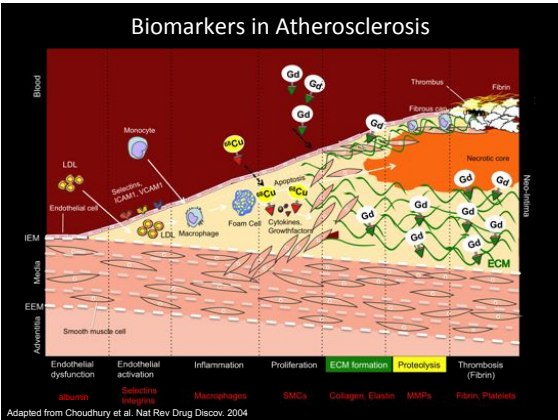


MR Imaging of Atherosclerosis

René M. Botnar, PhD
Chair of Cardiovascular Imaging

*Division of Imaging Sciences and Biomedical Engineering
 King's College London*



Vulnerable Plaque: Pathologists View

A) Pathogenesis of atherosclerosis. Falk E et al. J Am Coll Cardiol 2006; 47:C7-12
 B) The popcorn plaques. Jagat Narula & H William Strauss. Nature Medicine 13, 532 - 534 (2007)

Signal Quantification

Pulse sequences can be designed to allow

- quantify tissue T1, T2 and T2* relaxation times

T1 and T2* mapping

allows quantification of contrast agents based on their T1 and T2* values

T1 Mapping: Saturation Recovery

$M_2(t) = M_0 - M_0 \cdot \exp(-t/T_1)$

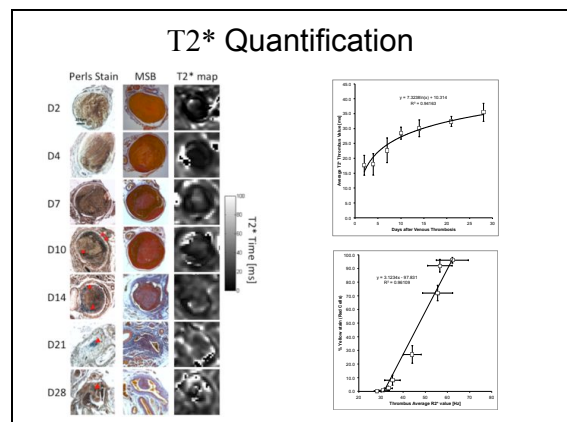
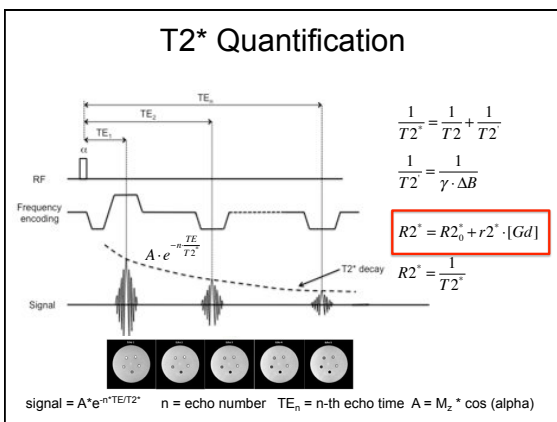
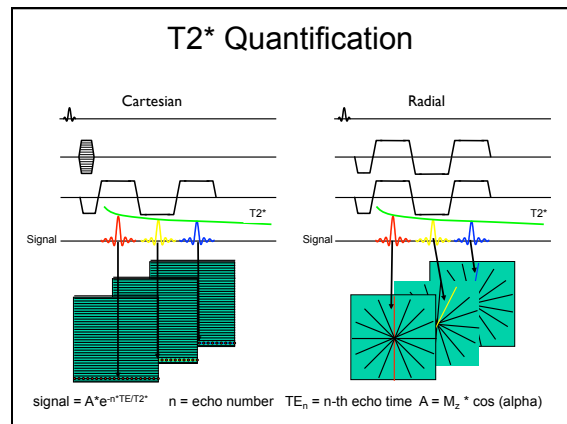
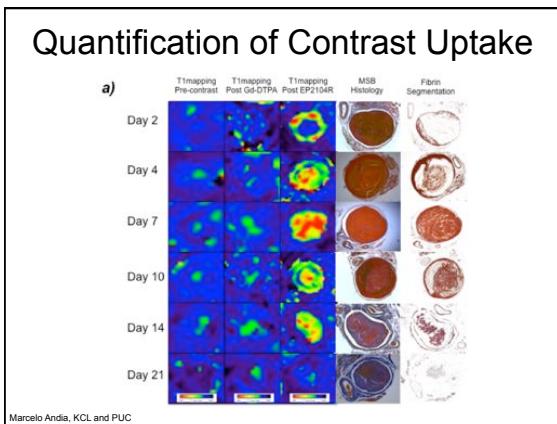
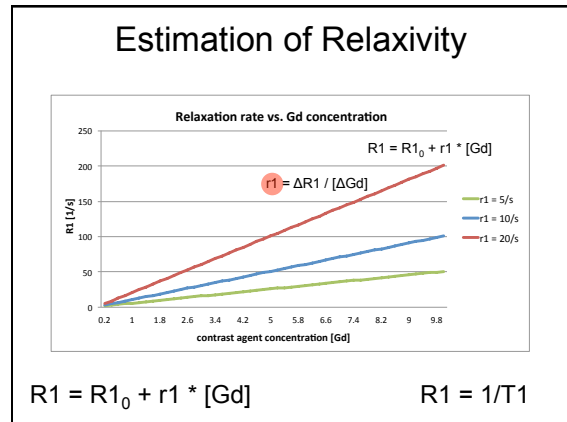
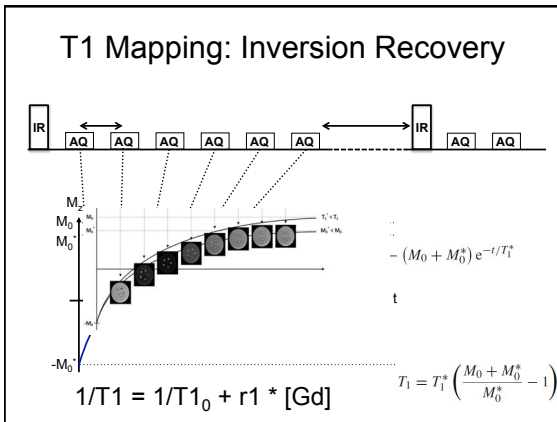
$1/T_1 = 1/T_{10} + r_1 \cdot [Gd]$


Heart rate independent!

S	Saturation pulse
N	Navigator
AQ	SSFP acquisition

Quantification of Contrast Uptake

subject	#1	#2	#3	#4	mean ± SD
T1 _{pre} [ms]	737	737	737	737	n/a
T1 _{post} [ms]	366	377	354	316	353 ± 27
c [μMol]	92	86	98	121	99 ± 15

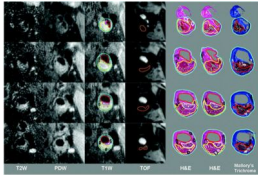





Tissue Characterization

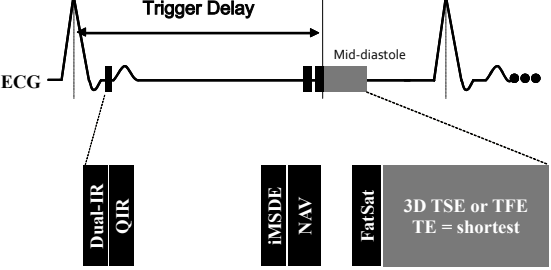
Pulse sequences can be designed to allow differentiation between tissues based on their T1 and T2 relaxation times

T1w, T2w and PDw MRI allows enhancing or suppressing tissues based on their T1, T2 or proton density values






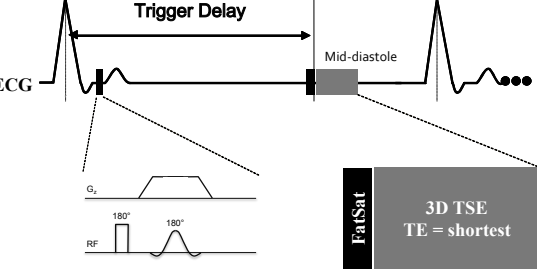
BLACK BLOOD T1W IMAGING




ECG triggered: TR = every heart beat
Non triggered: every TR= 300-500ms



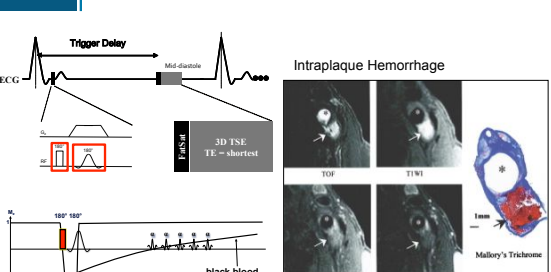
DUAL-INVERSION T1W IMAGING




ECG triggered: TR = every heart beat
Non triggered: every TR= 300-500ms



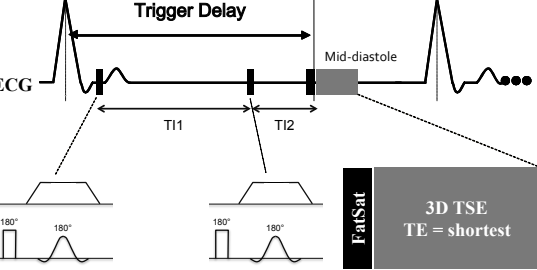
Dual-IR Black Blood Imaging




ECG triggered: TR = every heart beat
Non triggered: every TR= 300-500ms



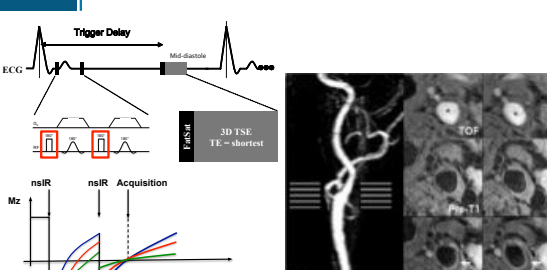
QUADRUPLE INVERSION



ECG triggered: TR = every heart beat
Non triggered: every TR= 300-500ms

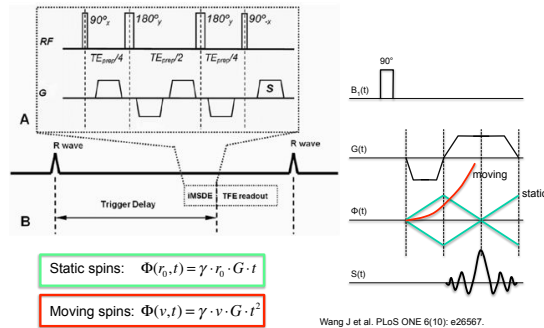


QIR Black Blood Imaging

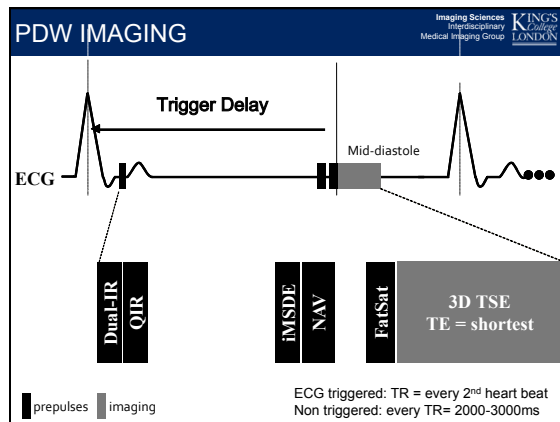
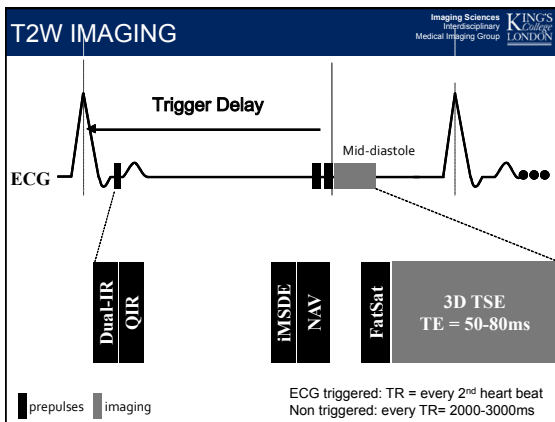
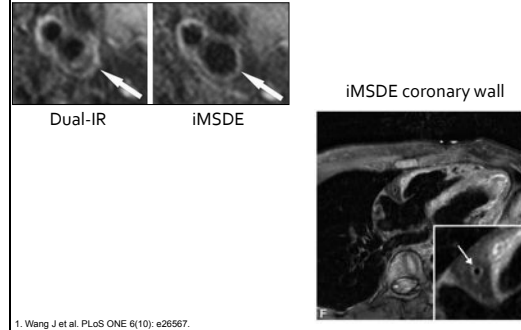


ECG triggered: TR = every heart beat
Non triggered: every TR= 300-500ms

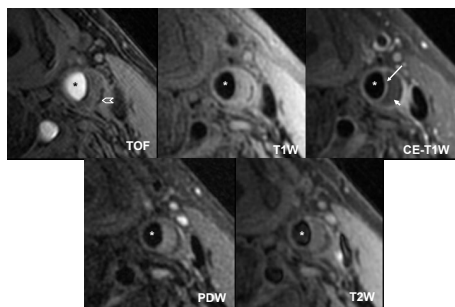
iMSDE Based Black Blood Imaging



Comparison– Dual-IR vs. iMSDE



T1w, T2w, PDw and TOF Images

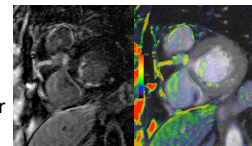


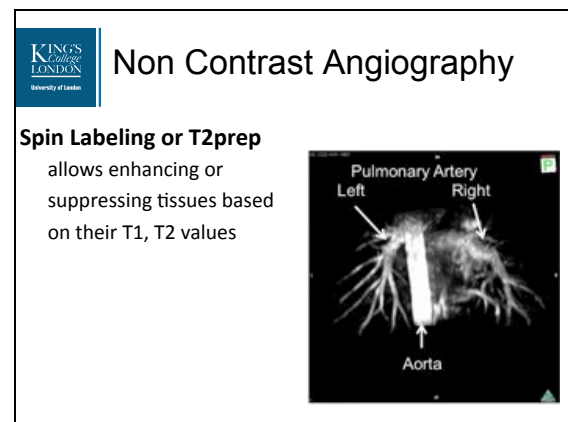
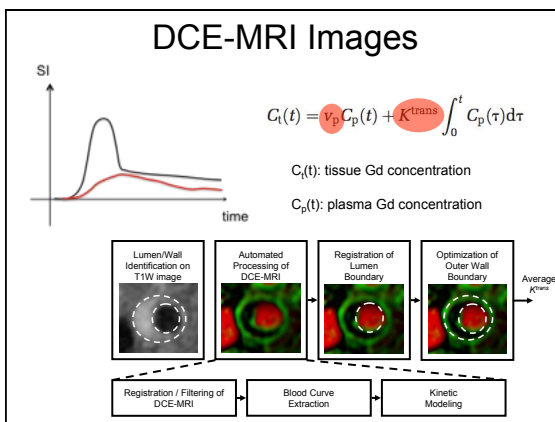
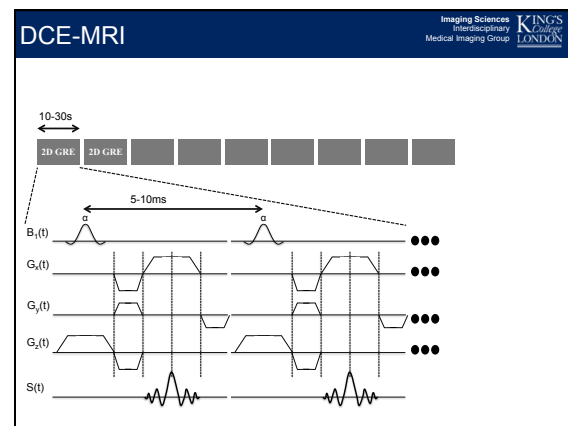
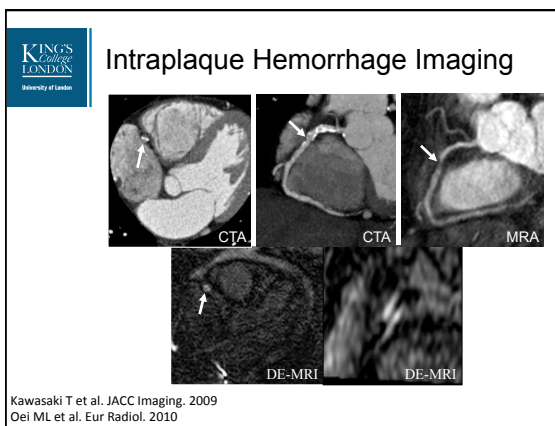
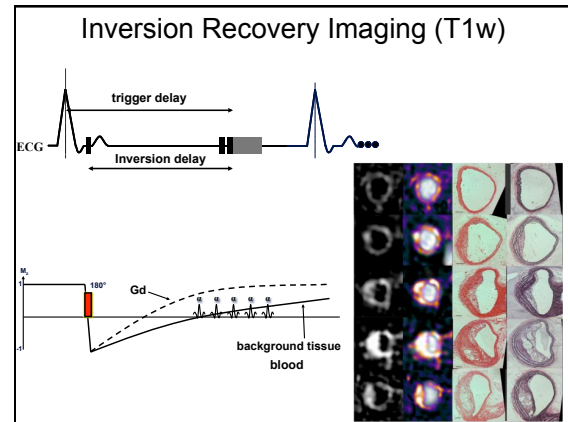
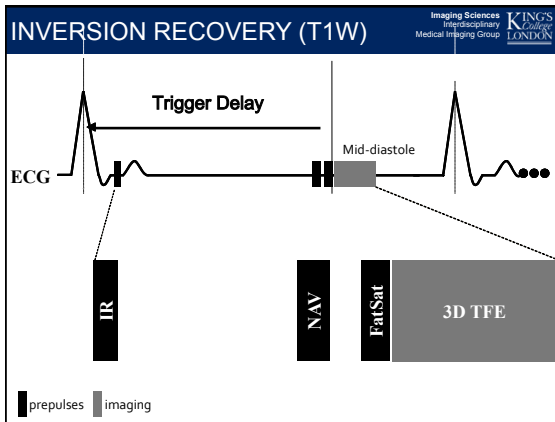
Contrast Enhanced Imaging

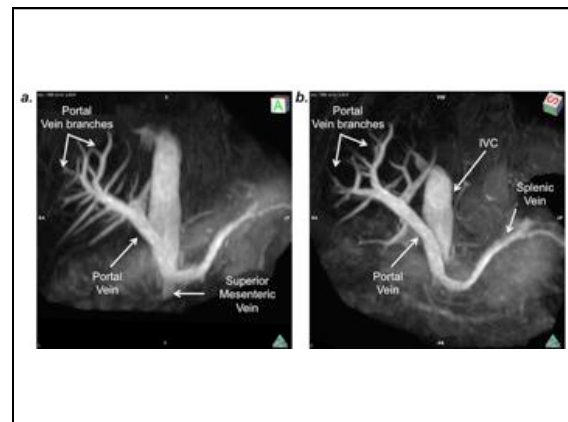
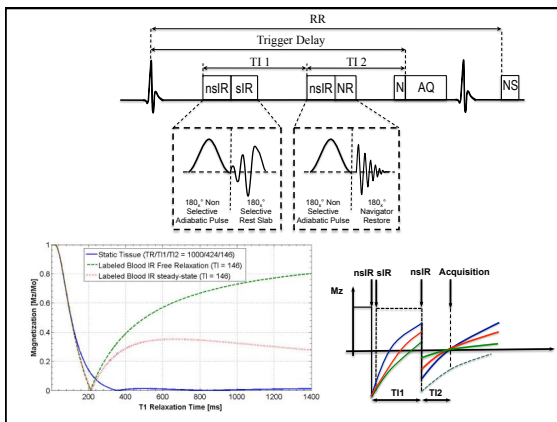
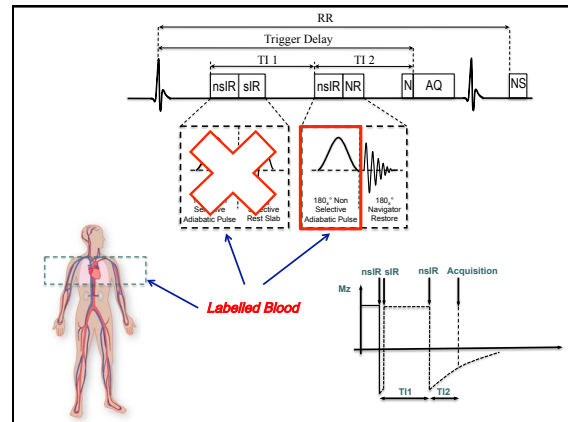
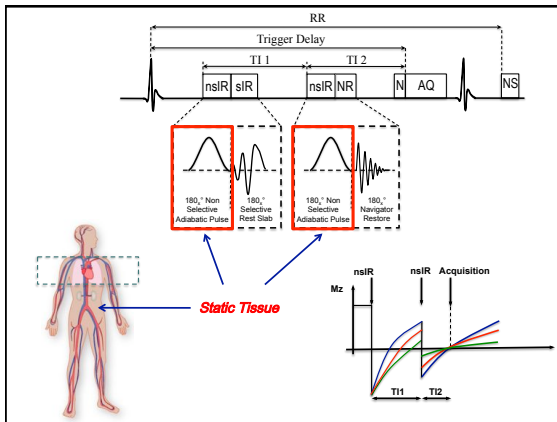
Pulse sequences can be designed to visualize contrast agents based on their T1 or T2 shortening effects

Inversion recovery or DCE-MRI

allows enhancing tissues with gadolinium uptake while suppressing tissues without contrast uptake based on their T1 relaxation time values



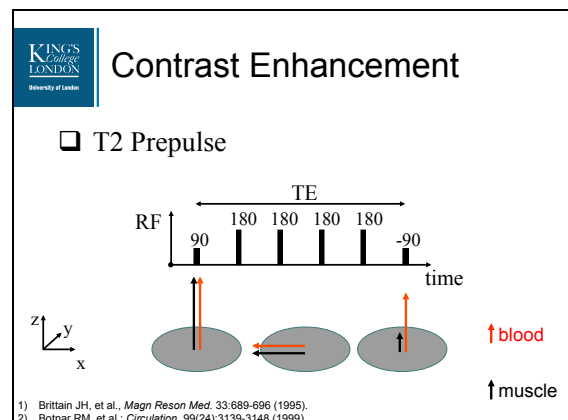


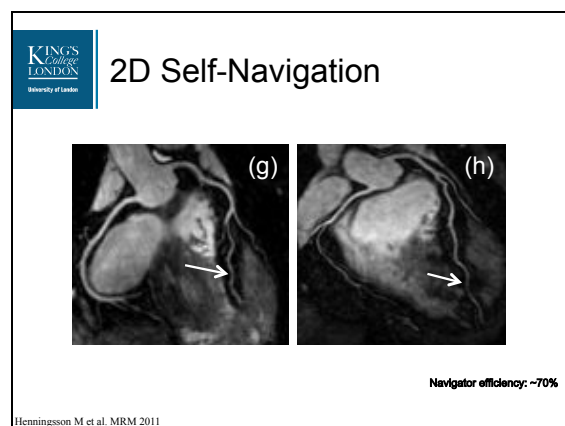
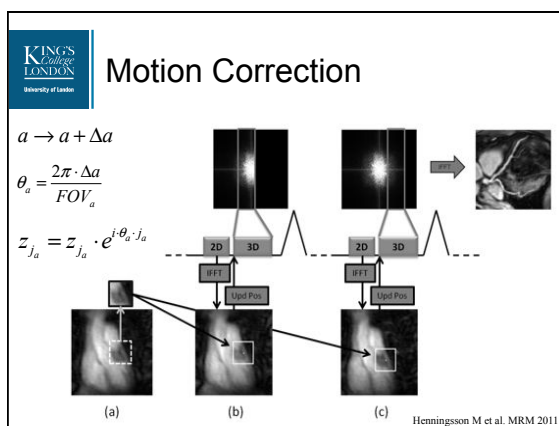
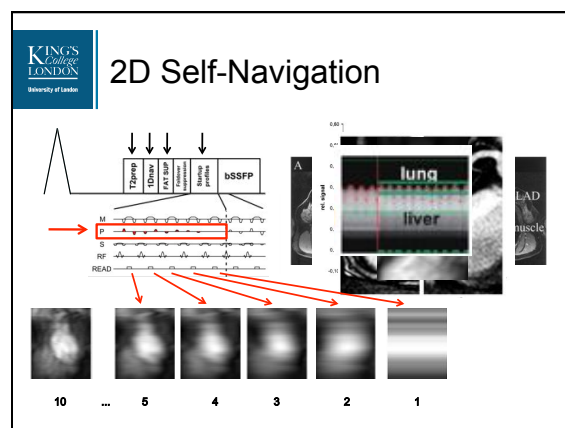
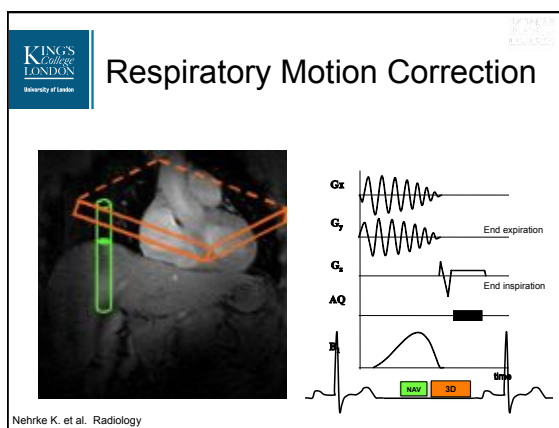
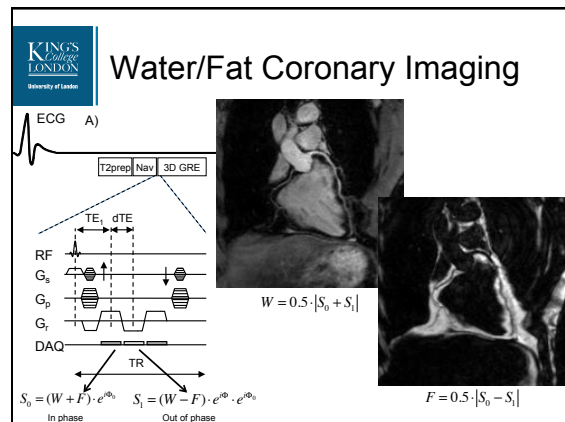
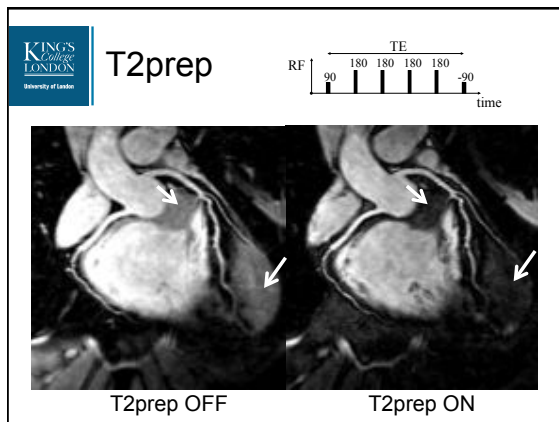


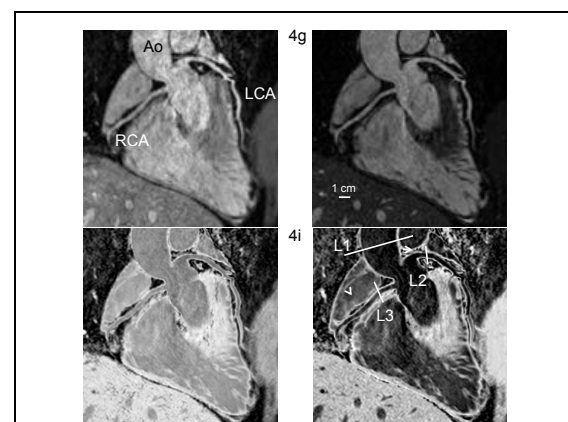
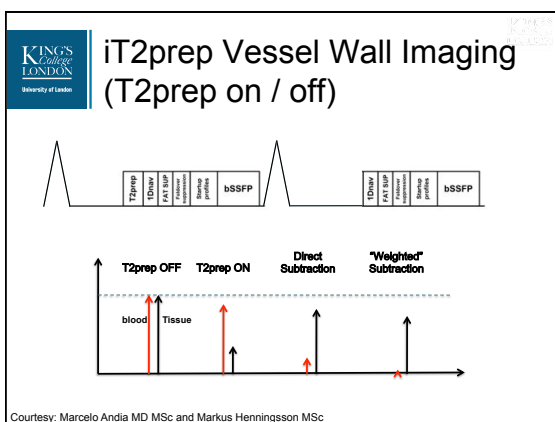
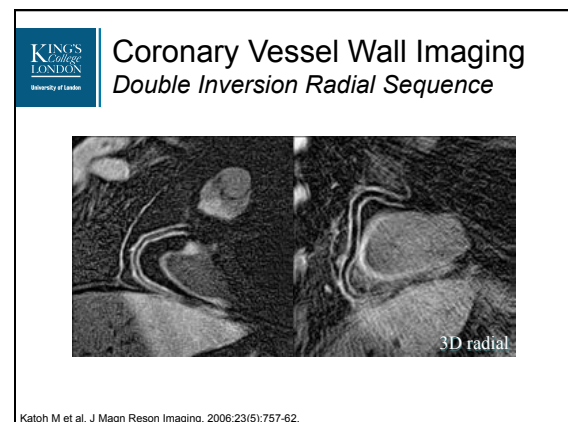
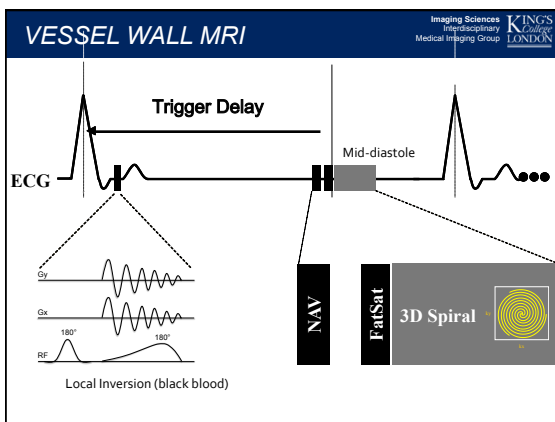
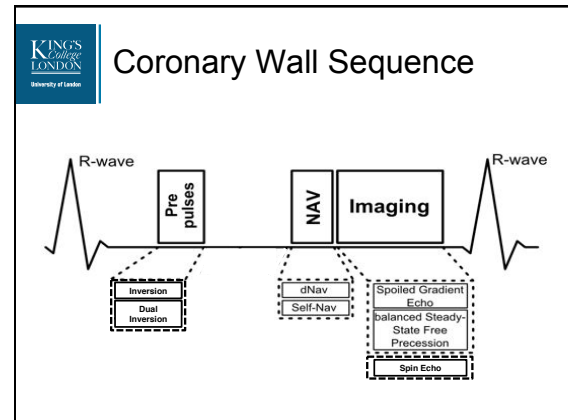
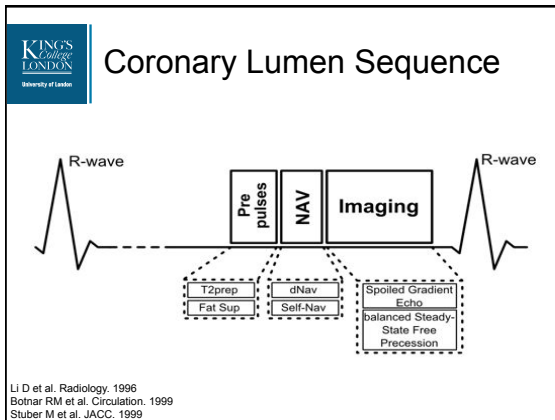
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Contrast Enhancement

	T1 [ms]	T2 [ms]	f_0 [Hz]	flow
Blood	1200	250	0	yes
Muscle	850	50	0	no
Fat	250	100	220	no







Conclusions

- MRI provides many contrast weightings that allow imaging
- vessel lumen
- vessel wall (morphology)
- vessel wall vascularity (DCE-MRI)
- vessel wall biology (CE-MRI)
- advanced motion correction → coronary lumen and vessel imaging

Thank You!

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