

Stroke volume and cardiac output measured on a beat-to-beat basis



JLA Carvalho, GM Pohost, KS Nayak

Department of Electrical Engineering, University of Southern California

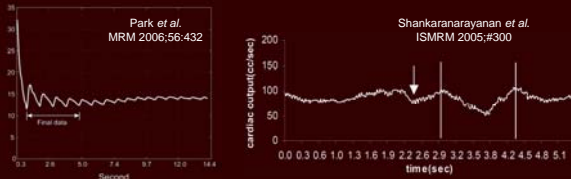
Cardiac output & stroke volume

- Cardiac output:
 - Volume of blood ejected per minute (L/min)
- Stroke volume:
 - Volume of blood ejected per heartbeat (ml)
- Applications: ischemia, valve disease, hypertension, lung disease
 - S.V.V.: indicator of sympathetic response

No non-invasive gold standard!

Recent CO methods in MRI

- Averaged through several heartbeats
- Can measure cardiac output only

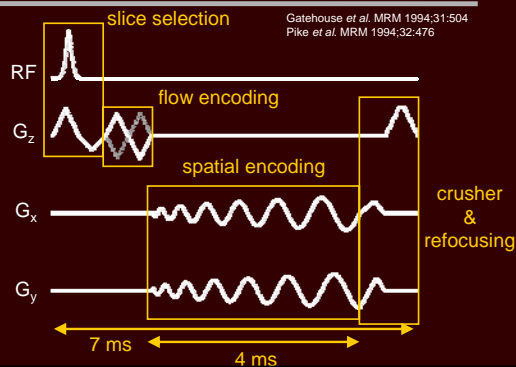


- We propose measuring stroke volume

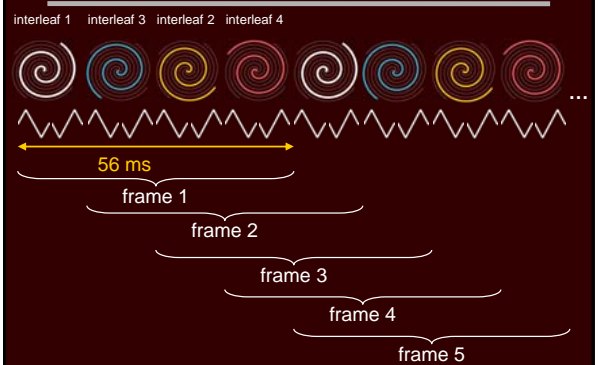
Scan parameters

- GE Signa 3T EXCITE HD system
 - 40 mT/m amplitude
 - 150 T/m/s slew rate
- Variable-density spiral phase contrast
 - Interleaves: 4
 - Resolution: 3 mm
 - FOV: 25–6 cm
 - Venc: 200 cm/s
 - Temporal resolution: 56 ms

Pulse sequence



View ordering



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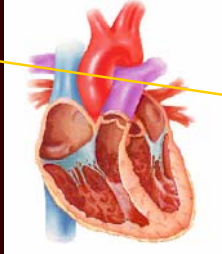
Feasibility evaluation: assumptions

- Partial volume:
 - PC velocity = average velocity within the voxel
 - Flow in voxel = voxel size x PC velocity
- Variable density spiral: aliasing artifacts are insignificant within the ROI
- No flow when aortic valve is closed

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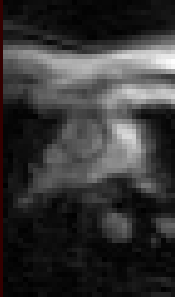
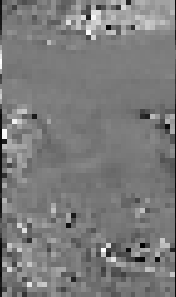
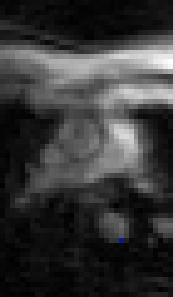
Slice prescription

- Perpendicular to aorta
- Before main bifurcations



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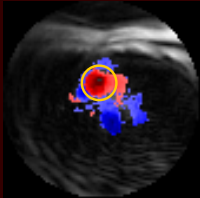
Phase contrast

Magnitude	Phase difference	Color flow
		

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ROI prescription

- Projection: show highest velocity in each pixel throughout entire acquisition

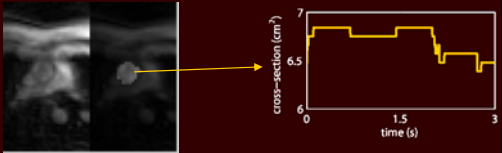


- Outer boundary for ROI

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ROI following

- Time-varying cross-section estimate
- Criteria
 - Voxels are inside prescribed boundary
 - Velocities in voxels exceed a threshold within a 2-second window

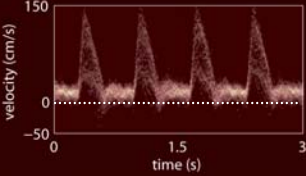


time (s)	cross-section (cm ²)
0	6.8
0.5	6.8
1.0	6.8
1.5	6.5
2.0	6.5
2.5	6.5
3.0	6.5

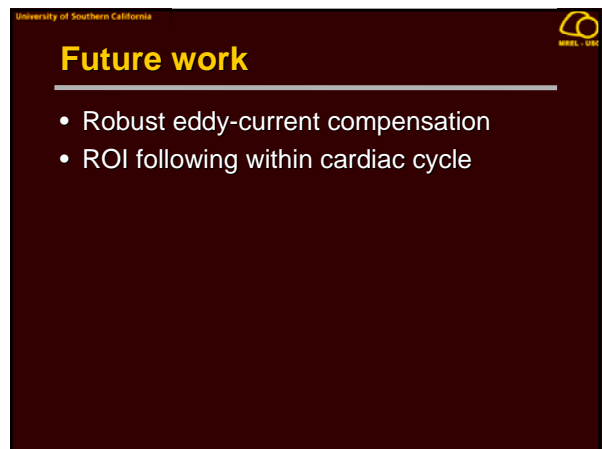
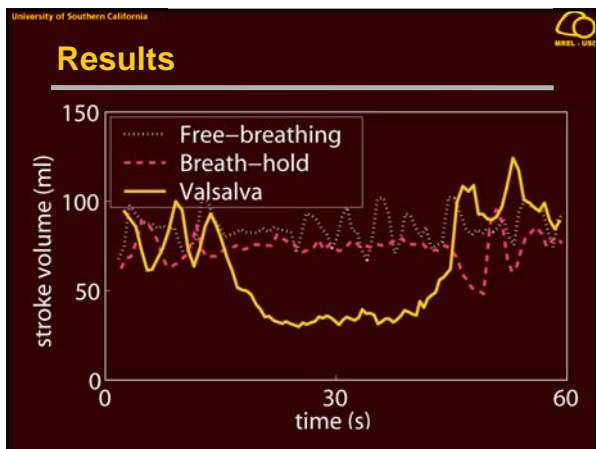
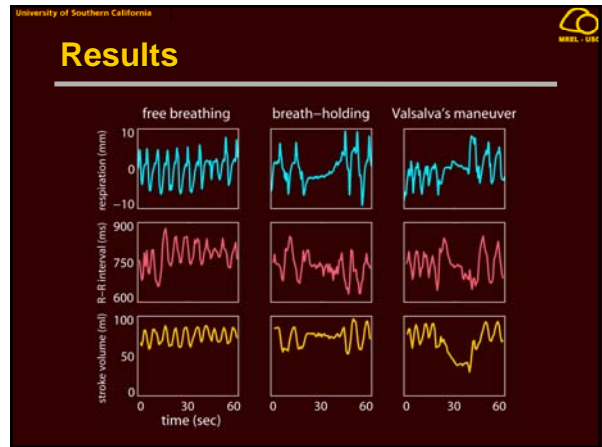
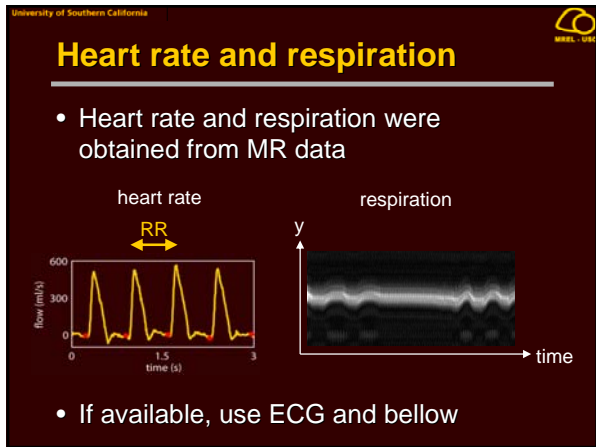
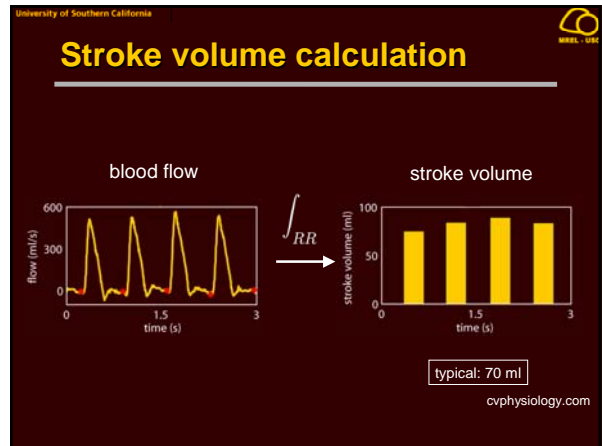
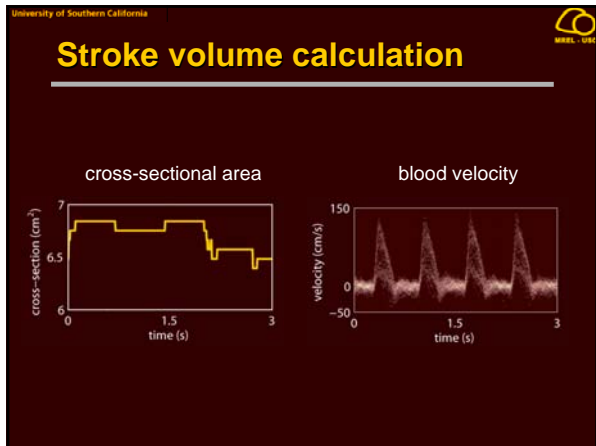
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Velocity off-set

- Eddy currents → velocity off-set



- Find "mode" of histogram and shift to zero
- WIP: estimation using static tissue





Conclusions

- Preliminary results suggest that SV may be measured on a beat-to-beat basis using real-time spiral phase contrast at 3T
- Operator interaction is minimal
- Measured changes in SV during free-breathing, breath-holding and Valsalva's maneuver were consistent with literature

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<http://mrel.usc.edu>

jcarvalh@usc.edu