
Reproducibility of Diffusion-Weighted Radial vs. Conventional EPI Protocols in GEM Model of Pancreatic Cancer

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Penn Quantitative Imaging Resource
for Pancreatic Cancer

Introduction

- Diffusion-weighted (DW-) MRI may be useful for assessing tumor response to stroma-directed drugs
- We compared two motion-resistant DW-MRI methods and compared test-retest results:
 - Cartesian spin-echo EPI (DW-SE-EPI)
 - Radial spin-echo (DW-SE-RAD)

Methods

- 4.7T horizontal bore DirectDrive® MR system (Agilent) interfaced with 12-cm gradients
- Respiratory-gated DW-MRI with b-values: 0.64, 535, 1071, 1478, 2141 s/mm²
- KPC mice (*LSL-Kras^{G12D/+};LSL-Trp53^{R172H/+};Pdx-1-Cre*)
- Test-retest (N = 10) performed with full recovery between scans, repositioned (2-4 hour interval)
- DW-SE-EPI:
- DW-SE-RAD: TE/TR = 30ms/2-3 respiratory periods; BW = 50kHz; FOV = 32x32mm²; 0.5mm thick; 12-18 slices; 64 readouts; 101 views, acquisition time = 20-38 min
- DW-SE-EPI: 128x128; 4 shots; TE/TR = 26ms/4 respiratory periods; 1.5mm thick; FOV = 32x32mm²; BW = 250kHz; 16 averages; acquisition time ~20-35 min

Results

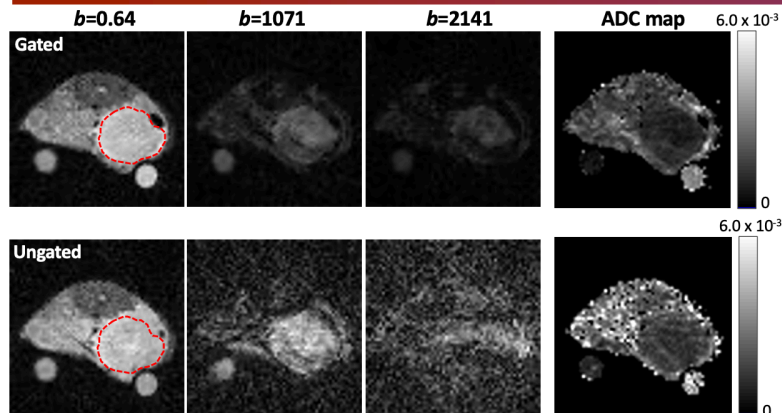
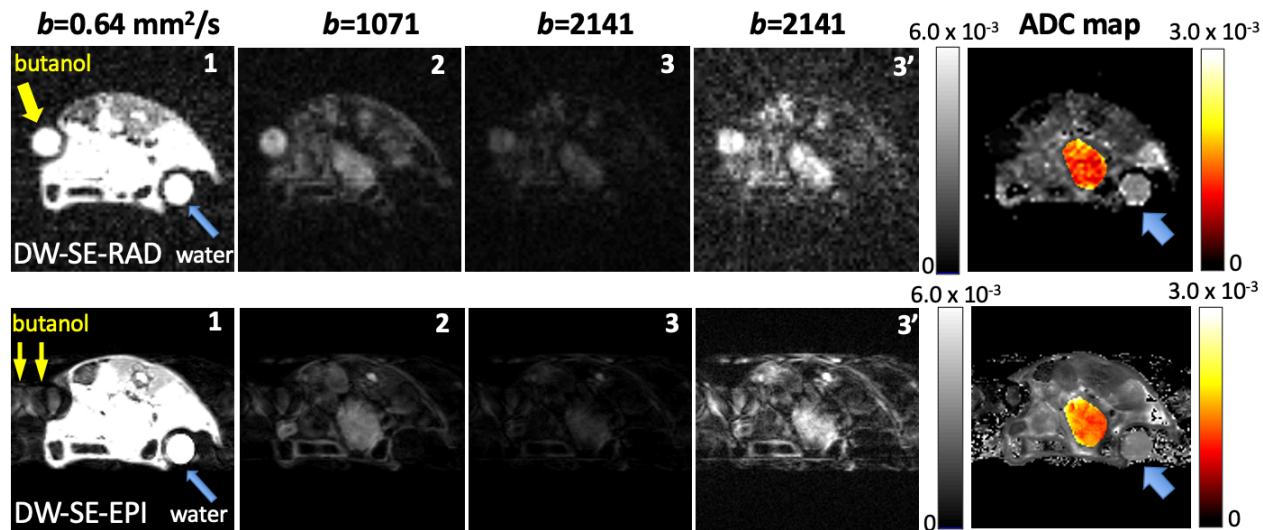


Fig. 1 (above) Diffusion-weighted images and the ADC maps from DW-SE-RAD protocol with and without prospective respiratory gating. Mean ADC (in $10^{-3} \text{ mm}^2/\text{s}$) of water in the gated scan was 3.2 ± 0.13 , closely matching literature values, while that of ungated scan was 4.0 ± 0.30 . The ADC estimates of the tumor were 1.1 ± 0.097 (gated) vs. 1.3 ± 0.17 (ungated).

Fig. 2 (below) Diffusion-weighted images and ADC maps obtained from the two DWI protocols. Frames 3 and 3' are same images windowed differently. ADC maps (mm^2/s) are displayed in color overlay for tumor and in gray scale for other tissues and phantom. Due to its low diffusion coefficient ($\sim 0.44 \times 10^{-3} \text{ mm}^2/\text{s}$), butanol appears with low intensities in the ADC maps.



Results

Table 1 Statistical parameters derived from ADC estimates in the test-retest study

	PROTOCOL	ADC (mean \pm sd)	ΔD (mean \pm sd)	SD_{ws}	CV_{ws}	RC
Water*	DW-SE-RAD	3.2 \pm 0.29*	-0.042 \pm 0.28	0.19	0.060	0.53
	DW-SE-EPI	2.8 \pm 0.15*	0.069 \pm 0.15	0.11	0.039	0.31
Muscle	DW-SE-RAD	1.8 \pm 0.27	0.045 \pm 0.20	0.14	0.073	0.38
	DW-SE-EPI	1.8 \pm 0.23	0.060 \pm 0.26	0.18	0.096	0.50
Tumor	DW-SE-RAD	1.3 \pm 0.24	-0.017 \pm 0.18	0.12	0.090	0.34
	DW-SE-EPI	1.5 \pm 0.28	-0.082 \pm 0.34	0.24	0.13	0.66

ΔD : Difference between test-retest; SD_{ws} : Within-subject standard deviation; CV_{ws} : Within-subject coefficient of variation; RC : Repeatability coefficient. CV_{ws} and RC are unitless. All other values reported in units of $\times 10^{-3}$ mm²/s

*: $P < 0.001$; for all others, $P > 0.05$.

Observations:

- Radial sequence yields more accurate ADC value of water (3.2 vs. 2.8 for Cartesian EPI).
- In test-retest, ADC variability in tissue is generally lower in radial images than those in Cartesian.



Discussion & Conclusion

- Cartesian EPI approach yielded better SNR than radial, but suffered from severe ghosting artifacts and under-estimation of ADC values in the water phantom.
- Radial images were free of motion and yielded more accurate water ADC and lower variability (coefficient of variation) in biological tissues.
- The main disadvantages of prospectively gated spin-echo radial acquisition is the long acquisition time (~30 min in this work) and lower SNR.
- Radially sampled DWI requires moderate gradient capabilities broadly available on preclinical scanners, and thus may be the recommended approach for imaging the abdomen of free-breathing mice.

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