Reproducibility of T_1 and T_2* weighted dynamic contrast-enhanced MRI: a multiparametric comparison of breast and abdominal tumours

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Introduction: Measurement and analysis methodology for the application of dynamic contrast enhanced MRI (DCE-MRI) for antivascular cancer treatment has been the subject of several consensus meetings[1]. The need to have reproducibility data to allow individual and intergroup comparisons with a uniform statistical approach was emphasised. This study reports the reproducibility statistics of multiparametric data acquired from both T_1 and T_2*-weighted DCE-MRI examinations and non-contrast R_2* measurements, in breast and abdominal tumours imaged twice on two different days in the same week.

Methods: 8 patients with primary untreated breast cancer and 22 patients with various abdominal tumours (of which 19 had gynaecological tumours and 9 had been treated previously with chemotherapy) were imaged at 1.5T. Breast cancer patients were imaged in a dedicated breast coil. Spoiled gradient-echo [FLASH] sequences with 8 different TE [5-75ms], TR=100ms, $\alpha=40^o$, 1 slice were used for R_2* measurement using an IDL® least-squares fitting routine[2]. Following this, T_1W DCE-MRI images were acquired using the same sequence (TE=4.7ms, TR=11ms, $\alpha=35^o$, 4 slices). 40 images were acquired every 12 seconds for 8 min 5s. An injection of 0.1mmol/kg Gd-DTPA (Magnevist®) was given using a power injector at 4ml/s during the 5th data acquisition point. The data were fitted to the Tofts and Kermode model[3] using methods previously described[4] with quantitative (K^{trans}, v_e, k_{ep}, and maximum Gd-DTPA concentration), and semi-quantitative (IAUGC-90 seconds, mean gradient and maximum signal amplitude) kinetic parameters calculated. Following this, a T_2*-weighted DCE-MRI sequence was used to acquire data every 2 seconds over 2 minutes (TE=20ms, TR=30ms, $\alpha=40^o$, 1 slice) with 0.2mmol/kg Gd-DTPA injected at 4ml/s after 20s. These data were used to calculate relative blood volume (rBV), relative blood flow (rBF) and mean transit time (MTT). All calculations were performed pixel-by-pixel using in-house software (Magnetic Resonance Imaging Workbench - Institute of Cancer Research, London). Regions of interest (ROI) were drawn around the tumour edge by an experienced observer. Reproducibility analysis used the methods of Bland and Altman[5] on spreadsheets and the StatsDirect™ analysis package. Summary statistical measures calculated were within-patient standard deviation wSD, repeatability r (absolute value and as a % of the mean), variance ratio (F – ratio of between-patient to within-patient variance), intra-class correlation coefficient (ICC) and the within-patient coefficient of variance wCV (wSD = wCV/mean parameter value).

Results: The table shows the reproducibility statistics of all the kinetic parameters. K^{trans}, k_{ep} and mean gradient showed that the difference between the paired examinations was proportional to the mean[5] and so a logarithmic transform was required to calculate r. This gives an asymmetric value for r.

	K^{trans}		v_e		$k_{ep}(=K^{trans}/v_e)$		Max Gd	
1a	**Breast**	**Abdominal**	**Breast**	**Abdominal**	**Breast**	**Abdominal**	**Breast**	**Abdominal**
r as %mean	-47.9 to +92.0	-39.7 to +65.9	12.1	21.1	-47.1 to +89.0	-35.8 to +55.9	26.4	20.5
F	5.7	8.0	27.2	24.1	5.4	10.9	6.2	25.0
ICC	0.67	0.77	0.92	0.92	0.65	0.92	0.69	0.92
wCV	26.5%	17.4%	4.4%	7.6%	25.8%	17.4%	9.5%	7.4%

Table 1a: T_1 DCE-MRI quantitative parameters

	Mean Gradient		Maximum Amplitude		IAUGC	
1b	**Breast**	**Abdominal**	**Breast**	**Abdominal**	**Breast**	**Abdominal**
r as %mean	-64.7 to +183.4	-30.9 to +44.7	24.4	30.1	37.4	30.8
F	7.3	10.0	14.1	16.9	14.3	16.3
ICC	0.73	0.81	0.85	0.88	0.85	0.88
wCV	45.7%	14.3%	8.8%	10.9%	13.5%	11.1%

Table 1b: T_1 DCE-MRI semi-quantitative parameters and area under the first 90s of the Gd concentration-time curve.

	rBV		rBF		MTT		R_2*	
2	**Breast**	**Abdominal**	**Breast**	**Abdominal**	**Breast**	**Abdominal**	**Breast**	**Abdominal**
r as %mean	76.9	54.5	58.5	46.4	12.7	9.4	12.8	48.5
F	16.7	11.0	30.3	15.7	5.4	8.61	24.4	6.4
ICC	0.87	0.82	0.93	0.87	0.65	0.78	0.91	0.72
wCV	27.7%	19.7%	21.1%	16.7%	4.6%	3.4%	4.6%	17.5%

Table 2: T_2* DCE-MRI parameters and R_2* measurement.

Discussion: Reproducibility values for K^{trans}, v_e and IAUGC are comparable to those reported previously[4]. The reproducibility of DCE-MRI data is dependent on the patient group being examined, the MRI technique used and kinetic parameter being estimated. Reproducibility for breast cancer is worse for most kinetic parameters. This may be related to the smaller number of breast cancer patients examined but equally could be due to the nature of the pathology imaged (innate vascular variability), coils and sequences used. Other factors include patient repositioning errors and motion. To minimise the effects of physical factors, the coils were fixed and identical sequences and parameters were used for both patient groups. These results are serving as our standards for ongoing antivascular clinical trials using DCE-MRI as a response indicator.

References:

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