ANNALES
UNIVERSITATIS MARIE CURIE-SKŁODOWSKA
LUBLIN-POLONIA
VOL. LVIII, N 1, 70 SECTIO D 2003

Department of Radiology, Medical University of Lublin

ELŻBIETA CZEKAJSKA-CHEHAB, ANDRZEJ DROP, LESZEK BUK

Multislice spiral computed tomography in evaluating renal focal lesions – new diagnostic possibilities

Multislice spiral computed tomography (MSCT) introduced in 1998 is a milestone in imaging many organs. Its major advantages include greater speed of acquisition and higher spatial resolution in z-axis, which enable routine reconstruction of thinner slices and multiphasic imaging of large body areas. The scans are obtained in one respiratory phase, which ensures their complete reproducibility and lack of motion artefacts. The progress in the construction of scanners is accompanied by the software advances, which enable storing and sending the data electronically and quick postprocessing and many reconstructions – including 3D, multiplanar and maximum intensity (MIP) on the basis of native axial scans (7).

Among 2300 multislice CT examinations performed so far in our centre, about 50 patients were suspected of renal tumours.

The aim of the paper is to present our experience in the diagnosis of renal focal lesions using the 8-parallel row tomography, and compare it with literature data concerning this issue.

METHODOLOGY OF MSCT

Technique. The diagnostic system used in the Department of Radiology, Medical University of Lublin since June 2002, includes the multi-detector scanner, Light Speed Ultra (General Electric) and two postprocessing stands – the workstation Advantage Window 4.0 and computer with Radworks software interconnected with it. The construction of the tomograph is based on 8 parallel rows of X-ray detectors, which simultaneously perform volumetric acquisition of the data. This provides up to 8 images during one tube rotation time – 0.8s and minimum thickness of the reconstructed slice – 0.6mm. The Advantage Window 4.0 console contains numerous ready reconstruction protocols and provides possibilities of creating new protocols for vascular options, multiplanar, three-dimensional, maximum and minimum intensity projections, which significantly shortens the analysis and provides the images extremely useful for clinicians, particularly of operative specialties.

Renal examinations may use spiral protocols with two, four or eight rows of detectors. The renal vessels are usually elevated using the reconstructions with 1.25mm collimation while parenchyma – at 2.5mm collimation. The 50% overlapping enables secondary reconstructions of thinner layers in small focal lesions during postprocessing.

Contrast media. In the abdominal CT examinations, IV iodine contrast media administrated at the dose of 80–140 ml are recommended. The concentrations 250–400 mg/ml

and manual or automatic forms of administration can be used (2,5,8). When the power injector is used the delivery rate, according to various authors, should vary from 2 to 5–6 ml/s. In some centres, smaller doses of contrast media are used with a 40–50 ml supplement of physiological saline. This method reduces both the risk of side-effects (adverse reactions) in patients and the cost of examinations, however, the power injector of a special construction is required. In our department, only non-ionic contrast media are applied. In renal examinations, when tumour lesions are suspected, they are injected as a single bolus of 300 mg/ml (Ultravist 300) using the power injector. The delivery rate depends on the aim of examinations, age and clinical condition of patients. In patients without any risk, the standard delivery rate for multiphasic CT is 3.5 ml/s. In patients with complication risks or when acquisition in the arterial phase is not indicated, the delivery rate is reduced to 2–3 ml/s. In cases when the US-detected focal lesion is small or peripherally located, the delivery rate should be high and the amount of the contrast medium higher, which enables us the most accurate evaluation of the arterio-venous supply of the kidney, which is important for partial resection selection. Gastrographin may be used as an oral contrast medium, however in our centre, due to many reconstructions performed during postprocessing, oral administration of 500–1000 ml water is preferable.

The course of procedure. MSCT is a rapidly developing method of examination, in which the clinical experience does not keep up with technical advances. The manufacturer's reconstruction protocols in various scanner versions include from 2 up to 16 rows of detectors and optimum protocols of examination and evaluation of usefulness for the individual postprocessing options ought to be prepared in the diagnostic centres.

The protocol used in our centre in the cases with suspected renal proliferation lesion includes four phases of scanning. The first phase (pre-contrast) covers the range from the diaphragmatic leaf to the L4 level performed at 120–140 kV, 200–300 mAs, the table speed –27.0 mm/s, collimation – 8 x 2.5 mm and overlapping – 50%. In some cases, particularly on differentiating small cystic lesions, the reconstructions are performed at collimation of 1.25 mm with accurate measurements of attenuation of foci detected within the kidneys, adrenal glands or the liver. Then, the contrast medium is administered and the second scanning phase performed. The routine start delay is 25–30s, which usually allows to obtain the corticomedullary phase and to visualize the vessels. However, in rare cases, particularly in elderly patients and those with circulatory failure, the enhancement obtained is insufficient. This problem can be solved using the technique of setting the scanning start time on the basis of determinations of contrast enhancement in the aorta lumen above the renal arteries (test bolus or Smart-Prep option). The third phase (nephrographic) uses the previous parameters and area determined 70–80 s. after contrast medium administration. The last phase (excretory) involves the renal areas, in some cases also ureters at the start delay of 3–4 minutes. This phase is extremely important in patients with haematuria without parenchymal focal lesions and with tumours located in the pyelocalyceal system (5,9). The individual phases are performed in a single breath-hold by the patient during expiration; with the exception of patients referred to for simultaneous examinations of the abdominal and thoracic cavity, in whom the inspiratory phase is preferable as the pulmonary evaluation is needed. In such cases, phases II and III also include the thoracic cavity. The time of subsequent series ranges from 7 to 20 s.

MULTIPHASIC CT EVALUATION OF RENAL FOCAL LESIONS

Computed tomography is thought to be the optimum imaging technique in the majority of renal and ureteral disorders, although it is used as a second-choice examination after ultrasound and intravenous urography due to its higher cost and smaller availability. Recently, however, it has been stressed that the multiple CT option is likely to be extremely useful in vascular renal diseases or even in the diagnosis of ureterolithiasis, which would substantially limit the traditional indications for angiography and urography. The renal CT indications include the differentiation of renal masses detected at other examinations, whose images suggest neoplastic

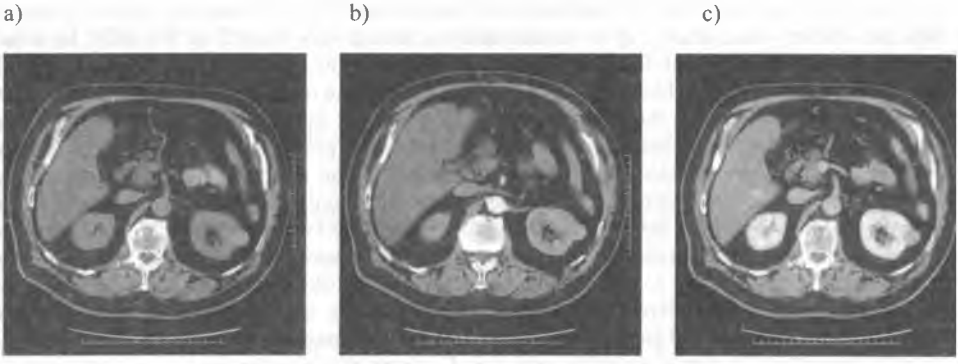

Fig. 1. High density simple cist of the left kidney: a) pre-contrast scan, b) corticomedullary phase, c) nephrographic phase

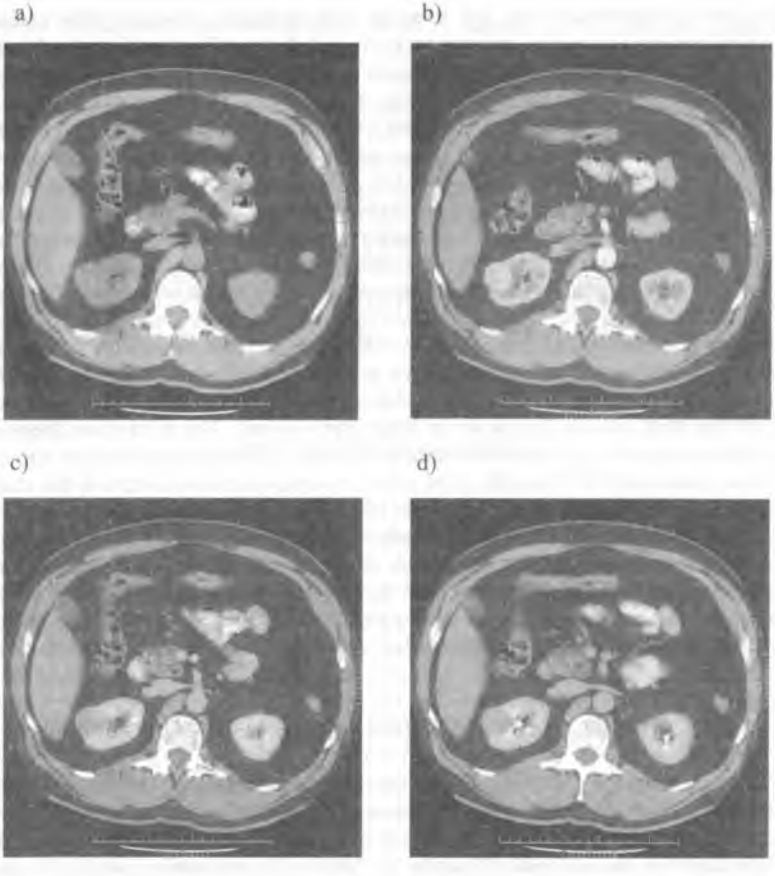

Fig. 2. Axial scans of small renal tumour (carcinoma clarocellulare) in: a) pre-contrast scan, b) corticomedullary phase, c) nephrographic phase, d) excretory phase

lesions or are inconclusive – tumours (Fig. 2, 3), pseudotumours, cystic lesions (Fig. 1), indeterminate calcify-cations, limited forms of infectious diseases or the presence of such symptoms as haematuria and pain without detectable US lesions (4, 9).

Renal cell carcinoma (RCC) is the most common neoplasm of kidney and it accounts for about 3% of neoplastic lesions in adults. Due to the fact that US and CT examinations are becoming increasingly common, RCC is more and more frequently diagnosed at the relatively early stage when radical oncological treatment is still possible. In typical cases, CT enables the diagnosis of angiomyolipoma, limited haematoma and abscess of the kidney. On the other hand, there are still no precise criteria of differentiating RCC from benign tumours, such as adenoma, oncocytoma, which, however, is of no practical importance due to similar algorhythm of therapeutic management (9, 10). Our experience shows that the corticomedullary and nephrographic phases are most relevant on evaluating the character of the earlier detected tumour. In well-vascularized foci, they show strong, early enhancement typical of clarocellulare carcinoma

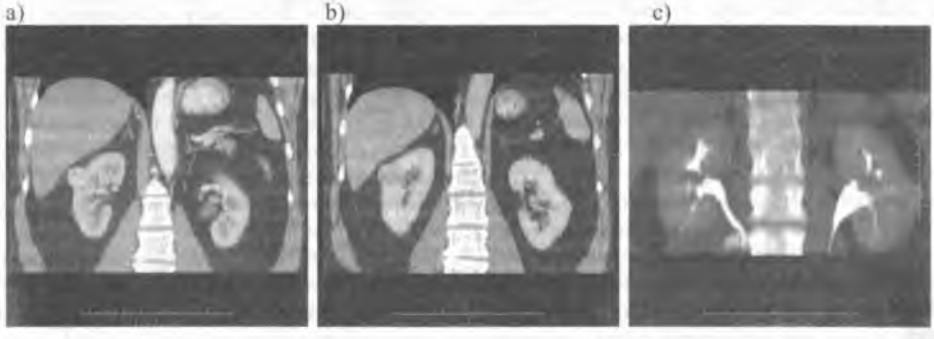

Fig. 3. Coronal views of tumour (from fig. 2); a) corticomedullary phase, b) nephrographic phase, c) excretory phase

and quick washing up of the contrast medium from the tumour which increases the attenuation between renal parenchyma and tumour in the nephrographic phase. Moreover, the early phase provides the best chance to differentiate quite common anatomical varieties of renal parenchyma, e.g. connecting parenchyma or hypertrophy of renal column and horseshoe kidney (5, 6, 11, 13). The nephrographic and excretory phases, on the other hand, provide the best conditions to evaluate the borders and size of proliferation lesions; the excretory phase, additionally, reveals the symptoms of impression or infiltration of the pyelocalyceal system. This phase is indispensable in patients with haematuria, and the proliferation lesion located within the pyelocalyceal systems or ureters (9, 12). The successive reconstructive phases at collimation of 2.5 and 1.25 mm with attenuation measurements are particularly important in atypical cases of cystic lesions and small masses, in which the risk of partial volumetric effect should be reduced to the minimum. The results of comparative studies for MSCT with reconstruction of very thin slices and of comparisons of multislice CT and MR effectiveness have not been published so far. There is also no uniformity of views as to the algorithms of contrast medium administration, and delay of successive phases. Moreover, only a few studies concerning the multiphasic diagnosis of the kidneys deal with one-slice spiral scanners (1, 2, 5, 14)

Zeman et al. (14) compared the indices of CT effectiveness for corticomedullary CT images and for early excretory phase and found out significantly higher sensitivity of the delayed phase for renal masses (97% versus 77% for one radiologist and 89% for two). The excretory phase specificity was found to be higher than that of corticomedullary phase for less

experienced radiologists (94% versus 85%). Kopka et al. (5) examining the group of 96 patients (173 lesions) studied CT sensitivity in the diagnosis of renal masses and observed significantly higher sensitivity in the nephrographic phase than in corticomedullary one (97% versus 84%). The diagnostic specificity was higher when the findings of both phases were combined than in each of the phases separately. Szolar et al. and Cohan et al. comparing the effectiveness of corticomedullary and nephrographic phases in detecting and evaluating small renal masses found out that although differentiation of the mass and cortex is higher in the corticomedullary phase than in the nephrographic one, differentiation between the mass and medulla is smaller (1,11). In the corticomedullary phase, attenuation of small well-vascularized masses localized peripherally in the renal parenchyma is likely to be similar to that of cortex, which may make their identification more difficult, however in the later phases they are well visible.

Similarly to Urban et al. we believe that each CT examination in cases when renal carcinoma is suspected must be a multiphasic procedure to detect, characterize and assess the extent of the lesion (12). MSCT, which enables quick multiphasic scanning of a big abdominal area, often additionally including thoracic organs, is an excellent method of simultaneous evaluation of the stage of neoplastic process and qualification for surgery. Furthermore, this examination is useful in controlling the outcome of surgical treatment, diagnosis of local recurrences and metastases in the abdomen, thoracic cavity, bones and brain.

It should be stressed that routine scanning in the pre-contrast phase is a condition of proper diagnosis of small cysts of high density and angiomyolipoma, in which thanks to the possibility of reconstruction of thin slices, MSCT may facilitate the diagnosis of small fatty tissue foci in the tumour (10). The problem connected with incidental detection of renal masses at CT angiography performed due to other reasons without pre-contrast scanning may be solved by evaluating the lesion in an additional scanning after 15–30 minutes (8).

In renal focal inflammatory diseases, CT is applied to determine the extent of disease, assess complications like abscess formation and haemorrhage, and to establish the diagnosis in clinically equivocal cases. Contrast-enhanced images demonstrate areas of altered parenchymal perfusion of solitary or multifocal wedge-shaped areas of absent or decreased enhancement, particularly well visible in nephrographic and excretory phases. In such cases, Dalla-Palma et al. recommend additional scanning in a very delayed post-contrast phase (3). We believe it may be easier to assess the extent of sequelae of renal infection with MSCT image reconstructions in the coronal, oblique or sagittal plane of view than with axial images alone.

EVALUATION OF RENAL VASCULARIZATION

The renal arteries are best visualized in the arterial phase (Fig. 4), which usually covers 20-40 period after the onset of contrast administration (4, 9). Therefore, in our protocol for corticomedullary phase of renal parenchyma the border time was selected in such a way as to enable us to reconstruct the vessels supplying the kidney and mass, to assess possible anatomical variations and to diagnose the atherosclerotic changes in the arterial system of the other kidney. The renal veins and the part of inferior vena cava situated above its ostium is best enhanced in the early parenchymal phase and, therefore, assessment of filling defects corresponding to neoplastic embolic or thrombolic material is mainly performed in this series. These lesions may be often differentiated on the basis of enhancement of the pathological mass similar to the primary tumour. MSCT with volume rendered images or MIP reconstructions provides a similar effect to those observed in inferior cavography (7).

Some authors question the usefulness of the routine early arterial phase in the diagnosis of renal masses (9) and thus, in our opinion, the use of protocols with post-contrast phase started in the late arterial phase (early corticomedullary phase) is a reasonable compromise between high diagnostic effectiveness and requirements of radiation protection based on ALARA rule.

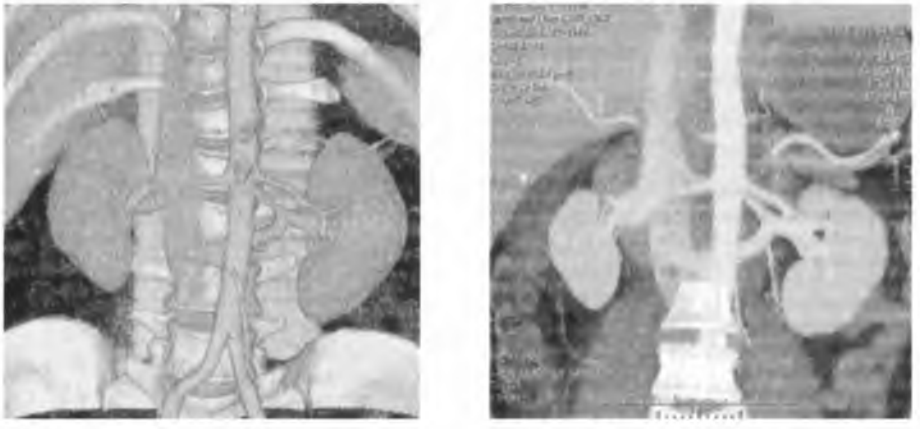

Fig. 4. MSCT angiography of the kidney area – volume rendering (VR) reconstruction and maximum intensity projection (MIP)

REFERENCES

1. Cohan R.H. et al.: Renal masses: assessment of corticomedullary - phase and nephrographic - phase CT scans. Radiology, 196, 445, 1995.
2. Dahlman P. et al.: Detection and characterization of renal lesions by multiphasic helical CT. Acta Radiol., 41, 361, 2000.
3. Dalla-Palma P. et al.: Delayed CT in acute renal infections. Semin Ultrasound CT MR, 18, 122, 1997.
4. Khan H.G., Trrier F.: Tailoring the imaging protocol. In: Terrier et al. (eds.): Spiral CT of the abdomen., Springer Verlag, 261,Berlin-Heidelberg-New York 2000.
5. Kopka L. et al.: Dual phase helical CT of the kidney: value of the corticomedullary and nephrographic phase for evaluation of renal lesions and preoperative staging of renal cell carcinoma. AJR, 169, 1573, 1997.
6. Lee C.T., Hilton S., Russo P.: Renal mass within a horseshoe kidney: preoperative evaluation with tree-dimensional helical computed tomography. Urology, 57, 168, 2001.
7. Loose R. et al.: Multidetector CT: What to do with all the data? In: M.F. Reiser et al (eds): Multislce CT, Springer Verl., 9, Berlin-Heidelberg-New York 2001.
8. Macari M., Bosniak M.A.: Delayed CT to evaluate renal masses incidentally discovered at contrast-enhanced CT: demonstration of vascularity with deenhancement. Radiology, 213, 674, 1999.
9. Mueller-Lisse U.G. et al.: Multi-detector CT of the kidneys In: Reiser et al. (eds).: Multislice CT, Springer Verl., 23, Berlin-Heidelberg-New York 2001.
10. Silvermann S.G. et al.: Small (-3cm) renal masses: correlation of spiral CT features and pathologic findings. AJR, 163, 597, 1994.
11. Szolar D.H. et al.: Multiphasic helical CT of the kidney: increased conspicuity for detection and characterization of small (<3-cm) renal masses. Radiology, 202, 211, 1997.
12. Urban B.A. et al.: CT appearance of transitional cell carcinoma of the renal pelvis. 1. Early-stage disease. AJR, 169, 157, 1997a.
13. Yuh B.I., Cohan R.H.: Different phases of renal enhancement: role in detecting and characterizing renal masses during helical CT. AJR, 173, 747, 1999.

14. Zeman R.K. et al.: Helical CT of renal masses: the value of delayed scans. AJR, 167, 771, 1996.

SUMMARY

Multislice computed tomography (MSCT) is a modern imaging method providing wider diagnostic possibilities. Its advantages include nearly isotropic imaging with high-quality, artefact-free two- and three-dimensional reconstructions, and scanning speed which allows routine multiphasic examinations of large body areas. The authors present their experience of multiphasic renal examinations using 8-row MSCT.

Tomografia wielorzędowa w ocenie zmian ogniskowych nerek
– nowe możliwości diagnostyczne

Tomografia wielorzędowa (*multislice computed tomography* - MSCT) jest nowoczesną metodą obrazowania o znacznie poszerzonych możliwościach diagnostycznych. Jej zalety to prawie izotropowe obrazowanie z możliwością uzyskiwania wysokiej jakości dwu- i trójwymiarowych rekonstrukcji, wolnych od artefaktów, i szybkość skaningu, pozwalająca na rutynowe wykonywanie badań wielofazowych dużych obszarów ciała. Autorzy przedstawiają własne doświadczenia dotyczące protokołu wielofazowego badania nerek za pomocą ośmiurzędowego MSCT.