mottled appearance of the renal veins and IVC. The tumour may cause thrombi (blood clots) in the vessels and may then present a confusing picture. Blood clots that break off and stop blood flow are called emboli. Figures 11.5d to j are examples of tumour spread.



Figure 11.5a. (1020): Enhanced axial CT scan showing renal veins (green arrows). Red arrow = IVC. RK = right kidney. LK = left kidney.



Figure 11.5b. Enhanced axial view showing a large filling defect in the right atrium (red arrow). A = aorta.

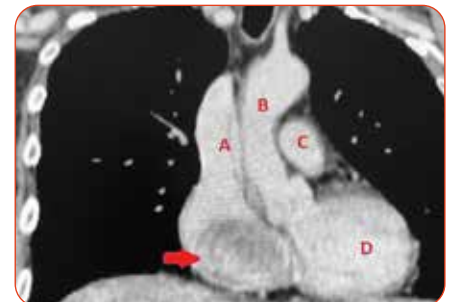


Figure 11.5c. Enhanced coronal view showing large filling defect (arrow) in the right atrium and ventricle in keeping with tumour mass. A = superior vena cava (SVC). B = aorta. C = pulmonary artery. D = left ventricle.

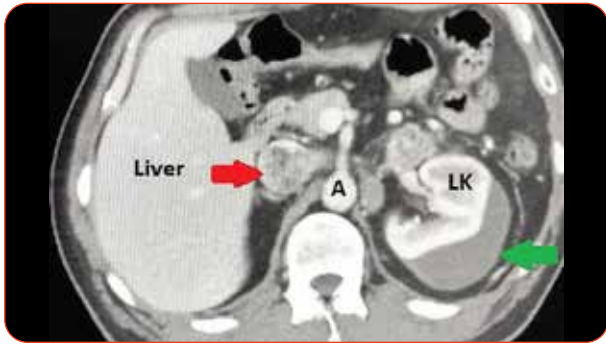


Figure 11.5d. Enhanced axial view showing left kidney (LK), aorta (A) and inferior vena cava (red arrow). The IVC shows filling defects indicating tumour spread from the LK. Green arrow = fluid around the kidney. Slightly increased density probably indicates the presence of blood.



Figure 11.5e. Enhanced axial view showing tumour spread into the left renal vein (yellow arrow) entering the IVC. Red arrow indicates cancer of the left kidney (LK). Green arrow = fluid around the kidney. Slightly increased density probably indicates the presence of blood. A = aorta. RK = right kidney.

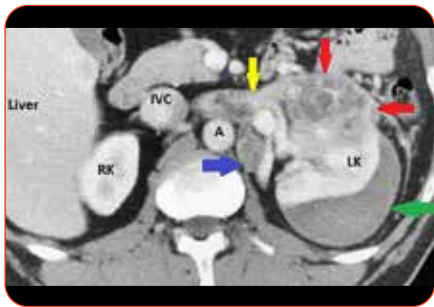


Figure 11.5f. Enhanced axial view showing tumour (red arrows) in the left kidney (LK) with tumour spread into the left renal vein (yellow arrow). Blue arrow indicates enlarged lymph node. Green arrow = fluid around the kidney suggest the some blood within the fluid. IVC = inferior vena cava. A = aorta. RK = right kidney.

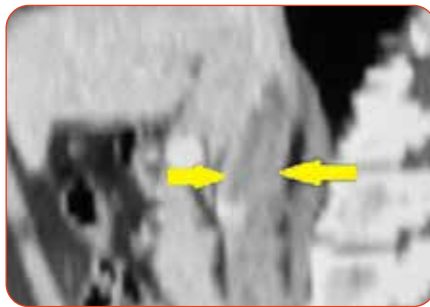


Figure 11.5g. Enhanced sagittal view. Yellow arrows indicate a large filling defect in the superior aspect of the IVC due to tumour embolisation.

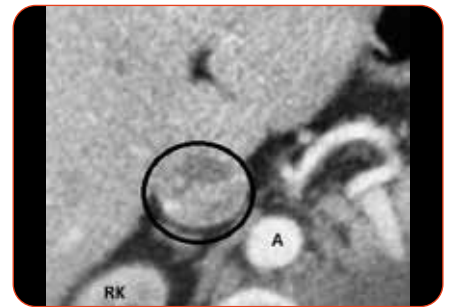


Figure 11.5h. Coned axial view following i.v. contrast administration showing poor enhancement of the IVC (black circle) due to tumour within the vessel. RK = right kidney. A = aorta.



Figure 11.5i. Enhanced axial image showing the renal veins (purple arrows) entering an enlarged proximal IVC (red arrows). Both kidneys (RK and LK) are normal and show no evidence of tumour. The left renal artery (white arrow) is clearly delineated. Histology revealed a sarcoma of the IVC.

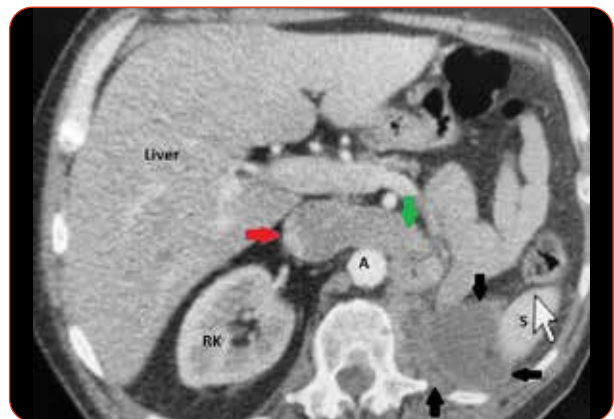


Figure 11.5j. Post-enhancement axial view showing left kidney nephrectomy with residual fluid in the renal bed (black arrows). Tumor spread into the left renal vein (green arrow) and the inferior vena cava (red arrow). RK = right kidney, A = aorta, S = spleen.

11.6 Kidneys

A renal tumour is usually unilateral and ranges in size from small to large sizes > 20cms. A tumour alters the outline of a kidney; it may be a small bulge resembling a cyst but with higher HUs. Within the affected kidney there may be areas of calcification or areas of decreased density indicating necrosis. In a small percentage of nephrectomy cases there may a recurrence in the remaining opposite kidney. Right renal tumours are presented in Figures 11.6a to f. Left renal tumours are presented in Figures 11.6g to m. Bilateral renal lesions are presented in Figures 11.6n to p.

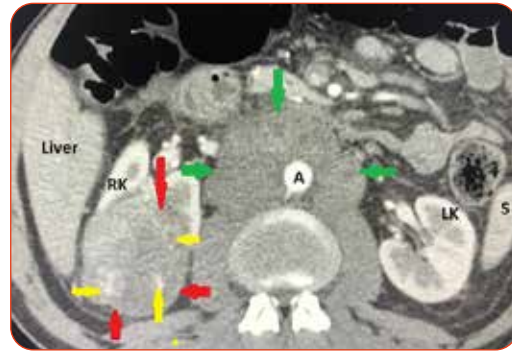


Figure 11.6a. Enhanced axial CT scan showing tumour mass arising from the upper and middle poles of the right kidney (red arrows) in keeping with renal cell carcinoma (RCC). Yellow arrows show calcifications. There is para-aortic lymphadenopathy (green arrows) in keeping with metastatic spread. A = aorta. LK = left kidney. S = spleen.



Figure 11.6b. Enhanced sagittal view of the same patient showing tumour (red arrows) in the upper and middle poles of the right kidney (RK). GB = gallbladder.

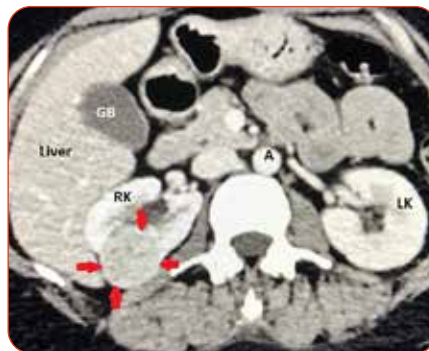


Figure 11.6c. Enhanced axial CT scan showing tumour mass in right kidney (red arrows). Histology confirmed RCC. A = aorta. LK = left kidney. GB = gallbladder.



Figure 11.6d. Enhanced axial CT scan showing tumour mass in right kidney (red arrows). Green arrow = right renal artery. A = aorta. LK = left kidney.



Figure 11.6e. Large well-defined mass (red arrows) arising from the mid and lower poles of the right kidney (RK) in keeping with RCC. Yellow arrows indicates a mass within the IVC. Slightly enlarged lymph node is noted between the IVC and aorta (A). LK = left kidney.



Figure 11.6f. Enhanced axial CT scan showing (i) RCC in the right kidney (purple arrow), and (ii) para-aortic lymphadenopathy (red arrows) causing encasement of the left renal artery (green arrow). A = aorta. LK = left kidney. GB = gallbladder.

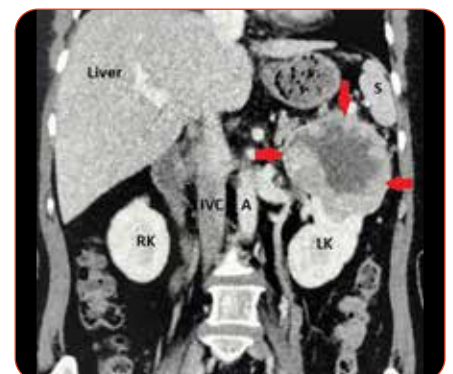


Figure 11.6g. Coronal enhanced CT scan showing large tumour mass in upper pole of the left kidney (red arrows). Histology showed renal cell carcinoma (RCC). RK = right kidney. IVC = inferior vena cava. A = aorta. S = spleen.

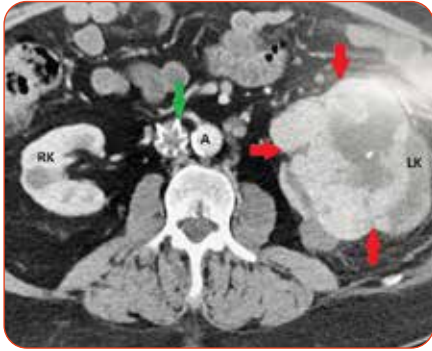


Figure 11.6h. Axial enhanced CT scan showing a large lobulated mass in the left kidney (red arrows) in keeping with RCC. There is a 'star-shaped' metallic artefact (green arrow) in the IVC. It is an IVC umbrella that is used to prevent thrombi or spread of tumour emboli. RK = right kidney. A = aorta.

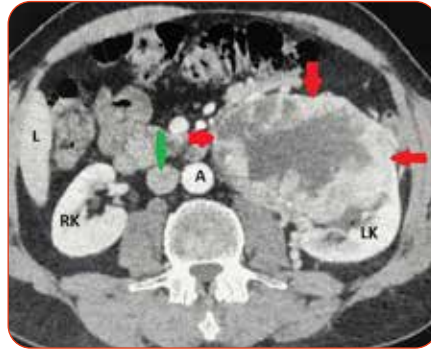


Figure 11.6i. Enhanced axial CT scan showing large mass in the middle and upper poles of the left kidney (red arrows). Histology showed RCC. RK = right kidney. A = aorta. IVC (green arrow). L = liver.

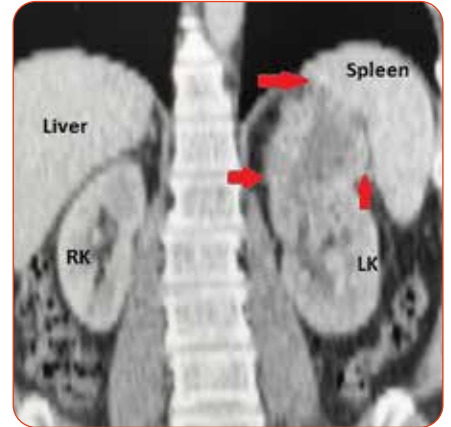


Figure 11.6j. Enhanced coronal view showing cancer of the upper pole (red arrows) of left kidney (LK) adjacent to the spleen. RK = right kidney.



Figure 11.6k. Enhanced axial CT scan showing a large irregular mass (red arrows) in the upper and mid poles of the left kidney (LK). RK = right kidney. A = aorta. GB = gallbladder.

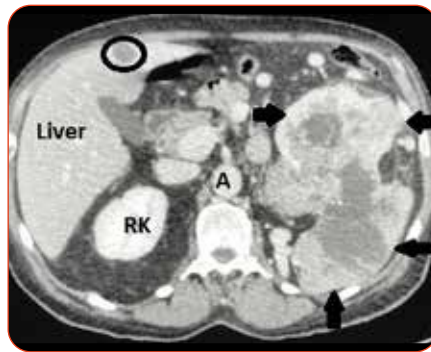


Figure 11.6l. Enhanced axial view showing large left renal carcinoma (black arrows) replacing the kidney. Low density in the left lobe of the liver (black circle) represents metastasis.

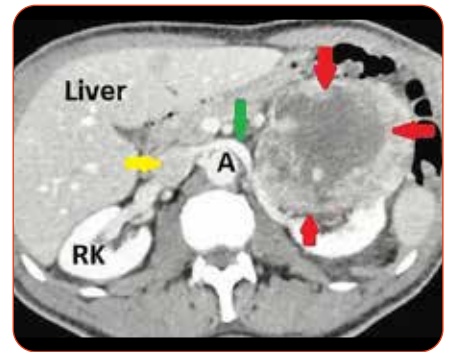


Figure 11.6m. Enhanced axial view showing large carcinoma of the upper and middle poles (red arrows) of the left kidney. Left renal vein (green arrow) is well opacified and appears normal joining the IVC (yellow arrow).

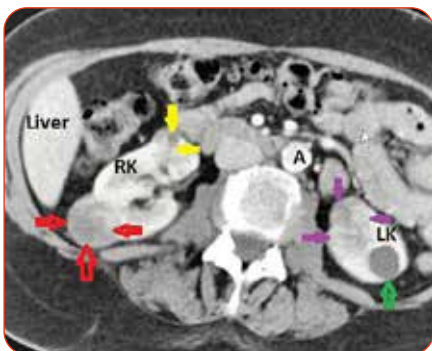


Figure 11.6n. Enhanced axial view showing bilateral pathology. Mass (red arrows) in the lower pole of the right kidney (RK) and a mass (yellow arrows) in the upper pole. Cyst (green arrow) and a mass (purple arrows) in the left kidney (LK). Aorta (A).

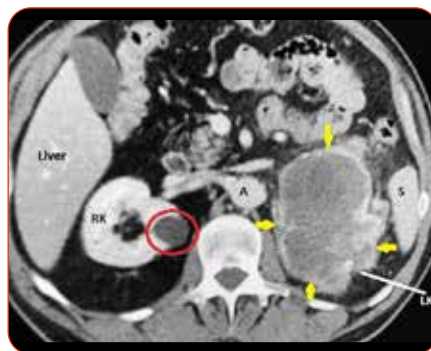


Figure 11.6o. Enhanced axial view showing a cyst (red circle) in the right kidney (RK), and a carcinoma (yellow arrows) in the left kidney (LK). Aorta = A. Spleen = S.



Figure 11.6p. Enhanced axial view showing bilateral carcinomas indicated by red and yellow arrows. Right kidney (RK) and left kidney (LK). Aorta = A. No para-aortic lymphadenopathy present.

11.7 Adrenal glands

As described in the anatomy section above the perinephric space includes the kidneys and adrenal glands (see Figures 2.4a and b). These glands lie above each respective kidney. They may be involved in renal cancer spread, which may be to one or both glands. Such spread is easily detected on CT by observing nodules in one or both limbs of the gland. As the secondary spread to a gland increases in size, it may replace the whole gland and this results in a unilateral or bilateral mass. Figures 11.7a to e are examples of spread to the adrenals.

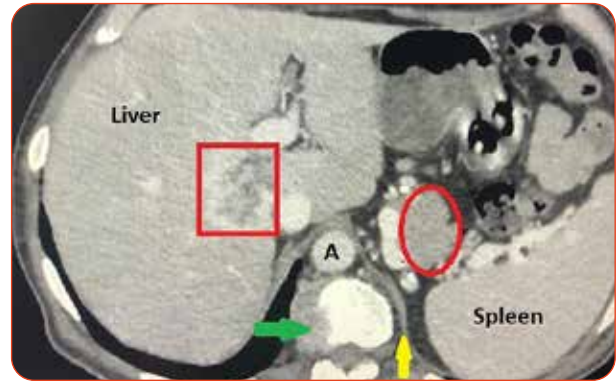


Figure 11.7a. Axial view showing mass in the left adrenal (red circle). The spleen is lying in the renal bed of the left kidney of a patient that had a nephrectomy. There is tumour in the liver (red square). A = aorta. Yellow arrow = crus of left diaphragm. There is destruction of the right side of the vertebral body with a soft tissue mass in keeping with a secondary (green arrow).

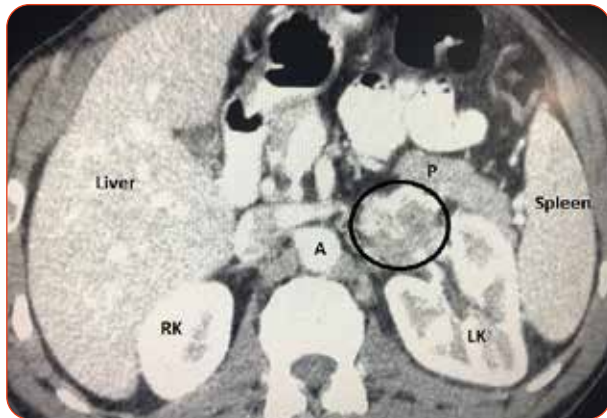


Figure 11.7b. Enhanced axial view showing tumour mass in the left adrenal gland (black circle). LK = left kidney. RK = right kidney. P = pancreas. A = aorta.

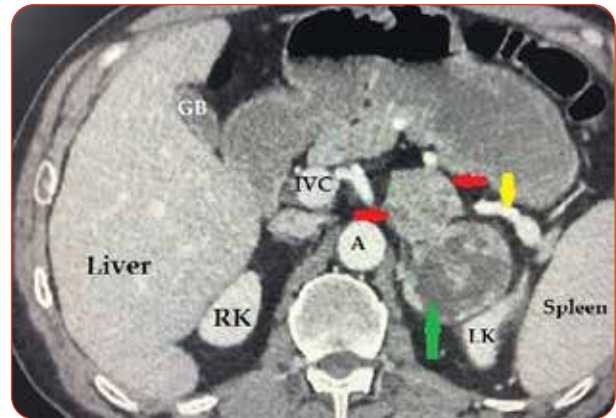


Figure 11.7c. Enhanced axial view showing bi-lobed left adrenal mass with hyperdense superior aspect (red arrows) and low density inferior aspect (green arrow) suggestive of necrosis. Features compatible with metastatic deposit. LK = left kidney. Left renal vein (yellow arrow). IVC = inferior vena cava. A = aorta. RK = right kidney. GB = gallbladder.

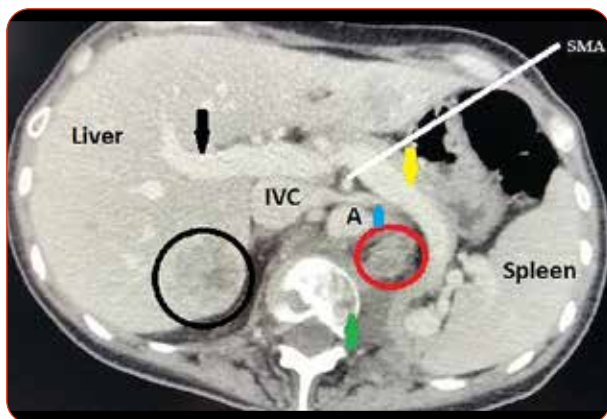


Figure 11.7d. Enhanced axial view showing secondaries in the left adrenal (red circle) of a patient who had a left nephrectomy. Black circle = metastases in the liver. Destruction of the vertebra (green arrow). A = aorta. IVC = inferior vena cava. Yellow arrow = splenic vein. Black arrow = portal vein. Blue arrow = left renal vein. White line = superior mesenteric artery (SMA).

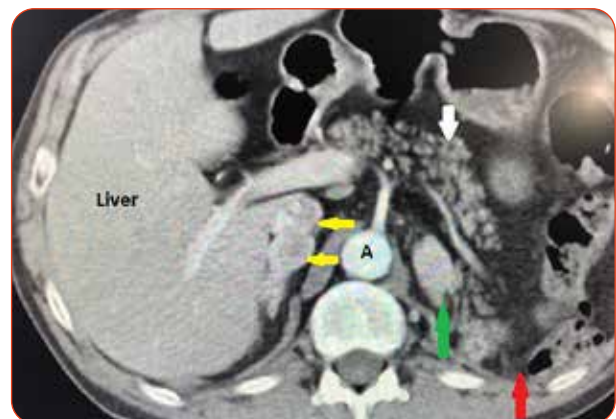


Figure 11.7e. Enhanced axial view of a post left nephrectomy. Opacity in the left renal bed (green arrow) probably represents recurrence of tumour. Bowel in renal bed (red arrow). Pancreas (white arrow). Right adrenal gland shows bi-lobed cystic mass (yellow arrows) compatible with metastasis. A = aorta.

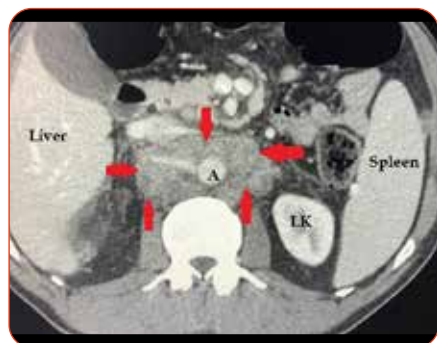


Figure 11.8a. Enhanced axial view showing para-aortic lymph nodes (red arrows) encasing aorta (A). Right nephrectomy. LK = left kidney.

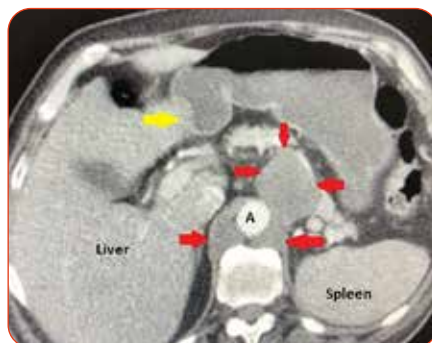


Figure 11.8b. Axial view showing para-aortic lymph nodes (red arrows). A = aorta. Yellow arrow indicates a gastric diverticulum.



Figure 11.8c. Enhanced axial view showing para-aortic nodes (red arrows) encasing the aorta (A). Blue arrows shows IVC filling defects suggestive of tumour. Green circle indicates tumour. Yellow arrows indicate tumour mass. RK = right kidney.

11.8 Lymph nodes

Lymph node involvement is a common finding when cancer of the kidney spreads. Involvement of the para-aortic region is frequent. This may be unilateral or bilateral and may also involve the anterior and posterior aspects of the aorta. When this occurs the aorta is shifted anteriorly away from the vertebral body. There is also often encasement of the renal vessels which causes narrowing. Lymph node spread to the chest is common; especially to the mediastinum area, as well as both hilar regions. Spread to the cervical area may also occur.

Occasionally the cancer may metastasise intra-peritoneally and may result in a mass. Such a mass may displace an organ such as the bladder. Although spread to the brain may occur it is not common. CT and/or MRI may be used to diagnose brain spread. Figures 11.8a to e are examples of spread to lymph nodes.

11.9 Bony structures

Spread to the bones is a fairly common occurrence. Sites involve the pelvic area with large bony destruction and soft tissue masses. Spread also occurs in the ribs, lumbar and thoracic spines. Figures 11.9a to f are examples of spread to bones.



Figure 11.8d. Enhanced axial view showing para-aortic nodes (red arrows). A = aorta. RK = right kidney. LK = left kidney.

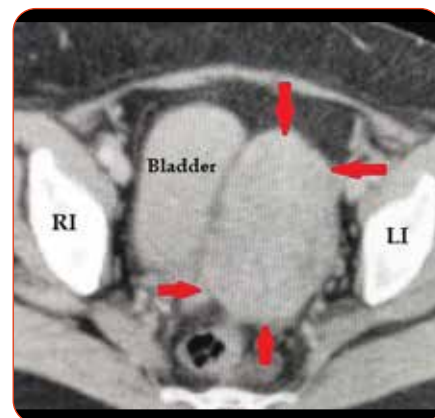


Figure 11.8e. Axial view showing metastatic spread (black arrows) from a renal carcinoma displacing the bladder to the right. RI = right ilium. LI = left ilium.



Figure 11.9a. Axial view showing destruction of sacrum (red eclipse). RI = right ilium. LI = left ilium.



Figure 11.9b. Axial view showing destructive lesion left sacrum (black arrows). RI = right ilium. LI = left ilium.



Figure 11.9c. Enhanced axial CT scan showing destructive lesion left iliac bone with a large soft tissue component (red arrows). Secondary from proven RCC. RI = right ilium. LI = left ilium.

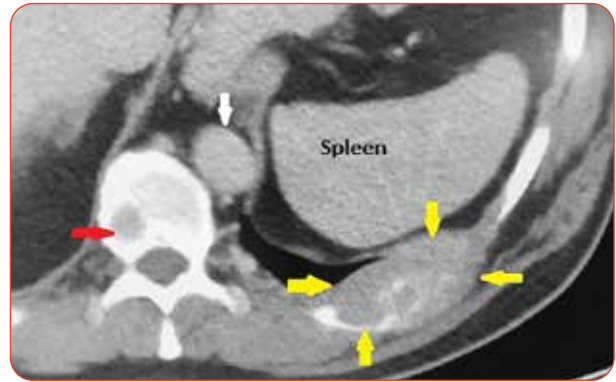


Figure 11.9d. Unenhanced axial CT scan showing left nephrectomy with spleen lying horizontally in renal bed. There is a large destructive lesion involving the left rib with bony destruction and a soft tissue mass (yellow arrows). There is a 2cm mass between the vertebral body and the left hemi-diaphragm in keeping with a secondary deposit (white arrow). There is a lesion in the vertebral body on the right (red arrow).



Figure 11.9e. Enhanced axial CT scan showing a lesion in sternum. Soft tissue mass anteriorly (yellow arrow). Secondary from RCC.

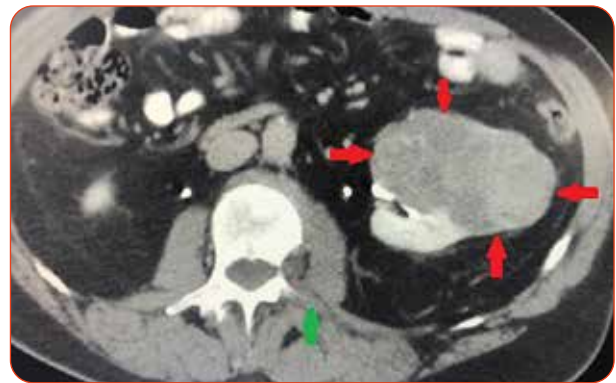


Figure 11.9f. Destruction of part of left vertebral body (green arrow). Red arrows indicate tumour arising from upper pole of left kidney.



Figure 11.10a. Enhanced axial CT scan showing right nephrectomy with large bowel displaced inferiorly in the renal bed (red). LK = left kidney. A = aorta.



Figure 11.10b. Enhanced axial CT scan showing right nephrectomy. Large bowel displaced inferiorly due to the nephrectomy (red arrow). Neoplastic mass anterior (red circle) to the aorta (A) and inferior vena cava (IVC) in keeping with spread from right RCC. Secondary deposits in the liver (purple circles). LK = left kidney. Left renal vein (green arrow).

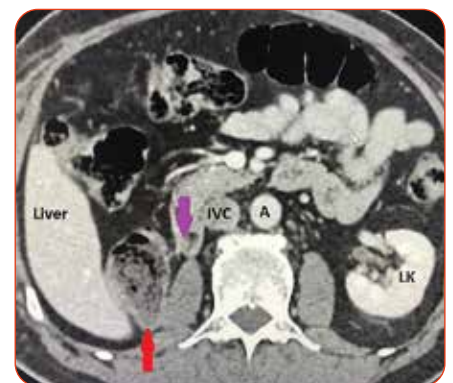


Figure 11.10c. Enhanced axial CT scan showing right nephrectomy. Large bowel (red arrow) and small bowel (purple arrow) in region of the right renal bed. LK = left kidney. A = aorta. IVC = inferior vena cava.

11.10 Post-nephrectomy patients

Patients who have had a kidney removed for cancer do not fall under the usual CT screening protocol. The focus of post-nephrectomy CT scan is to check whether the original cancer has spread. The CT examination always requires administration of i.v. contrast. The protocol includes CT of the abdomen, pelvis and the entire chest. In other words not just the lung bases as described above. An unenhanced and enhanced CT examination is performed. If the clinical history points to a possible lesion in the brain then the protocol is to also perform an unenhanced and enhanced CT of the brain. Depending on the findings of these CT scans they may be followed by PET and/or MRI of a particular region.

If the right kidney has been removed then usually loops of bowel (small or

large bowel) lie in the right renal bed. In the case of the removal of a left kidney then the CT findings may include displacement of the spleen into the left renal bed. The orientation of the spleen may change and may assume a more horizontal position as described above. The orientation of the pancreas also changes quite markedly; the body and tail dip into the renal bed as described above. Loops of bowel, both large and small, may also occupy the left renal bed. Post-right nephrectomy CT examples are shown in Figures 11.10a to e. Post-left nephrectomy CT examples are shown in Figures 11.10f to j.

REFERENCES

See Part 5.



Figure 11.10d. Enhanced axial view showing right nephrectomy with bowel lying in the renal bed (red line). There is a lesion in the liver (black circle). Gallbladder (black line). Left kidney (LK) and the left renal vein (black arrow) entering the inferior vena cava (IVC). Aorta (A).



Figure 11.10e. Enhanced axial view showing right nephrectomy with bowel lying in the renal bed (red arrow). Left kidney = LK. Aorta = A. Inferior vena cava = IVC.



Figure 11.10f. Enhanced axial view showing the spleen lying horizontally in the left renal bed. Pancreas = P. Aorta = A. Right kidney = RK.



Figure 11.10g. Enhanced axial view showing bowel in the region of the left renal bed (black arrows). Left nephrectomy. Right kidney = RK.



Figure 11.10h. Axial view showing the spleen lying horizontally due to left post nephrectomy. Aorta = A. Inferior vena cava = IVC. Right kidney = RK.



Figure 11.10i. Enhanced axial view showing a low-lying spleen. Tail of pancreas (P) is in the left renal bed. Aorta = A. Right kidney = RK. Purple circle = lesion.



Figure 11.10j. Enhanced axial view showing the spleen lying horizontally. Tail of pancreas (P) dipping posteriorly. Aorta = A. Right kidney = RK.