Role of color Doppler and power Doppler imaging in renal masses

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Abstract

Ultrasonography is usually the first investigation to distinguish between solid and cystic renal masses and to further characterize these lesions. The role of needle aspiration to confirm the diagnosis is limited. Color flow Doppler sonography is a reliable means of differentiating between benign and malignant renal masses. Power Doppler sonography is a better measure of tissue perfusion. Twenty-three patients with renal masses were studied with power and color Doppler sonography and imaging diagnoses were correlated with final histopathological reports (benign or malignant). All the twenty-three cases were subjected to histopathological examination. It was found that the radiological diagnosis was correct in 22 (95%) of 23 cases. One case with Grade III vascularity was diagnosed as malignant on color Doppler sonography but as inflammatory mass on histopathology.

INTRODUCTION

The major objective of studying renal masses by ultrasound is to distinguish between cystic and solid masses and to further characterize them if possible. The role of fine needle aspiration cytology in renal masses is limited and angiography is an invasive procedure. Color Doppler sonography is a non-invasive procedure and pathological vessels can be easily demonstrated as vessels showing irregular course without progressive diminution in the caliber and presence of arterio-venous shunting in malignant tumors. Color flow Doppler sonography is a reliable means of differentiating between benign and malignant renal masses. Power Doppler ultrasonography is a new Doppler imaging technique that encodes an estimate of the integrated Doppler power spectrum in color rather than mean frequency and is a better measure of tissue perfusion.

MATERIAL & METHODS

Patients presenting with focal renal masses were studied with both ultrasonography and color Doppler. Twenty-three histopathologically proved cases were included in the study. Gray scale sonography, color and power Doppler examination was done using a wide band convex probe on GE logiq 400 and GE logiq 500. Vascular areas in the focal renal masses were identified on color Doppler and the peak systolic Doppler shift frequency of the lesions was recorded and those with 2.5 KHz and higher were regarded as ‘tumor signals' are based by Ramos et al 1988. Power Doppler imaging of focal renal masses was done to identify and localize slow moving blood flow, i.e. the signals which could not be localized by Color Doppler. Final diagnosis was confirmed by fine needle aspiration cytology/histopathological findings and all the findings were correlated to characterize the lesions as benign or malignant.

OBSERVATIONS

Renal cell carcinoma was found to be the commonest malignant (56%) lesion followed by Angiomyolipoma (13%), Wilm's Tumor (13%), inflammatory lesions (9%) and lymphoma (9%). On KUB X-ray soft tissue haze was detected in 7 (54%) out of 13 cases of renal cell carcinomas and one (8%) out of 13 showed central speckled calcification. Soft tissue haze was also detected in 2 (67%) out of 3 cases of Wilm's tumor. No specific features on KUB X-ray were detected in other renal masses. Intravenous urogram was done wherever required. Eight out of 13 (62%) cases of renal cell carcinoma showed distortion of calyces. A non-functioning kidney was observed in two (15%) cases. Two out of three (67%) Wilm's tumor cases showed stretching and splaying of calyces. Two (67%) out of three angiomyolipomas were avascular. Only one case showed peripheral vascularity Grade 1 on color Doppler and peak Doppler frequency shift was less than 2.5 KHz. One (50%) out of two inflammatory lesions showed peripheral Grade 2 vascularity on color Doppler and the peak Doppler frequency shift was more than 2.5 KHz.

Of the cases of renal cell carcinomas, six (46%) of 13 cases showed Grade 2 vascularity, three (23%) of 13 showed Grade 1 vascularity and four (31%) of 13 showed Grade 3 vascularity. None was found avascular. On power Doppler sonography vascularity was observed in all the cases of renal cell carcinomas; the pattern of vascularity was diffuse in the majority of the cases. In three (23%) of 13 cases, vascularity was improved. In two cases, vascularity improved from Grade 1 to Grade 2 and in one case, vascularity improved from Grade 2 to Grade 3. In 10 (77%) of 13 cases there was no improvement in vascularity and the vascular signal in power Doppler correlated with the vascular signal in color Doppler. Renal cell carcinomas showed a variable pattern of vascularity. A diffuse pattern was observed in seven (54%) of 13 cases, a central pattern was observed in 4 (31%) of 13, while a peripheral pattern was observed in two (15%) of 13 cases only.

The Wilm's tumors were found to be well defined and mostly heteroechoic. On color Doppler, one (33%) of three cases showed Grade 0 vascularity and two (67%) of three showed Grade 2 and Grade 3 vascularity on power Doppler. In one case, vascularity improved from Grade 2 to Grade 3 and both cases showed diffuse vascularity. Two (67%) of three cases of Wilm's tumor presented a Doppler shift frequency above 2.5 kHz and the flow was mainly of low resistance type. Similar findings were observed on power Doppler. Both lymphoma cases were less than 4cm in size and were hypoechoic with ill-defined margins. In one case the renal involvement was unilateral and in the other case it was bilateral. Both were found to be avascular on color Doppler and the findings on power Doppler were consistent with color Doppler. Both cases were avascular; so no peak systolic frequency shift was recorded.

The benign lesions were mostly smaller in size (80% less than 4 cm) while most of the malignant lesions (72%) were larger in size (more than 4cm; the size ranged from 4-12cm on gray-scale sonography). The consistency and echogenicity of malignant masses was heteroechoic in 61%; most of them had well defined margins. Echogenicity of benign masses was either hyperechoic or hypoechoic. Calcification was only found in malignant masses. Vascularity was detected in 15 (83%) of 18 cases of the malignant renal masses while 3 (60%) of 5 cases of the benign masses were avascular. In three (13%) of the total of 23 cases, enhanced vascularity was detected on power Doppler. Mostly a diffuse pattern of vascularity was detected in malignant renal masses while a peripheral pattern was detected in benign lesions. A peak Doppler shift frequency > 2.5 kHz was recorded in most (67%) of the malignant lesions while <1 kHz was recorded in most (80%) of the benign lesions. All the twenty-three cases were subjected to histopathological examination and it was found that the radiological diagnosis was correct in 22 (95%) of 23 cases except in one case showing Grade III vascularity diagnosed as malignant on color Doppler and as inflammatory mass on histopathology.

DISCUSSION

Angiography was used to detect tumor vessels but angiography is invasive. Color Doppler ultrasonography is based on the principles of mean Doppler frequency shift. Power Doppler sonography is a recent technique for detection of tumor vessles. Twenty-three patients with renal masses were studied with gray scale ultrasonography, color Doppler and power Doppler. X-ray chest, KUB, and IVU were also performed wherever required.

BENIGN LESIONS

INFLAMMATORY LESIONS

Two cases of inflammatory lesions in this study with the size 0-4 cm were hypoechoic with ill-defined margins. One of them showed peripheral vascularity grade 2 which enhanced to grade 3 on power Doppler. The peak Doppler frequency shift detected was more than 2.5 kHz. In a similar study, Kier[1] detected vascularity in inflammatory renal masses with peak Doppler shift frequency more than 2.5 kHz and falsely diagnosed these as malignant masses. Kuijpers[2] studied renal masses with duplex Doppler and found 33% of cases with peak Doppler frequency shift >2.5 kHz giving false positive diagnoses of malignant renal masses. As for angiomyolipoma, all the three cases (100%) were females in the age group of 30-50 years. Similar incidences of age & sex were also reported by others[3,4]. All the three cases of the present study were hyperechoic with well-defined margins; similar features were also shown by Banavali[4] and Hartman[3]. The marked echogenicity is due to a high fat content. Two out of three cases (67%) were avascular while in one case grade I vascularity was detected on color Doppler with no improvement of vascularity on power Doppler. The peak Doppler frequency shift detected was 1.6 kHz. Kuijpers detected a Doppler shift less than 2 kHz in one case of angiomyolipoma.

MALIGNANT RENAL MASSES

RENAL CELL CARCINOMA

In the present study, 13/18 lesions (72%) were renal cell carcinomas and were in the age group of 46-85 years. A similar view was put forward by others[2,4]. Male to female ratio was 8:5. Banavali [46] observed the same features and a 3:2 men:women ratio. KUB X-ray showed one case (8%) with fine calcifications. Similar results were also shown by others[4,5]. On gray-scale sonography nine out of 13 (69%) were heteroechoic, three (23%) were hyperechoic and one out of 13 (8%) was solid hypoechoic. Banavali [46] stated that US appearance was variable and 21% were echogenic. Chou[6] concluded that in larger RCCs the echotexture was usually heterogenous, especially when necrosis occurred. Ramos et al.[7] found that 34% of RCCs were hyperechoic and 48% showed mixed echogenicity. In one out of 13 (8%), the mass was extending to the IVC. Similarly, caval extension in 5-10% was reported by Madayag et al.[8] On color Doppler, three out of 13 (23%) showed grade I, six out of 13 (46%) showed grade 2 and four out of 13 (31%) showed grade 3 vascularity. Erden[9] showed that 83% of the malignant lesions were vascular and 2/12 (17%) were avascular tumors. Power Doppler sonography displays the integrated power of Doppler signals depending upon the number of RBCs. Power Doppler sonography is independent of the insonating angle and aliasing is not a problem.

In the present study, on power Doppler in two out of 13 (15%) cases the vascular signal was improved from Grade 1 to Grade 2 and in one case (8%), Grade 2 signals on color Doppler improved to Grade 3. The remaining 10 cases (76%) showed the same vascular signal. The present study concluded that power Doppler sonography detected the vascularity better. A peak Doppler frequency shift of 2.5 kHz or more was observed in 10/13 renal cell carcinomas (77%) and an end-diastolic shift of more than 1 kHz was observed in seven out of 13 cases (54%). Very high velocities resulted from anteriovenous anastomosis in malignant masses. Erden reported 83% sensitivity and recommended a threshold value of 2.5 kHz to provide high sensitivity for malignancy, Kier reported 70% sensitivity.

WILM'S TUMOR

In the present study, two out of three patients (67%) were below the age of 4 years and one case (33%) was above 4 years of age. Banavali reported a mean age of 3 years. All the three cases (100%) presented with a palpable abdominal mass. Banavali reported that 90% of the Wilm's tumors presented with a palpable abdominal mass.

On color & power Doppler ultrasound all the cases (100%) showed vascularity from Grade 1 to Grade 3. In two out of three cases (67%) the pattern of vascularity was diffuse and in these cases a low-resistance flow with spectral broadening was observed. Two out of three (67%) cases showed a peak Doppler shift frequency above 2.5 kHz. In the study conducted by Compenhout, 63 Wilm's tumors (80%) demonstrated high frequency Doppler shift.

LYMPHOMA

Two cases of lymphoma were included in the study. History of non-Hodgkin's lymphoma was positive in both cases. So the diagnosis of lymphoma of the kidney was suspected. Bosniak[10] concluded that lymphoma of the kidney is readily diagnosed if the history for lymphoma is positive. In the present study, the size of the lesions was below 2cm, there were multiple lesions and in one case (50%), the renal involvement was bilateral. On gray-scale sonography, the lesions were hypoechoic with ill-defined margins. No posterior enhancement was noticed. Banavali reported that the lesions were multiple hypoechoic masses without posterior enhancement. On color and power Doppler sonography no vascularity could be observed. Hence no Doppler shift could be recorded. Ramos studied 26 renal masses that subsequently proved to be malignant[11]. He observed no tumor signal in patients with lymphoma. In a similar study, Kuijpers found that lymphoma was avascular on angiography and the lesion revealed no signal on Doppler sonography.

CONCLUSION

We recommend that whenever a renal mass lesion is encountered on grey-scale ultrasonography, color Doppler and power Doppler imaging should be performed to categorize the lesion further as this provides valuable information in diagnosis and management of the patients at the cost of few minutes.

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