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ORIGINAL ARTICLE

Role of Color and Duplex Doppler in Differentiating Malignant from Benign Thyroid Nodules

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ABSTRACT

Background: Thyroid nodules is a common clinical problem and the chances of malignancy in solitary thyroid nodule is quite variable and recently reported to be as high as 34.4%. Ultrasonography is the most useful and a commonly employed modality to evaluate thyroid nodules with the main concern to differente malignant from benign nodules. Doppler is expected to enhance its diagnostic capabilities through the Doppler parameters (RI, PSV) of the intra- and the peri- nodular vessels. The type of flow in the nodule, correlation of the nodule size and the vascularity and changes in the Doppler characteristics with malignancy are the areas to raise curiosity in the minds of the researchers.

Aim: The purpose of study was to evaluate the role of color and spectral Doppler in differentiating benign from malignant thyroid nodules.

Methods: Doppler examination was performed on 61 nodules in 47 patients and recorded the pattern of vascularity on colour Doppler while resistivity index and peak systolic velocity was determined in both the peri-nodular and intra-nodular regions using spectral Doppler. All of these nodules subsequently underwent ultrasound guided fine needle aspiration cytology.

Results: Out of 61 nodules, 9 nodules were malignant while 52 nodules were benign on fine needle aspiration cytology. Six (66.67%) of nine malignant thyroid nodules and five (9.62%) of 52 benign nodules had predominately intranodular flow. Predominately intranodular flow had sensitivity, specificity, PPV and NPV of 66.67%, 90.38%, 94% and 54.54% respectively for diagnosing malignancy in thyroid nodules. Malignant thyroid nodules had significantly (P value=0.015) higher intra nodular mean systolic velocity (22.08cm/sec) in comparison to benign nodules (13.49cm/sec) while there was no significant (P value=0.953) difference in mean systolic velocities in peri nodular region. The resistivity indices of malignant nodules in both peri nodular (0.84) and intra nodular region (0.77) was not significantly different than those of benign nodules (peri nodular RI= 0.83 and intra nodular RI=0.83) with P vaues of 0.963 and 0.527 respectively.

Conclusion: The pattern of vascularity and intra-nodular peak systolic velocity can be used as color and spectral Doppler parameters to differentiate benign from malignant thyroid nodules. Intranodular flow is strongest predictor for diagnosing malignancy among color Doppler parameters.

Key words: Thyroid Nodules, Diagnosis, Ultrasonography, Doppler, Blood Flow velocity, Vascular resistance

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Introduction

Thyroid nodules are a common medical problem with approximately 8% of the adult population having clinically apparent nodules. The prevalence of palpable thyroid nodule in South India is about 12.2% [1]. The detection of these nodules has increased multifold due to the use of Imaging in the recent times [1,2]. Most of the thyroid nodules hyperplastic, with only 5-20% being true neoplasms [3].Thyroid cancer has been reported variably but occurs in approximately 5% of all thyroid nodules independent of their size [4] and the prevalence is known to increase in the recent times. [4, 5] . The incidence of malignancy in solitary nodule is seen in up to 16.5% of population residing in the costal region in an Indian study [6]. Keh et al have reported 34.4% of thyroid nodules to be malignant in their retrospective study [7]. Therefore, it is extremely important to differentiate the malignant thyroid nodules from the benign lesions.

The role of gray scale ultrasound (USG) in diagnosing thyroid malignancies has been extensively studied and features like hypoechogenicity, microcalcifications, and irregular margins have been found to be associated with malignant thyroid nodules. [8,9,10]

Malignancy is known to be associated with increased cellular proliferation leading to increased vascularity. Addition of Doppler to gray scale USG can increase the diagnostic performance of US for better detection of the malignant nodules. Five patterns of vascularity have been described in the thyroid nodules on color as well as on power Doppler examination. [11] .Even if fine needle aspiration cytology (FNAC) does not reveal malignancy nodules suspicious of being malignant on US can be kept under close Doppler follow-up and FNAC repeated whenever required.

Researchers have shown that increased intranodular flow on color Doppler examination helps in diagnosing thyroid malignancies[12,13]. While others concluded that malignant thyroid nodules have significant higher resistive index (RI) than benign thyroid nodules[14,15]. Further, power duplex Doppler facilitates scanning of thyroid nodules at risk of malignancy with increased sensitivity (92.3%) and specificity (88%) [11] . Chamas et al also demonstrated that RI was higher in malignant as compared to the benign thyroid nodules [11]. On the contrary Tamsel et al did not find any significant difference between the malignant and benign thyroid nodules with respect to the mean RI of either the intranodular (mean RI = 0.60) or the perinodular (mean RI=0 .58) vascularity[16]. Similarly the mean peak systolic velocity (PSV) was also not significantly different in both the intra- and perinodular vessels between the benign and the malignant nodules [16]. As there are conflicting reports regarding the role of Doppler in diagnosing thyroid malignancy, we conducted this study to determine the color and spectral Doppler characteristics of thyroid nodules for differentiating malignant from benign nodules.

Patients and Methods

After obtaining due clearance from the institutional review board, we performed a cross sectional study on 47 patients referred to the department of Radiology for a sonographic evaluation of thyroid gland due to clinical suspicion of thyroid disease. Patients with thyroid nodules detected clinically or on sonography and consenting to be a part of the study were included while patients refusing consent or having a FNAC proven diagnosis of the type of thyroid nodule were excluded from the study.

Sonographic Technique

The sonography was performed using Philips ATL HDI 5000 Bothell, WA, USA; equipped with a phased array linear broadband 5 MHz to 12 MHz transducer. The routine sonographic evaluation of the thyroid and the detected nodule was done. All the nodules were subjected to Doppler study. In cases where multiple nodules were detected one representative nodule was selected and interrogated on Doppler examination. All the nodules having different sonographic appearance underwent Doppler in multi-nodular goiter. The flow settings were adjusted to detect even the slow flow in the nodule without appearance of color artifacts. The vascular pattern of thyroid nodules was classified as one of the following as shown in table1.

Table 1: Type of vascularity in the thyroid nodules

Type of vascularity	Description
Avascular	Absence of any color or vascularity
Peri-nodular	Nodules with only peri-nodular or predominant peri-nodular flow
Both peri- and intra-nodular	Presence of both intra and peri-nodular vascularity
Intra-nodular	Nodules with predominately intra-nodular flow or only intra-nodular flow.

Each vascularized nodule was then evaluated on Duplex Doppler examination. The resistivity index (RI) and the peak systolic velocities (PSV) were recorded for three vessels both in the peri-nodular and the intra-nodular region and the average RI and PSV was then calculated for peri-nodular and intra-nodular vascularity. The nodule evaluated on Doppler was recorded diagrammatically on a representative image of the thyroid gland and the same nodule/ nodules were subjected to US guided FNAC.

Fine Needle Aspiration Cytology

Ultrasound guided FNAC was done from the nodules in collaboration with an experienced pathologist. FNAC was taken from every nodule that had been evaluated by color and spectral Doppler. If the sample taken at first attempt seemed inappropriate, a maximum of three attempts per nodule were made.

Both air dried and Pap wet fixed slides were made with the aspirated material. The air dried and the Pap slides were fixed by methanol and ethanol respectively and the air dried slides stained by May Gounwald Giemsa stain. The pathologist was blinded to imaging findings categorized the nodules as: malignant, benign or indeterminate based on the cytology result. A repeat FNAC was done in nodules with previously non-diagnostic/indeterminate results.

A statistical analysis was done using mean test for quantitative data and Fisher's exact test for qualitative data.

Results

A total of 47 patients of which 42 (89.36 %) were females, twenty nine patients had solitary thyroid nodule while eighteen had multinodular thyroid disease. The mean age of the patients was 41.43 years. A total of 61 nodules were identified for evaluation with color and spectral Doppler examination.

FNAC revealed that out of 61 nodules 45 were benign, 8 were malignant and 8 were non- diagnostic on first FNAC examination. One out of eight non- diagnostic nodules underwent surgery and was malignant on histopathological examination, while the rest seven were benign on repeat FNAC examination. Therefore the final study constituted of 52 benign and 9 malignant nodules.

No vascularity was appreciated in 4 (7.69%) of the nodules, all of which were benign. 57 (93.44 %) nodules

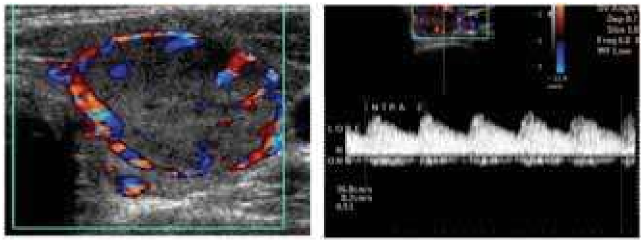

Fig. 1: a Fig. 1: b

Fig. 1: a) Showing an isoechoic solid nodule in the left thyroid lobe with peri nodular vascularity on color Doppler Imaging and b) Duplex Doppler shows a low resistance flow, with RI of 0.51. Histological diagnosis was a benign- Adenomatous nodule.

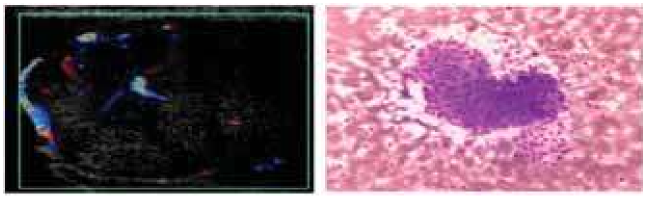

Fig. 2: a Fig. 2: b

Fig. 2: a) Color Doppler image showing both intra and perinodular vascularity and b) Photomicrograph at 200x of cytological specimen from thyroid gland showing increased number of thyroid cells with benign features s/o adenomatous goiter, benign nodule

Fig. 3: a Fig. 3: b

Fig. 3: a) Right thyroid lobe shows an isoechoic nodule with showing predominately intra-nodular vascularity and & b) Duplex Doppler shows high resistance flow with RI of 1. Cytology revealed a Medullary carcinoma- a malignant nodule.

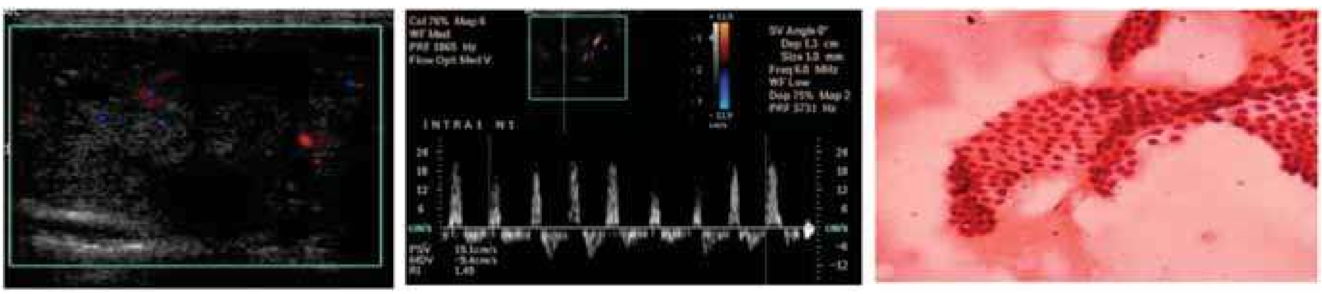

Fig. 4: a Fig. 4: b Fig. 4:c

Fig. 4: a) Color Doppler image showing predominately intra-nodular vascularity heteroechoic thyroid nodule with lobulated margins and foci of micro b) Duplex Doppler image showing high resistance intra-nodular flow (RI of 1.49) c) Photomicrograph at 200x of Pap smear showing thyroid cells with spindle shaped nuclei with grooving and irregular margins suggestive of papillary carcinoma a malignant thyroid nodule.

showed vascularity on colour Doppler imaging. Six (66.67%) of nine malignant thyroid nodules and five (9.62%) of 52 benign nodules had intranodular flow. Perinodular vascularity was present in 31 (50.82%) nodules and all were benign in nature. (Fig. 1) Of 15 nodules displaying equal peri-nodular and intra-nodular vascularity 12 were benign and 3 were malignant. (Fig. 2) Therefore, 23.07% of the benign and 33.33% of the malignant nodules demonstrated both perinodular and intranodular vascularity. (Table 2). All the 9 malignant nodules had intranodular vascularity. (Fig. 3 & 4).

Table 2: Distribution of color Doppler characteristics among benign and malignant thyroid nodules

Colour Doppler Characteristics	Benign (n=52) No. (%)+	Malignant (n=9) No. (%)*	Total (n=61) No. (%)@
Absent vascularity	4 (7.69%)	0 (0%)	4 (6.56%)
Perinodular vascularity (predominately peri-nodular or only peri-nodular flow)	31 (59.62%)	0 (0%)	31 (50.82%)
Equal distribution of vascularity	12 (23.07%)	3 (33.33%)	15 (24.59%)
Intranodular vascularity (predominately intra-nodular or only intra-nodular flow)	5++ (9.62%)	6# (66.67%)	11 (18.03%)

+Percentage is indicated taking 52 as 100 %, ++All had predominant intra-nodular flow
* Percentage is indicated taking 9 as 100, @ Percentage is indicated taking 61 as 100 %
# two of the six malignant nodules showing predominately intranodular vascularity had only intranodular vascularity.

Table 3: Predictive value of color Doppler characteristics suggestive of malignancy in a thyroid nodule.

Color doppler characteristics	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Intranodular vascularity	100	32.69	20.45	100
Perinodular vascularity	88.89	7.69	14.28	80
Predominately intranodular vascularity	66.67	90.38	94	54.54

Table 4: Duplex Doppler parameters of resistive index and peak systolic velocity in thyroid nodules for both malignant and benign thyroid nodules.

	Resistive Index (RI) (mean±2 SD)			Peak systolic velocity (PSV) (mean±2 SD in cm/s)		
Type of vascularity	**Benign**	**Malignant**	**P value**	**Benign**	**Malignant**	**P value**
Perinodular	0.83±0.19	0.84±0.17	0.963	18.75±10.156	19.60±16.86	0.953
Intranodular	0.83± 0.27	0.77±0.28	0.527	13.49± 6.58	22.08± 15.51	**0.015***

* Significant

For diagnosis of a malignant nodule intra-nodular flow had the highest sensitivity of 100%, but a very low merely 32.69% specificity. The PPV and NPV were 20.45% and 100% respectively for intra-nodular blood flow. Presence of perinodular vascularity had a sensitivity, specificity, PPV and NPV of 88.89%, 7.69%,80%, 14.28% and 80% respectively for diagnosing malignancy in thyroid nodules. Predominant intra-nodular flow had a sensitivity, specificity, PPV and NPV of 66.67%, 90.38%, 94% and 54.54% respectively for diagnosing malignancy in thyroid nodules. (Table 3)

Discussion

A total of 61 nodules of which 9 patients were subject to malignant and the rest 52 were benign on FNAC. Color and spectral Doppler examination in order to differentiate between benign and malignant thyroid nodules.

It was found that intranodular vascularity had strong association with malignancy in thyroid nodules (P value =0.015).

When studied as an independent predictor it had sensitivity, specificity, PPV and NPV of 66.67%, 90.38%, 54.54% and 94% respectively for detection of malignancy in thyroid nodules. According to our findings intranodular flow is strongest predictor for diagnosing malignancy among color Doppler parameters.

In concordance to our findings Cerbone et al 1999 [15] reported that predominately intranodular blood flow has a sensitivity of 98.1% and specificity of 100% for differentiating benign from malignant thyroid nodules. They explained that malignant lesions have more cellular proliferation in intranodular region. They also reported that there was no significant correlation between nodule size and vascularity. Papini et al [12] was in agreement and also reported intra-nodular vascularity to be significant predictor of malignancy in thyroid nodules. They reported a sensitivity of 74.2% and specificity of 80.8% for this feature.

Though Frates et al [13] showed that solid hypervascular thyroid nodules have high risk of malignancy, but found that it is a non specific sign as more than 50% of the hypervascular solid thyroid lesions were benign.

However, present results are not concordant with findings of Wienke et al [17] and Iannuccilli et al [18] who found that benign nodules also exhibited high grades of intranodular vascularity. Similarly, Tamsel et al [16] found that intranodular vascularity is the most common vascular pattern for both benign and malignant thyroid nodules and it cannot be used as a predictor of thyroid malignancy because of its low specificity. This difference in the studies can be attributed to the relative larger size of the thyroid nodules in their study as compared to ours; as with growth of the benign nodule there is progressive recruitment of intra-nodular vessels.

Chan et al [19] reported that all papillary thyroid carcinomas in their study had some intrinsic blood flow, and they concluded that a completely avascular nodule is very unlikely to be malignant. This was in total agreement to the findings in our study as all the avascular nodules in our study were benign and all the malignant nodules showed presence of intra-nodular blood flow.

The presence of large quantities of stenosis and occlusions in the neo-vascularisation of thyroid carcinoma tend to increase the vascular resistance and thus the resistive index.

The duplex Doppler findings showed no statistical significant difference between benign and malignant thyroid nodules when resistivity index was studied as parameter for diagnosing malignancy both in the peri-nodular as well as the intra-nodular blood flow. In concordance to these results, Tamsel et al [16] reported that duplex Doppler can not differentiate between benign and malignant thyroid nodules and they did not find any statistically significant difference between resistive indices of benign and malignant thyroid nodules.

However there is gross disagreement with Cerbone et al [15] and Chammas et al [11] with respect to the RI between the benign and malignant thyroid nodules. The former reported a significant difference in RI of benign and malignant thyroid nodules and suggested a cut off value of 0.75 for RI of intra-nodular vessels for predicting malignancy in thyroid nodules. Chammas et al [11] found that thyroid nodules with RI of >0.77 in intranodular location were at high risk for malignancy.

A statistically significant difference was found in the peak systolic velocities in intranodular location of benign (13.49 cm/sec) and malignant thyroid nodules (22.08cm/sec), but peak systolic velocities in perinodular location were not significantly different. When a cut off value of 16cm/sec was taken for peak systolic velocity in intranodular location for diagnosing malignancy in thyroid nodules, it had a sensitivity of 55.55% and specificity of 78.85%.

Cerbone et al [15] suggested Power Doppler to have a higher sensitivity (100 vs. 91%) and specificity (95.1 vs. 86.2%) than color Dopler in investigating thyroid nodules in comparison to the results of cytology. However, in our study neither power Doppler nor duplex power Doppler was used to evaluate the thyroid nodules.

Conclusion

From our study we concluded that intranodular flow and increased intranodular peak systolic velocity can be used as predictors of malignancy in thyroid nodules, while resistivity index is not helpful as both benign and malignant thyroid nodules can show high resistivity index in both the peri-nodular and intra-nodular blood flow. Intranodular flow is strongest predictor for diagnosing malignancy among color Doppler parameters.

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Ethics:	There is no ethical violation as it is based on voluntary anonymous interviews
Funding:	No external funding
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References

1. Usha Menon V, Sundaram KR, Unnikrishnan AG, Jayakumar RV, Nair V, Kumar H. High prevalence of undetected thyroid disorders in an iodine sufficient adult south Indian population. J Indian Med Assoc 2009;107:72-7.
2. Unnikrishnan AG, Kalra S, Baruah M, Nair G, Nair V, Bantwal G, et al. Endocrine Society of India management guidelines for patients with thyroid nodules: A position statement. Indian J Endocrinol Metab 2011;15:2-8.
3. Ross DS. Non-palpable Thyroid Nodules- Managing an Epidemic. Journal of Clinical Endocrinology and Metabolism. 2002; 87(5): 1938-40.
4. Yeung MJ, Serpell JW. Management of the solitary thyroid nodule. Oncologist 2008;13:105-12.
5. Tai JD, Yang JL, Wu SC, Wang BW, Chang CJ. Risk factors for malignancy in patients with solitary thyroid nodules and their impact on the management. J Cancer Res Ther 2012;8:379-83.
6. Chetan RV, Veeresalingam B, Kishore KM, Durbesula PT, Rao PS. A study on the manifestation and the incidence of benign and malignant tumors in a solitary thyroid nodule. Int J Res Med Sci. 2013; 1(4): 429-32.
7. Keh SM, El-Shunnar SK, Palmer T, Ahsan SF. Incidence of malignancy in solitary thyroid nodules. *J Laryngol Otol.* 2015 Jul. 129 (7):677-81.
8. Kim EK, Park CS, Chung WY, et al. New sonographic criteria for recommending fine-needle aspiration biopsy of non-palpable solid nodules of the thyroid. AJR 2002; 178: 687–691.
9. Tae HJ, Lim DJ, Baek KH, et al. Diagnostic value of ultrasonography to distinguish between benign and malignant lesions in management of thyroid nodules. Thyroid 2007; 17: 461-466.
10. Moon HG, Jung EJ, Park ST, et al. Role of ultrasonography in predicting malignancy in patients with thyroid nodules. World J Surg 2007; 31: 1410-1416.
11. Chammas MC, Gerhard R, Oliviera IRSD, et al. Thyroid nodules: evaluation with power Doppler and duplex Doppler ultrasound. Otolaryngology, head and neck surgery 2005; 132:874-882.
12. Papini E, Guglielmi R, Bianchini A, et al. Risk of malignancy in non-palpable thyroid nodules: predictive value of ultrasound and color-Doppler features. J Clin Endocrinol Metab 2002; 87:1941–1946.
13. Frates MC, Benson CB, Doubilet PM, Cibas ES, Marqusee E. Can color Doppler sonography aid in the prediction of malignancy of thyroid nodules? J Ultrasound Med 2003; 22: 127–131.
14. Holden A. The role of color and duplex Doppler ultrasound in the assessment of the thyroid nodules. Aust Radiol 1995; 35: 343-349.
15. Cerbone G. Spiezia S, Colao A, Di Sarno A, Assanti AP, Lucci R, Siciliani M, Lombardi G. Fenzi G. Power Doppler improves the diagnostic accuracy of color Doppler ultrasonography in cold thyroid nodules: follow-up results. Horm Res 1999; 52: 19–24.
16. Tamsel S, Demipolat G, Erdogan M, et al. Power Doppler ultrasound patterns of vascularity and spectral Doppler ultrasound parameters in predicting malignancy in thyroid nodules. Clin. Radiol 2007; 62:245-251 993; 59: 415-419.
17. Wienke JR, Chong WK, Fielding JR, Zou KH, Mittelstaedt CA. Sonographic features of benign thyroid nodules. J Ultrasound Med 2003; 22: 1027–1031.
18. Iannuccilli JD, Cronan JJ, Monchik JM. Risk for malignancy of thyroid nodules as assessed by sonographic criteria: the need for biopsy. J Ultrasound Med 2004; 23: 1455-1464.
19. Chan BK, Desser TS, McDougal R, Weigel RJ, Brooke JR. Common and uncommon sonographic features of papillary thyroid carcinoma. J Ultrasound Med 2003; 22: 1083–1090.

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Enhanced Image Registration Technique for Medical Image Segmentation

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ABSTRACT

In image processing and image analysis the final result is obtained by combining information from various sources. To obtain better result from combined information, image registration plays an important role, which is an earlier step in image segmentation. Generally it follows feature extraction, feature matching, and transformation and sampling, dominant extracted features and matching algorithm gives the better registration accuracy. In proposed system contourlet transform and mutual information is combined to increase the accuracy in registration process. Contourlet transform extracts efficient curves and edges from MRI images, these features from MRI brain images helps to match the information using mutual information. Performance comparison of proposed results shows high performance using Contourlet transform.

Key words: Feature extraction, Transform modeling, Image resampling, Contourlet transform, Mutual Information.

Introduction

The processing of transforming different forms of data into single co-ordinate system is called image registration. Data may be different images, data which is reconstructed from different sensors, depths, times or viewpoints [1]. It is used in computer vision applications, medical imaging, biological imaging, and satellite imaging. Registration is important in order to match or fuse the data which is obtained from different measurements. The discrete expansion of curvelet transform is known as contourlet transform, first it is processed in continuous domain [2] using multi-scale filtering and then undergo with a block ridge let transform [3] on each band pass data, later it is directly used in frequency partitioning without using ridge let transform . Instead of key points contourlet transform captures curves; apart from curvelets and contourlet many transformation techniques are developing which efficiently represent geometrical regularity, for example band lets, the edge-adapted multiscale transform [3] etc, but these techniques need edge detection stage which is followed by adaptive representation.

Contourlet representation is a type of fixed transform, these characteristics made contourlet transform to be effectively applied in a computer vision tasks, similar to wavelets. In computer vision techniques Magnetic Resonance Imaging (MRI) play an important role, it is used in medical examination, assistant diagnosis of brain tumors and breast cancers owing to its high resolution to soft tissues and no damage to human body during acquisition. Medical knowledge and experience of doctors can obtain the information's like sizes, locations, shapes and other pathological features of brain tumors. According to the information in MRI images are used to make scientific and reasonable therapeutic treatment. Because there are several MRI examinations for every patient in the whole therapeutic treatment, each of which can give data in multiple sequences, it is a large amount of data to be dealt with for the doctors. Long time of hard work will inevitably lead to mistakes in the diagnosis of the tumor contours for the doctors. Moreover, it is subjective for the doctors to determine the state of the diseases according to their medical knowledge and clinical experiences. Therefore, developing an automatic or a semi-automatic computer-aided diagnosis system is meaningful in real medical treatments, which can release the workload of doctors and improve the accuracy by

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