PICTORIAL ESSAY Abdominal Imaging

CT imaging in adrenal lesions-is it still relevant?

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ABSTRACT

Lesions involving any of the two adrenal glands can be detected incidentally by any of the imaging tools like ultrasound, computed tomography (CT) or magnetic resonance imaging (MRI). CT however, is the most widely used technique for characterisation of adrenal lesions. In most circumstances after detection of the lesion, CT can differentiate benign from malignant lesions of the adrenal. We present herewith a pictorial review of few common adrenal lesions encountered on CT imaging [1].

Introduction

Our body has two adrenal glands, each structurally and functionally divided into two parts, the adrenal medulla and cortex. The right adrenal gland is located superior to the right kidney and the left kidney lies anterior to the superior pole of left kidney. Each adrenal gland consists of a body measuring up to 10 mm in thickness and two limbs which can measure up to 4 cm in length. The adrenal cortex is divided into three zones the glomerulosa, fasciculata and reticularis. Most of the encountered adrenal lesions are benign adenomas. However, encountering adrenal lesions in the settings of a patient with a known malignancy and differentiating them from metastasis has a very important implication with respect to further mode of treatment. In a remote place as ours where Magnetic resonance imaging (MRI) may

KEY WORDS: Adrenal gland, Adenoma, Metastases, Washout criteria, Neuroblastoma

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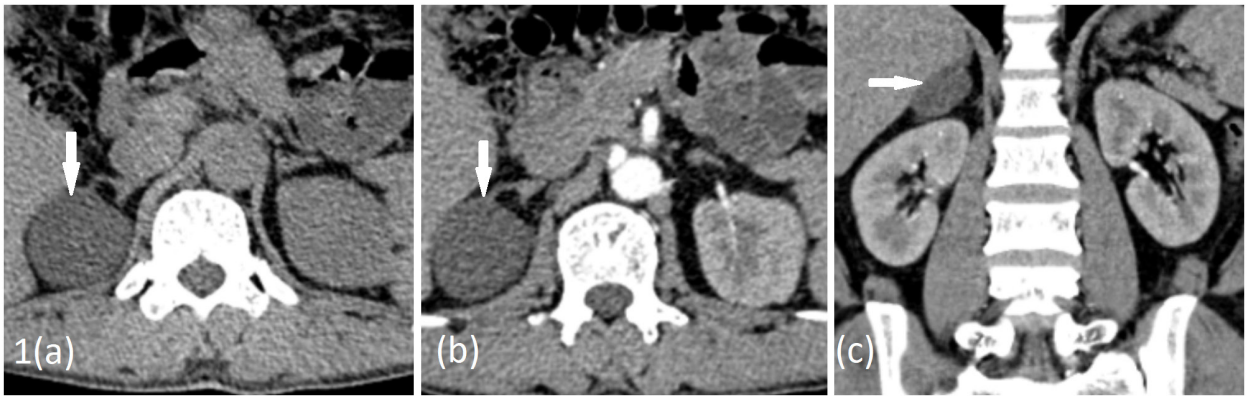

Fig. 1: *Right adrenal cyst (arrows).* ***(a)*** *Plain axial CT showing a round fluid density lesion in the lateral limb of the right adrenal.* ***(b)*** *Arterial phase post-contrast axial CT showing no enhancement of the lesion.* ***(c)*** *Coronal reconstructed image showing the cyst related to the upper pole of the right kidney.*

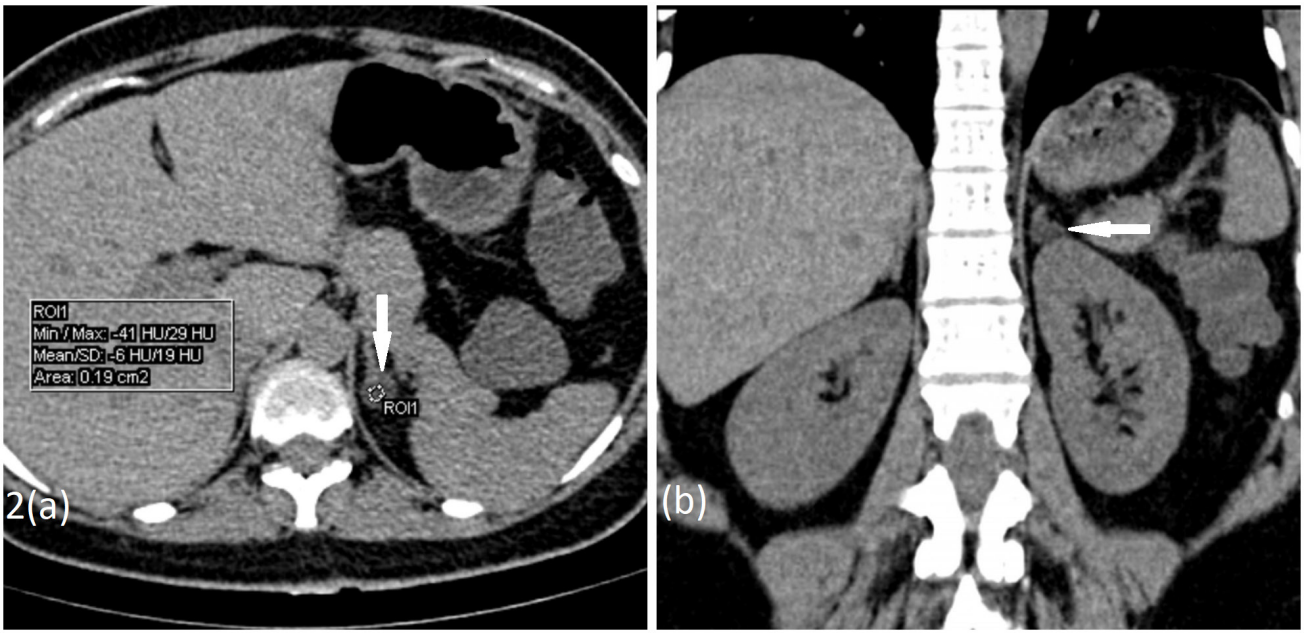

Fig. 2: *Adrenal lesion (arrows) detected while evaluating for suspected renal stones.* ***(a)*** *Axial unenhanced CT showing a low attenuating (-6 HU) left adrenal lesion.* ***(b)*** *Same lesion in coronal plane. Note the difficulty in differentiating possible fat rich adenoma from lipoma, needing possible histological confirmation, not done in this case as it was asymptomatic and accidentally discovered while screening for other lesions.*

not be available for characterisation of these lesions, computed tomography (CT) remains the mainstay imaging tool for detection as well as for characterisation of these lesions.

The aim of this review is to present a pictorial essay of representative adrenal lesions encountered on CT imaging in our centre and to review important CT imaging characteristics for approaching adrenal lesions. The workup for an adrenal mass depends on the patient's clinical scenario and whether the intention is for detection or characterisation of the lesion. Therefore, workup of an adrenal mass can fall in any of the fol-

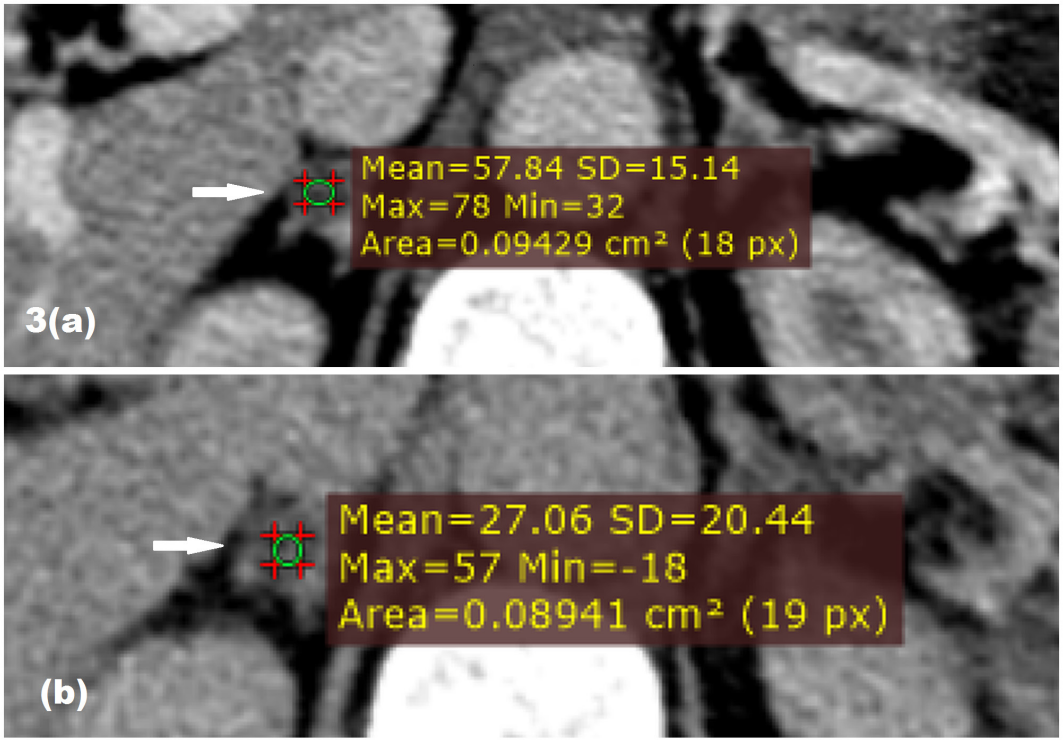

Fig. 3: *Patient with suspected adrenal lesion on screening ultrasound. (**a**) and (**b**) Axial contrast-enhanced portal and delayed phase images shows a well-defined right adrenal lesion with a RPW of 53 % suggesting fat poor adenoma (arrows).*

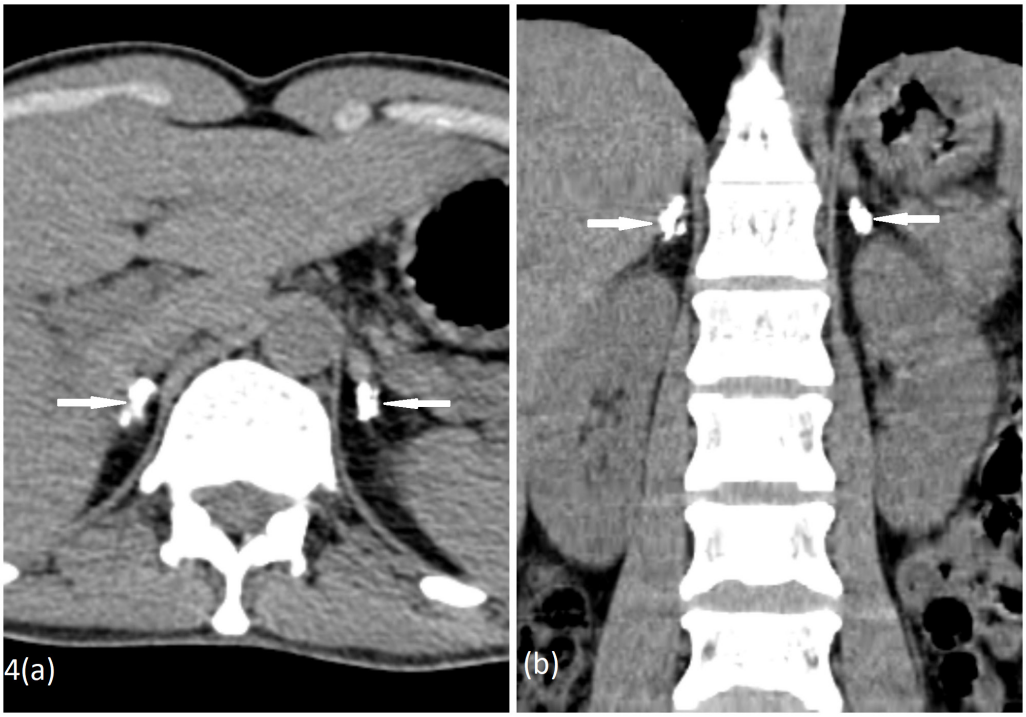

Fig. 4: *Adrenal calcifications (arrows). Axial (**a**) and coronal (**b**) unenhanced images shows bilateral adrenal calcifications.*

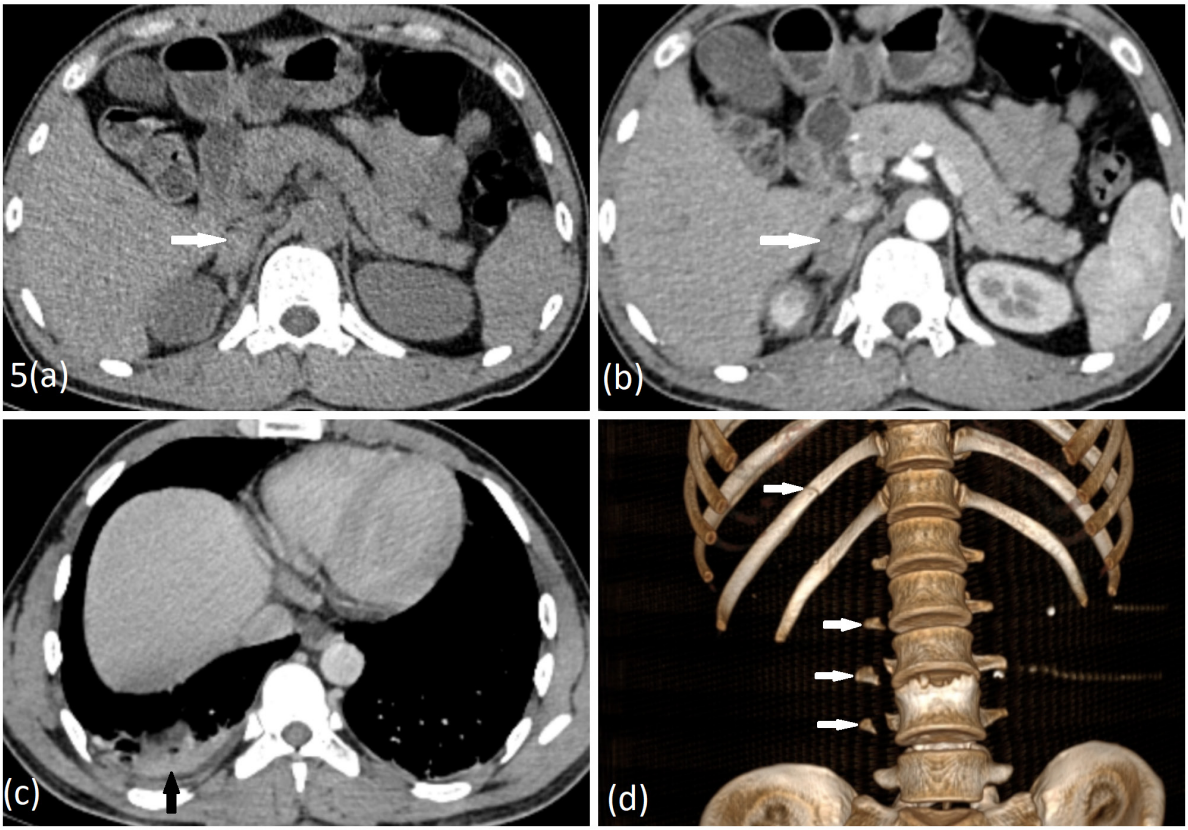

Fig. 5: *Patient with history of trauma showing adrenal hemorrhage (arrows). (**a**) Plain CT. (**b**) Post-contrast arterial phase showing non enhancing lesion in the right adrenal. (**c**) CT section in the thorax showing associated right pleural effusion with underlying lung contusion (arrow). (d) Volume rendered image showing multiple bony fractures involving right 11th rib and right transverse processes of L 2,3,4 (arrows).*

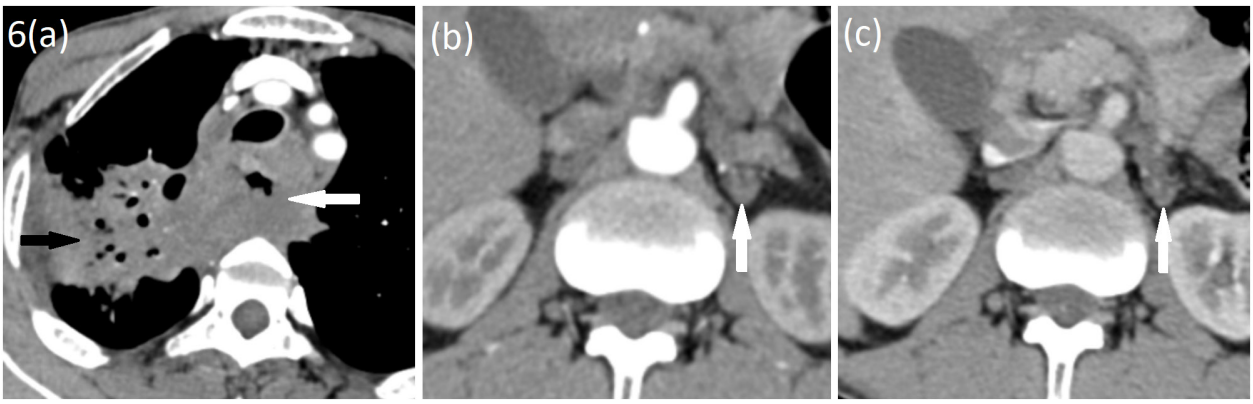

Fig. 6: *History of oesophageal carcinoma with metastases. (**a**) Arterial phase CT showing circumferential oesophageal thickening (white arrow) with contiguous areas of right lung consolidation (black arrow). (**b & c**) Axial arterial and portal phase scans show enlarged left adrenal gland with no significant washout indicating metastases (white arrow).*

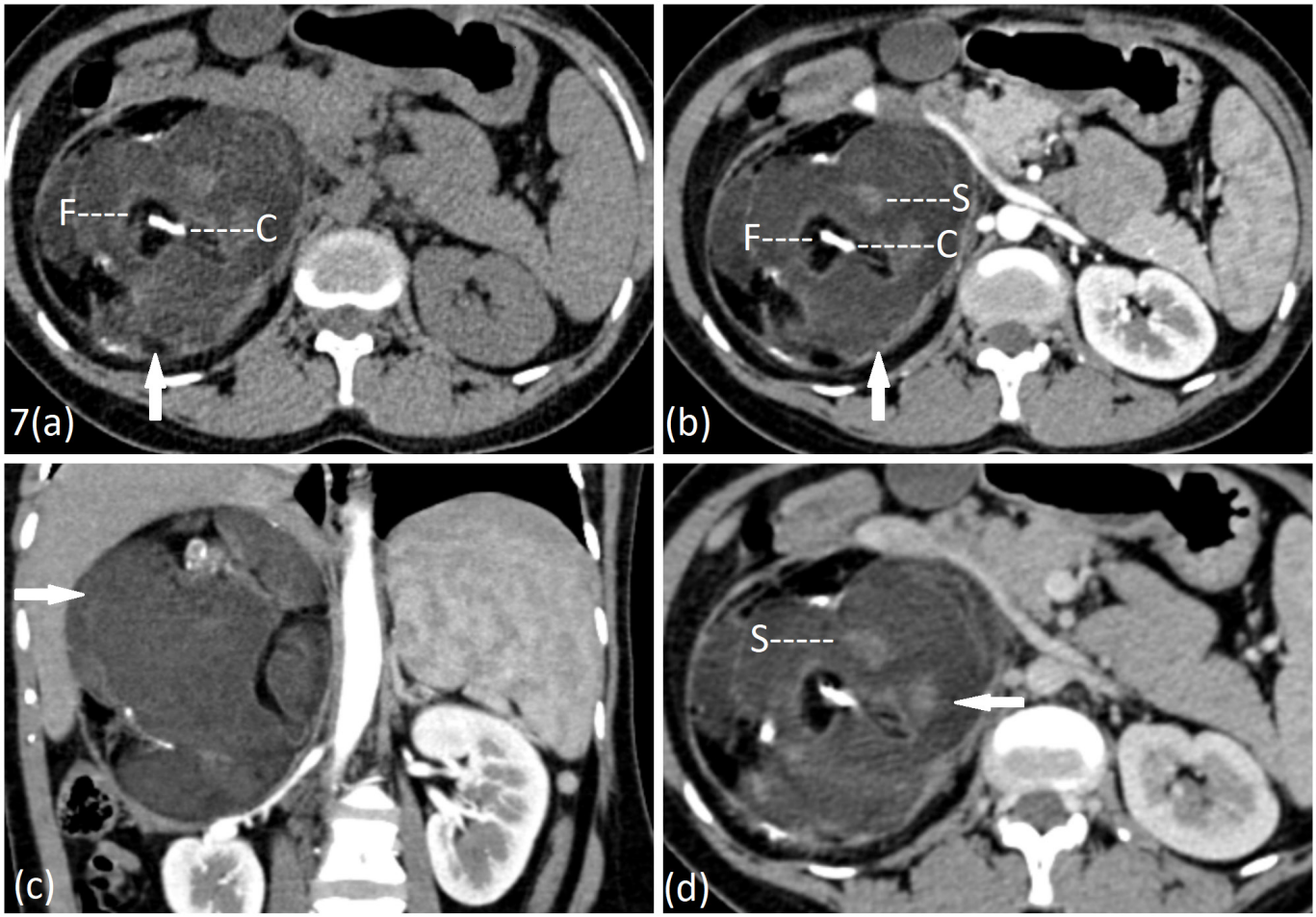

Fig. 7: *Young female with chronic abdominal distension showing right adrenal teratoma (arrows).* ***(a & b)*** *Axial unenhanced and arterial phase images shows a large well defined mixed density right adrenal lesion with hypodense fat (F), mildly enhancing soft tissue components (S) and hyperdense calcifications (C).* ***(c)*** *Coronal arterial phase images.* ***(d)*** *Axial portal phase images shows no infiltration into the adjacent structures.*

lowing: To detect an adrenal lesion in a patient with a known biochemical abnormality of suspected adrenal cause or to characterise an incidental adrenal mass in a patient with or without a known primary malignant neoplasm [2].

Basic imaging features to be considered while evaluating an adrenal lesion on CT are size, composition, infiltration and washout parameters. A lesion of size greater than 4 cm is considered to be of malignant potential. Benign lesions are mostly homogeneous in attenuation. Malignant lesions show heterogeneous attenuation with central necrosis and calcifications. Any lesion containing fat within is most of the time a myelolipoma. Infiltration into adjacent fat and organs indicate a more aggressive lesion. These criteria although well established, a number of exceptions do exist. Lesions more than 4cm are sometimes seen to be of benign aetiology (adenoma, cyst). Intralesional fat can also be seen in adrenocortical carcinoma and very rarely in adrenal metastasis [2,3,4].

We present herewith a CT pictorial review of some common adrenal lesions followed by a short discussion on CT imaging approach in adrenal lesions.

Common adrenal lesions

Adrenal cysts: Adrenal cysts are uncommon lesions, with a reported combined autopsy incidence of 0.073% (14/19,096) [5]. They are seen as round lesions of fluid

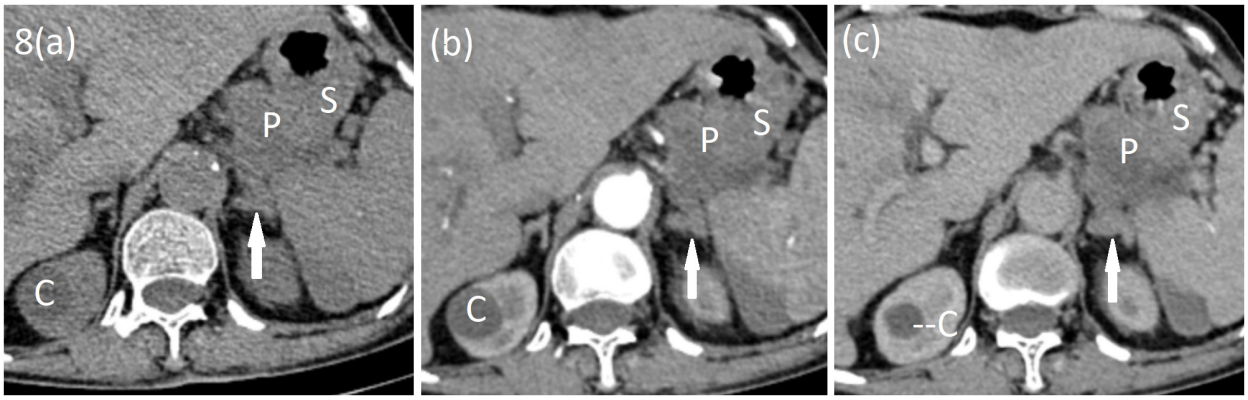

Fig. 8: *A known case of pancreatic cancer with left adrenal involvement (arrow).* ***(a)*** *Plain CT.* ***(b)*** *Arterial phase CT.* ***(c)*** *Delayed phase. Showing a hypodense non-enhancing pancreatic tail mass (P) extending into the posterior wall of the stomach (S) and left adrenal. Incidental finding is of right renal simple cyst (C).*

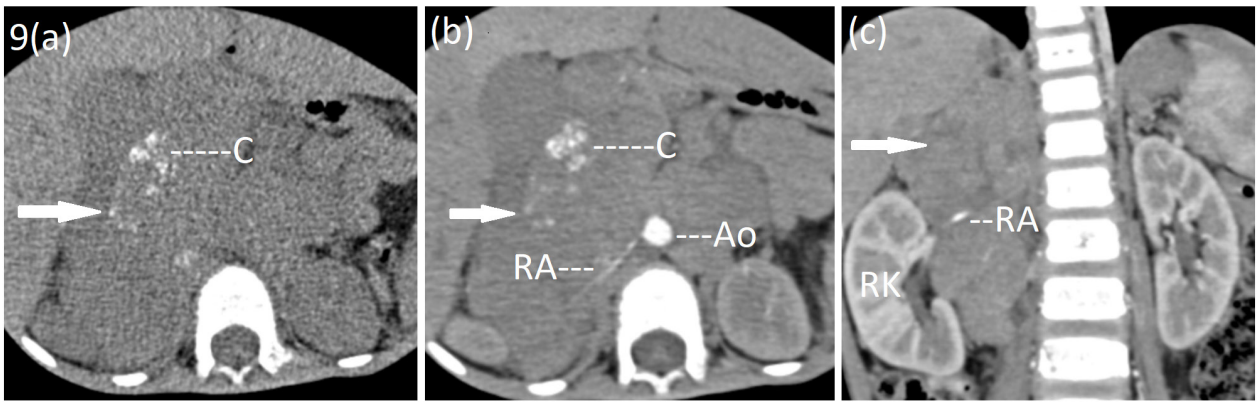

Fig. 9: *9 year old child with neuroblastoma.* ***(a)*** *Axial non-contrast image shows a large lobulated right suprarenal mass with internal amorphous calcifications (C) extending across the midline.* ***(b & c)*** *Axial and coronal enhanced images shows heterogeneous enhancement within the lesion with encasement of right renal artery (RA) and effacement of abdominal aorta (Ao). Note right kidney (RK) displaced laterally.*

attenuation in the adrenal gland. These lesions show no contrast enhancement. (Fig. 1). Most adrenal cysts were of fluid attenuation on CT, with only 15% of lesions having an attenuation value greater than 20 HU. Imaging findings in benign adrenal cyst are same as those of a benign simple or mildly complicated renal cyst, though they may have comparatively acceptable more wall thickness and calcification[6].

Lipomas: Most of adrenal lipomas are incidentally diagnosed on CT due to their fatty attenuation on CT. However in some rare situations, while analysing low attenuation incidentally encountered small benign adrenal lesions, we may not be able to differentiate with certainty between fat rich adenoma or lipoma, as these lesions are not surgically intervened for availing histological confirmation (Fig. 2) and therefore many may be left untreated. Nevertheless, some of the lipomas can attain large size demanding surgical removal [7]. Lipomas are well-demarcated lesions containing lobules of fat tissue. On CT, in contrast to myelolipomas, they show no or minimal soft-tissue attenuation and may contain focal areas of intra-lesional calcifications [8]. Other fat containing adrenal lesions which can be considered as differentials can be adrenal adenoma, adrenocortical carcinoma and adrenal teratoma [1].

Adenomas: Adrenal adenomas are the most common

Table 1. Distinguishing features between neuroblastoma and Wilms tumour [1, 21, 22]

	Neuroblastoma	Wilms tumour
Age	<2 years	>2 years
Mass effect on kidneys	Extrinsic compression of kidney	"Claw sign", lesion originates from the kidney
Relation to aorta	Encasement	Displacement
Calcifications	Common	Uncommon

adrenal tumours. They are encapsulated, well circumscribed, homogeneous solid lesions. Fat poor adenomas can be differentiated from malignant lesions with high degree of confidence using CT wash out criteria (Fig. 3). Through using a threshold of 10 HU, on unenhanced CT, we can have a sensitivity and specificity of 71% and 98% respectively for characterising lipid-rich adrenal adenomas [2], seen in a majority of adenomas. In a small percentage of lesions (approximately remaining 20%) where attenuation is more than 10 HU washout properties can be used to differentiate lipid poor adenomas from metastases, where both lesions enhance early in arterial phases but wash out is faster in adenomas compared to metastases [9, 10]. Absolute percentage washout (APW) is calculated following the formula: (70sec enhanced HU – 15min delayed HU) / (70sec enhanced HU – unenhanced HU) x 100% and relative percentage washout (RPW) is calculated using the formula: (70sec enhanced HU – 15min delayed HU) / (70sec enhanced HU) x 100% [8]. With respect to characterising adenomas, with a combination of unenhanced and delayed enhanced CT, nearly all adrenal masses can be categorised as adenomas or non-adenomas, and this protocol correctly characterised 160 (96%) of 166 masses [10]. Using a cut off of APW > 60% or RPW > 40% after 15min from contrast administration, adenomas can be characterised with a high level of sensitivity (83-88%) and specificity (93-96%) [8]. This pattern of washout however can also be seen in highly vascular tumours such as pheochromocytoma and metastasis from hepatocellular and renal cell carcinoma [11].

Adrenal Cortical Hyperplasia: Estimated prevalence of adrenal cortical hyperplasia -as seen in an autopsy series of 35,000 patients- is 0.51% [3,12]. It can present as diffuse or nodular types with most of the nodular types presenting multifocally and bilaterally. Patients may present with features of Cushing's syndrome or hyperaldosteronism if the lesion is producing hormones. On CT diffuse variety shows enlarged glands with homogeneous enhancement. Nodular variety may show isodense nodules with normal or atrophic intervening parenchyma [12].

Calcifications: Incidental detection of adrenal calcification in adults is not a rare finding and is sometimes seen incidentally while investigating for other abdominal lesions or in rare occasion may be detected in a completely healthy asymptomatic individual (Fig. 4). This may be attributed to previous history of hemorrhage or post-infectious like tuberculosis. Though incidentally detected adrenal calcifications in adult are not very rare, yet when adrenal calcifications are detected in children, an underlying neoplastic aetiology needs to be ruled out [13]. Calcifications in adrenal gland without any obvious lesion favours benign aetiology. Bilateral presence of calcification also suggests benign cause. Microcalcifications in adrenal gland are in most of the cases accompanied by malignant lesions [14].

Haemorrhages: Can be detected in adrenal glands in both traumatic and non traumatic conditions (Fig. 5). In non traumatic conditions it is usually in the setting of an underlying neoplastic lesion. Causes of non traumatic adrenal haemorrhage include stress, haemorrhagic diathesis or coagulopathy, neonatal stress, renal vein thrombosis with simultaneous adrenal haemorrhage, underlying benign or malignant adrenal lesion and idiopathic [15]. Trauma is the most common cause of adrenal hemorrhage, with post-traumatic hemorrhage being usually unilateral [16].

Myelolipoma: Benign adrenal lesion of mixed composition. Varying degrees of fat and myeloid cells are

present within the lesion. Symptoms predominantly are secondary to size from mass effect. Myelolipomas mostly are hormonally inactive. CT characteristically shows the presence of fat attenuation within the lesion with intervening soft tissue attenuation [1].

Pheochromocytoma: Originates from adrenal medulla and secretes catecholamines which are responsible for the symptoms, such as palpitations, headache, hypertension, sweating, anxiety and tremors. On CT most of the lesions show homogeneous attenuation of >10 HU. On post-contrast CT, lesion shows slow arterial enhancement with delayed washout. Most of pheochromocytomas show an APW <60 % and RPW <40%. Thirty per cent of pheochromocytomas may show APW > 60% and RPW >40% respectively [1,17].

Metastases: Of all the malignant conditions, metastases are the most frequent, commonly from lung cancer, breast, colon, melanoma, kidney, and hepatocellular carcinoma [18] (Fig. 6). Bilateral metastases are more frequent than unilateral metastasis [18]. Metastatic lesions tend to be >4 cm in size, heterogeneous in appearance and shows irregular boundaries. Any adrenal lesion showing interval growth over a period of 6 months should raise the suspicion of metastasis in a patient with a known malignancy. These features help us to differentiate adenomas from metastatic lesions of the adrenal gland. In contrast-enhanced CT metastases show APW <60 % and RPW <40% [1]. Metastasis from fat containing lesions may have intra-lesional fat density. In such cases, features like larger size, irregular margins and adjacent infiltration favour malignant aetiology over benign lesions.

Collision tumour: Presence of two adjacent adrenal tumours which are histologically different with no evidence of microscopic admixture of tissues. Most commonly one is an adenoma mixed with metastasis. On non-contrast CT it can be suspected in an adrenal lesion where one portion of the lesion shows an attenuation value of <10 HU and another portion shows value of >10 HU [1].

Teratoma: Primary adrenal teratoma is a rare tumour, which is more common in adults compared with children. The appearance of teratoma on CT is quite characteristic and its diagnostic accuracy is superior to that with ultrasound. CT images of mature teratoma reveal the presence of calcification and adipose tissue [19] (Fig. 7). Adult primary adrenal teratoma occurs more often in men; however, among paediatric cases, there were more female compared with male patients [19].

Pancreatic cancer: pancreatic malignancies particular involving the tail can invade the adrenal as a part of loco-regional invasion (Fig. 8). Pancreatic ductal adenocarcinoma involving the tail region can extensively invade peri-pancreatic tissue including perineural, lymphatic and venous invasion with local invasion of adrenal gland, stomach wall, mesocolon and renal vein [20].

Neuroblastoma: Neuroblastoma though rare in adults, yet it is the second most common neoplasm in childhood after Wilms tumour [21] (Fig. 9). Of all adrenal masses, neuroblastoma is the commonest childhood neoplasm, histologically constituting 58 % of all adrenal masses in children [22]. Though sometimes confused with Wilms tumour, yet in most cases they can be easily differentiated [Table 1].

Based on all the above mentioned characteristics of the adrenal lesions a structured reporting system can be derived which should include points like presence of fat within the lesion, interval growth of lesion, size, enhancement pattern, infiltration by the lesion and associated features like presence of malignancy elsewhere, symptoms of Cushing's or other endocrinological disturbance [23].

Conclusion

CT still plays an important part in management of patients with detectable adrenal lesions. Characterisation of adrenal lesions using lesion's attenuation and washout criteria are the two most important characteristics on CT scan. As far as imaging is concerned, especially in care-centres or hospitals where advanced imaging by MRI is not available or affordable, CT with all these properties will still be a relevant imaging tool in adrenal lesions. **R**

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Conflict of interest

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