Arterial input functions from sub-second MR and CT imaging: quality and accuracy

E. Charles-Edwards[1], K. Newbold[2], E. Castellano[2], A. Tang[1], J. D'Arcy[1]

[1]Cancer Research UK Clinical Magnetic Research Group, Royal Marsden NHS Foundation Trust and Institute of Cancer Research, Sutton, Surrey, United Kingdom,
[2]Royal Marsden NHS Foundation Trust, London, United Kingdom

Introduction: There is considerable interest in using quantitative pharmocokinetic parameters derived from dynamic contrast enhanced (DCE) MRI techniques to identify hypoxia within tumours. MR-derived arterial input functions (AIFs) are difficult to obtain due to conflicting requirements of temporal resolution and image quality and the lack of a direct relationship between image intensity changes and MR contrast agent concentration. This work compares MR-and CT derived AIF data obtained at a temporal resolution of 0.5 seconds in a group of patients with head and neck cancer with a MR AIF derived from arterial sampling (1).

Methods: MR AIF: Scans were performed on two 1.5T Philips Intera scanners using the manufacturer's head and neck coil. A proton density weighted 3D volume was positioned sagittally encompassing the entire length of the common carotid, verified by reference to a previously acquired time-of-flight angiogram. This was followed by a dynamic T1-weighted scan of identical geometry during which a small quantity (5-9 mls) of Magnevist®, (Berlex Inc) followed by a 10 ml saline bolus was administered intravenously by a power injector (Medrad Inc®, PA, USA) at a rate of $4mls^{-1}$. Flow compensation was employed and scanning geometry ensured that inflow effects were minimised. **CT AIF** The same patients had a cine perfusion sequence with a rotation time of 1 sec (reconstructed to 0.5 sec scan time) and total acquisition time of 50secs, using 80kV and 100mAs on a GE Lightspeed 16® scanner. Intravenous contrast agent, iohexol 300 was injected at a dose of 0.5ml/kg at 4ml/sec.

Table 1: MR sequence parameters	TR (ms)	TE (ms)	NSA	Flip Angle	FOV (mm) Matrix	Scan time (s)	No. of scans
PD	4	1.79	3	2	300 (SI) x 150 (AP) x 20 (RL)	1.5	1
					112 (SI) x 36 (AP) x 5 (RL)		
T1	4	1.79	1	10	300 (SI) x 150 (AP) x 20 (RL)	0.496	240
					112 (SI) x 36 (AP) x 5 (RL)		

Post-processing: MR AIF: Post-processing was performed on MRIW software (2) at a position not lower than the second cervical vertebra. Signal intensity was converted into Gadolinium concentration using the method described by Parker et al. (3). **CT AIF:** The right and left ICA was identified and changes in Hounsfield units (HU) within the artery obtained using the manufacturer's software and converted into concentration of iodine using a previously obtained calibration for this sequence.

Results: CT-derived AIFs from right and left ICAs were similar in appearance. Fig. 1 shows the right ICA CT-derived AIFs for 3 patients. The MR-derived AIFs from the same 3 patients are shown in Fig 2. Included in both figures is a concentration time curves determined from arterial sampling following the administration of 0.1mmol/kg Gd derived from an average of 6 samples, corrected to a common onset time of 10 seconds (1).

Fig 1: CT-derived AIF

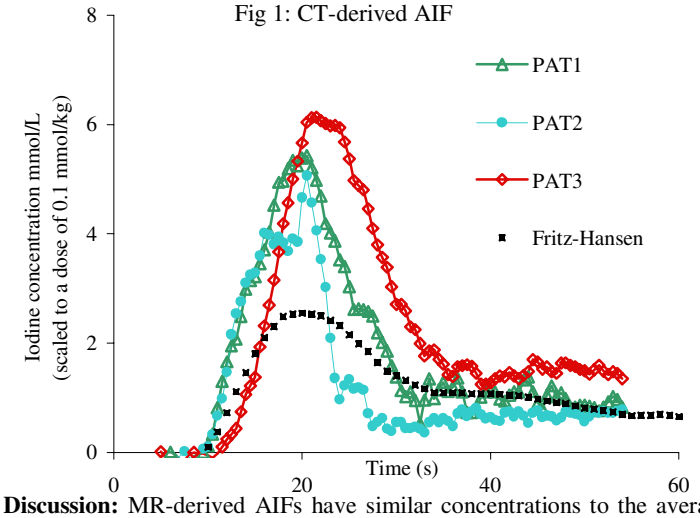
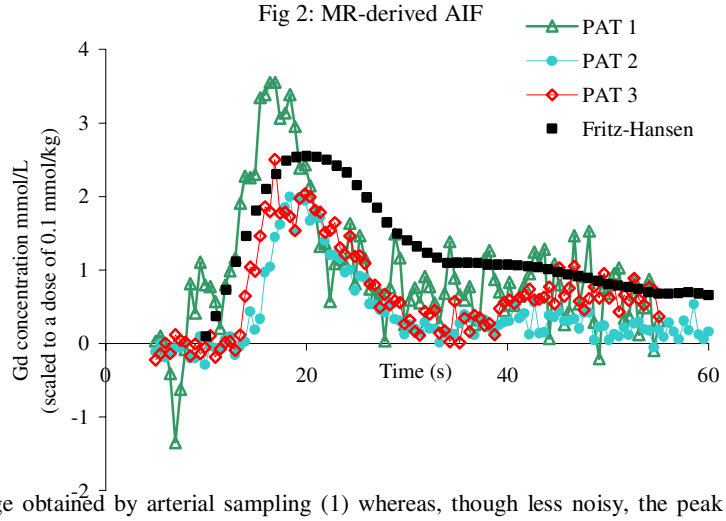


Fig 2: MR-derived AIF



Discussion: MR-derived AIFs have similar concentrations to the average obtained by arterial sampling (1) whereas, though less noisy, the peak concentrations demonstrated by the CT-derived AIFs are nearly 3 times higher. Han et al (4) have shown in canine CT studies that for identical amounts of iodine and administration rates, peak enhancement increases with the contrast agent volume. Data in Fig. 1, corrected to a standard concentration will require a further correction for contrast agent volume before being applied to DCE-MRI data. We have previously demonstrated statistically significant correlations between the presence of hypoxia (indicated by pimonidazole staining) and pharmacokinetic parameters derived from a standard AIF in 7 patients with head-and-neck cancer (5). Future work will assess the impact on these correlations when individual dose and volume-corrected CT and MRI-derived AIFs are included in the analysis.

References

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4. Han JK et al. Korean J Radiol 2001;2:28-364. 5. Newbold K et al European Journal of Cancer Supplements 3(2) (2005) p 310

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