Associations between MR derived vascular, shape and texture parameters with histological descriptors

M. D. Pickles[1], P. Gibbs[1], M. Lowry[1], and L. W. Turnbull[1]
[1]Centre for MR Investigations, University of Hull, Hull, East Yorkshire, United Kingdom

Introduction An overall survival rate of 82% and progression free survival of 65% at four years have been reported[1] for patients who have undergone neoadjuvant chemotherapy (NAC). This indicates that for a significant minority of patients some form of relapse can be anticipated. Consequently, biomarkers of reduced survival intervals are currently being sought. Imaging features such as shape (round, irregular), enhancement (homogeneous, heterogeneous), and kinetic curve assessment (persistent, plateau and washout) have been used to aid in the classification of breast lesions[2]. These same features may also help to highlight those patients who subsequently have a reduced overall (OS) and disease free (DFS) survival intervals. The aim of this work was to determine if there were any associations between pre-treatment MR derived quantitative descriptors (shape, enhancement and kinetic curve assessment) and traditional prognostic indicators.

Methods One hundred patients were scanned prior to NAC on a 3.0T HDx scanner (GE Healthcare). In each case a 3D dynamic dataset was acquired utilising VIBRANT. Shape, texture (enhancement) and vascular kinetics [pharmacokinetic (PK) and model free (empirical)] parameters were acquired. Semi-automated ROI's were generated on each slice that demonstrated malignant tissue throughout the breast from an early arterial phase. For kinetic analysis the signal intensities from the individual ROI's were averaged for each individual phase prior to analysis. Texture and shape anlysis were undertaken purely from the early arterial phase. For the texture analysis multiple 2D datasets were averaged to provide a pseudo 3D analysis. This averaging approach was felt to be unsuitable for shape analysis consequently a 2D approach was adopted whereby only the ROI with the largest cross sectional area was interrogated. Two patient groups were generated based on traditional prognostic indicators. These groups were nodal status (node +ve vs. –ve) and a combination of nodal and hormonal status (node +ve, ER –ve, and PR –ve vs. all others). Statistical analysis was then undertaken to see if MR parameters provided any significant differences within these groups.

Results Of the one hundred patients scanned the nodal status was determined in 90 (46 node +ve, 44 node -ve) while the nodal and hormonal status was known in 87 (10 node +ve, ER –ve and PR –ve vs. 77 all others). Regarding nodal status no significant parameters were noted for either PK modelled vascular kinetics or texture analysis. However, for empirical vascular kinetics and shape parameters several significant differences were noted with node +ve patients generally demonstrating poorer initial vascular kinetics (BI-RADS Initial rise), more complex, less circular and less convex borders than node –ve patients. Similar vascular kinetic results were noted for node +ve, ER –ve and PR –ve patients. However, for this group shape was not significant but 5/16 texture parameters were with F6 (sum average) providing the most significant result. All significant parameters are displayed in the table for both patient groups.

Parameter	Group	Mean (±SD)	p value	Parameter	Group	Mean (±SD)	p value
Rise Time	Node +ve	0.49 (0.17)	0.021	Max EI	N +ve, ER -ve, PR -ve	1.03 (0.26)	0.024
	Node -ve	0.41 (0.13)			All others	1.32 (0.39)	
% EI 30sec	Node +ve	55.6 (19.2)	0.031	Time to Max	N +ve, ER -ve, PR -ve	3.57 (0.97)	0.009
	Node -ve	64.1 (17.5)			All others	2.53 (1.18)	
Initial Slope	Node +ve	1.39 (0.68)	0.043	AUC 90sec	N +ve, ER -ve, PR -ve	1.23 (0.39)	0.032
	Node -ve	1.70 (0.74)			All others	1.64 (0.58)	
AUC 30sec	Node +ve	0.35 (0.17)	0.041	F6	N +ve, ER -ve, PR -ve	0.35 (0.11)	<0.001
	Node -ve	0.43 (0.19)			All others	0.30 (0.34)	
Complexity	Node +ve	53.5 (42.8)	0.002	F7	N +ve, ER -ve, PR -ve	74.45 (2.99)	0.037
	Node -ve	33.9 (22.2)			All others	76.60 (3.19)	
Circularity	Node +ve	0.27 (0.09)	0.012	F8	N +ve, ER -ve, PR -ve	4.94 (0.005)	0.006
	Node -ve	0.22 (0.09)			All others	4.93 (0.02)	
Convexity	Node +ve	0.71 (0.15)	0.002	F15	N +ve, ER -ve, PR -ve	-39.42 (20.69)	0.003
	Node -ve	0.81 (0.13)			All others	-60.78 (21.05)	
K_{ep}	N +ve, ER -ve, PR -ve	2.13 (1.11)	0.021	F16	N +ve, ER -ve, PR -ve	10954.01 (627.13)	0.043
	All others	4.38 (3.75)			All others	10498.90 (664.38)	

Conclusions This work has demonstrated that when comparing traditional prognostic indicators (nodal ± hormonal status) significant differences in shape, texture and vascular kinetics are apparent. Vascular kinetics were significant for both nodal and hormonal status. Additionally, the results suggest that shape was linked with nodal status and texture with hormonal results. The significantly lower vascular kinetics of the node +ve tumours may seem counterintuitive. However, a link has been demonstrated between hypoxic microenvironments and increased metastatic potential[3] which may explain this result.

Future Work Follow this patient cohort to establish if pre-treatment MR parameters shape, texture and vascular kinetics provide a more useful insight into DFS and OS than traditional prognostic indicators.

References [1]van de Hage et al. J. Clin Oncol 2001;19:4224-37, [2]ACR BI-RADS MRI Lexicon, [3]Knowles et al. Breast Cancer Res 2001; 3:318-322.