

FIELD DIVE MONITORING: BUBBLE PRESENTATION IN RECREATIONAL-TECHNICAL CLOSED- CIRCUIT REBREATHER TRIMIX DIVING

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Montreal, Quebec
June 2015

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INTRODUCTION

- ◆ Rec-tech diving is growing, particularly with closed-circuit rebreathers (CCR)
 - divers rely on dive computers to manage decompression
 - often with little or no human testing of such exposures
- ◆ We evaluated decompression stress in rec-tech CCR dives conducted beyond 40 msw (130 fsw)
 - left heart bubbles were of special interest



METHODS

- ◆ Observational studies on multi-day CCR trips
 - divers controlled their diving activity
- ◆ Monitoring included
 - dive profiles / breathing gas
 - daily health surveys
 - two-dimensional transthoracic echocardiographic (TTE) imaging (GE Vivid q)
 - ❖ 20 min intervals for 120 min post-dive
- ◆ Scored right and left heart status, in three conditions:
 - ❖ at rest
 - ❖ after three full engagement, single arm movements
 - ❖ after three full engagement, single leg movements
 - grades reported is highest of the three conditions
- ◆ Data presented as mean \pm SD or distributions

TTE SCAN SCORING

- ◆ Bubble loads scored on a semi-quantitative ordinal scale:
 - 0** - no observable bubbles
 - I** - occasional bubbles
 - II** - at least one new bubble every four cardiac cycles
 - IIIa** - at least one new bubble every cardiac cycle
 - b** - at least six new bubbles every cardiac cycle
 - IVa** - at least one bubble·cm⁻²
 - b** - at least three bubbles·cm⁻²
 - c** - near whiteout; individual bubbles still discerned
 - V** - whiteout; individual bubbles cannot be discerned



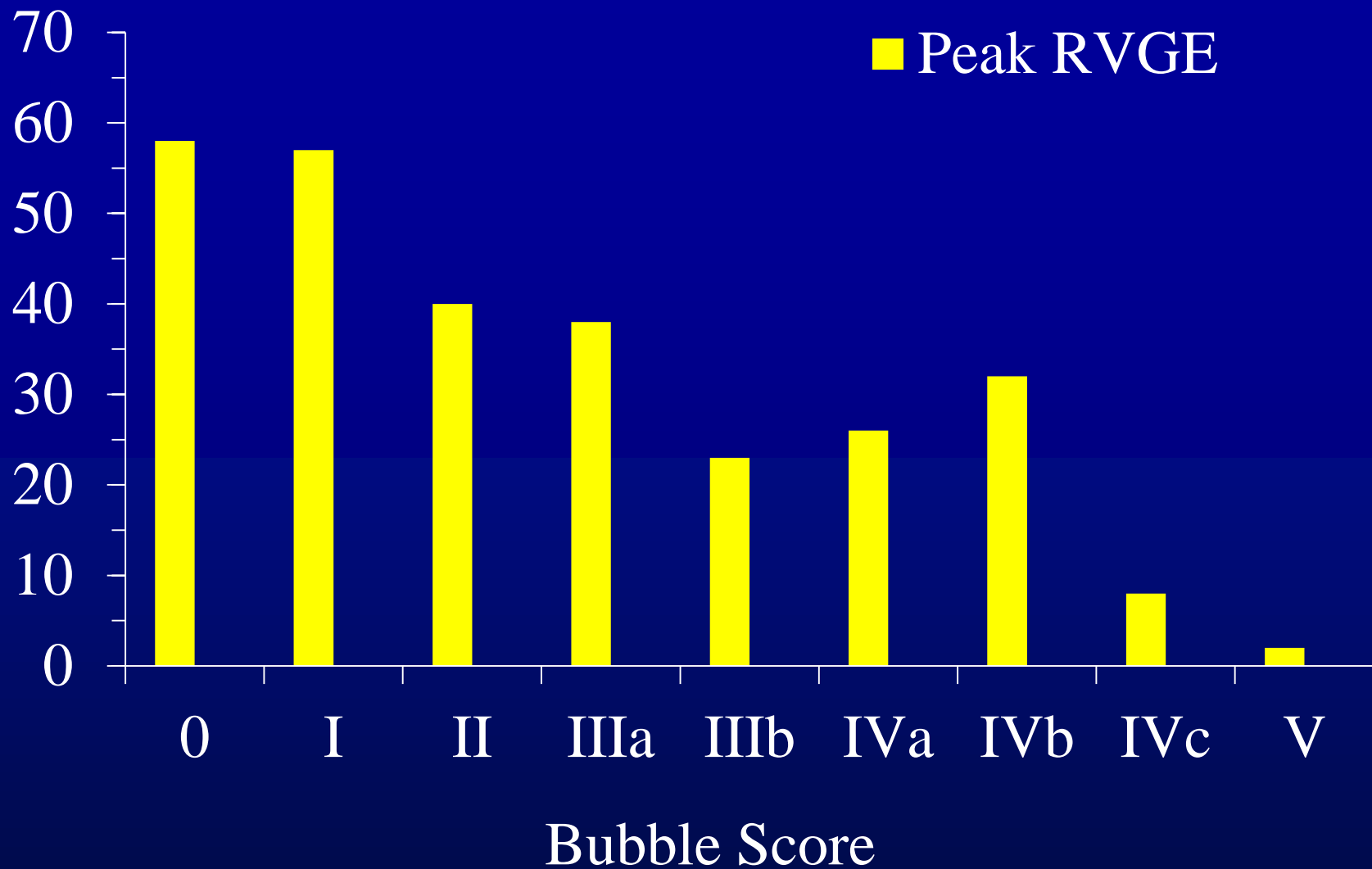
RESULTS

◆ 5 research trips; 287 dives

Parameter	Overall	Male	Female
Count	55	41	14
Age (y)	48±8	47±10	50±3
Weight (kg)	85±15	90±13	69±9
BMI (kg·m ⁻²)	27.2±4.0	27.9±4.1	25.5±3.0
Waist-Hip Ratio	0.86±0.08	0.90±0.06	0.76±0.04
Body fat (%)	21±8	18±5	31±6

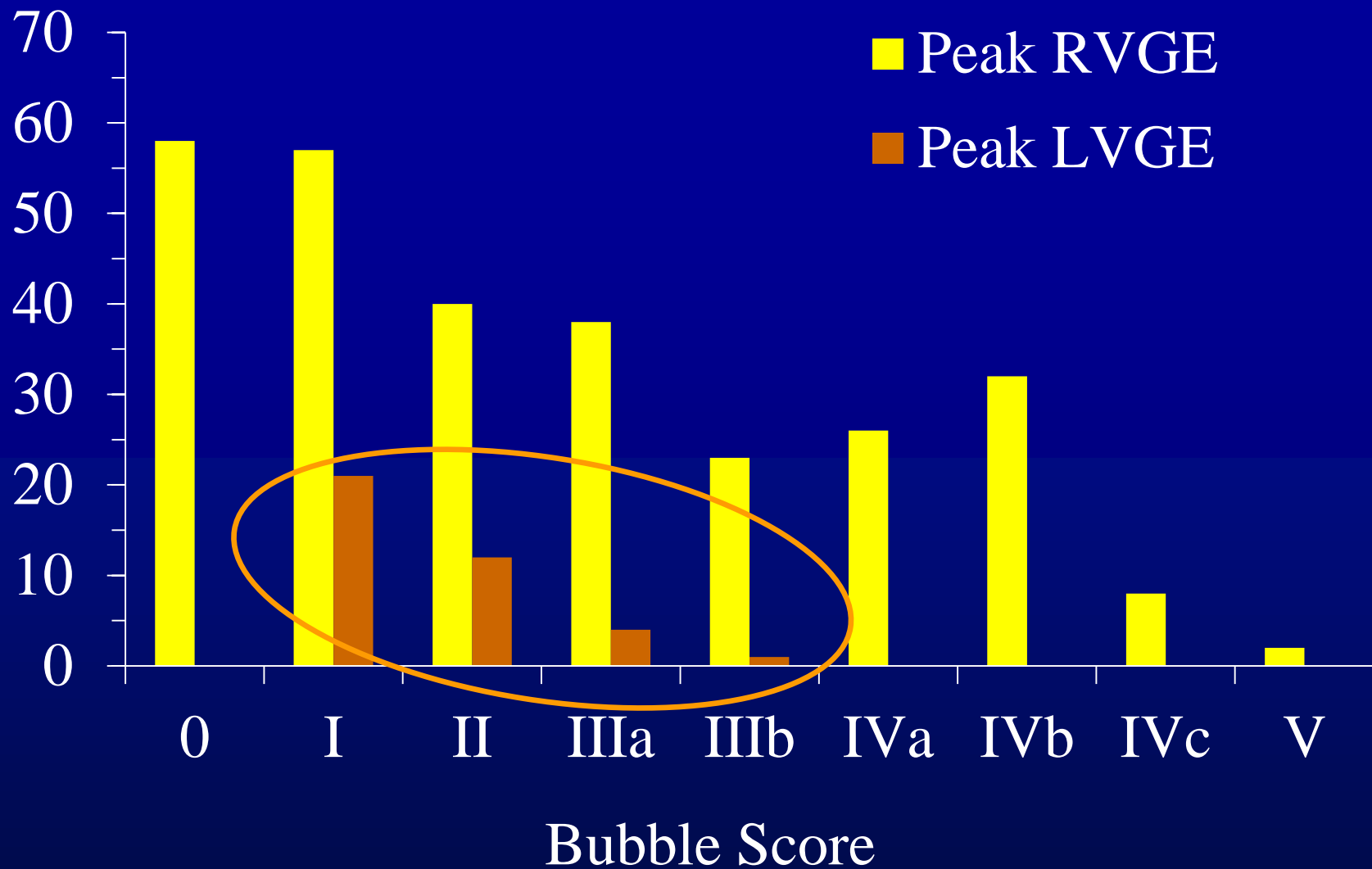
Parameter	Overall	Male	Female
Max dive depth (msw)	73±17	74±17	71±16
(fsw)	238±56	241±57	231±52
Total run time (min)	103±32	105±34	100±26

Case
Count



RVGE - 54/55 divers; >0 in 80% of dives; >II in 39%

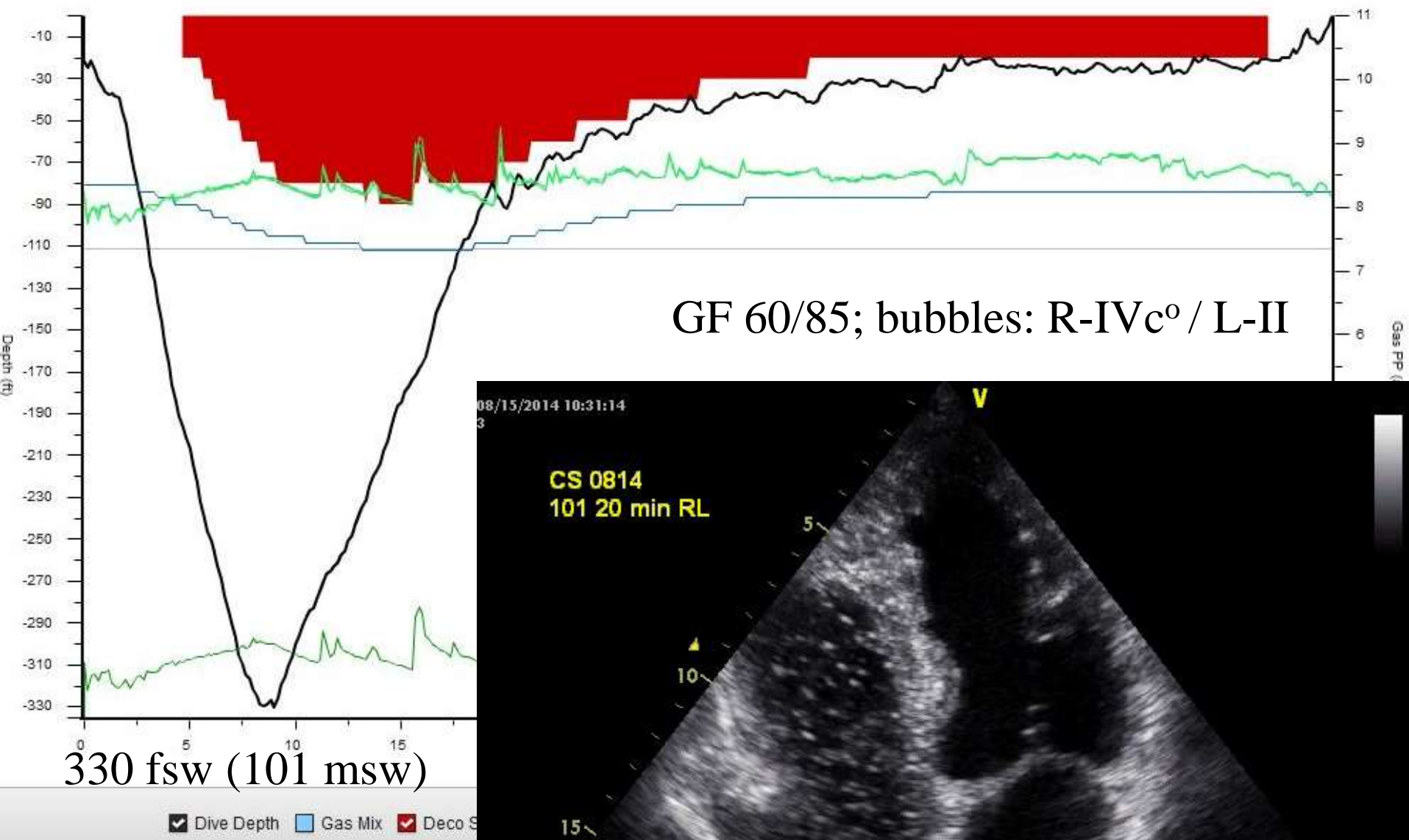
Case
Count



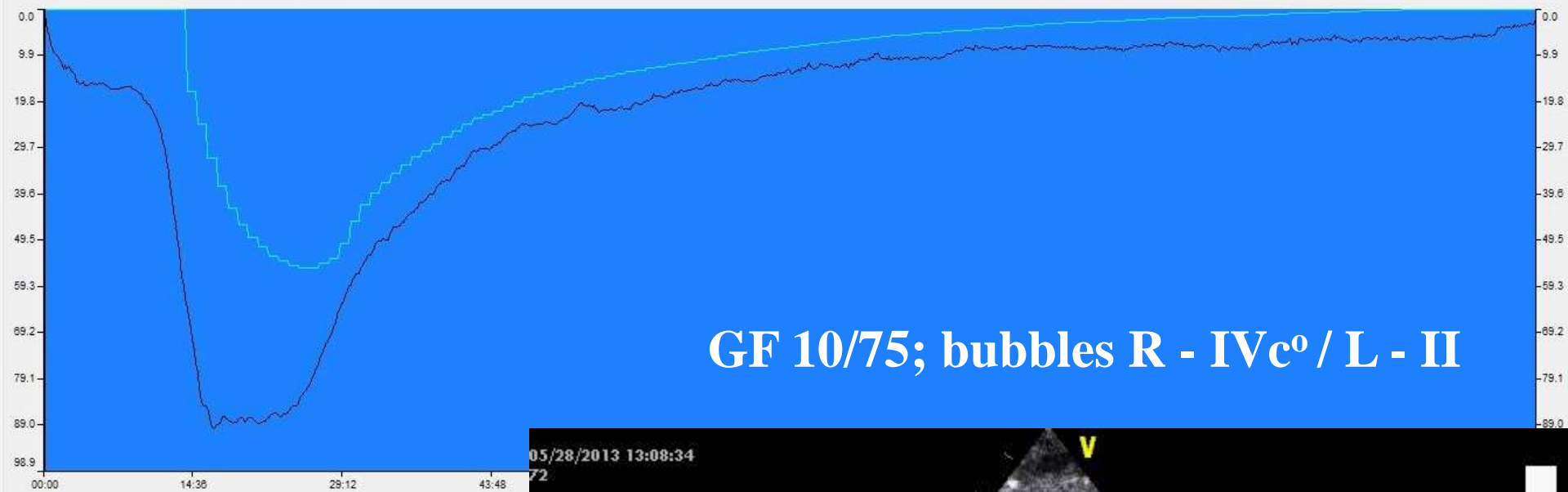
RVGE - 54/55 divers; >0 in 80% of dives; >II in 39%

LVGE - 18/55 divers; >0 in 13% of dives; >II in 2%

DCS - 2 + 4 ambiguous

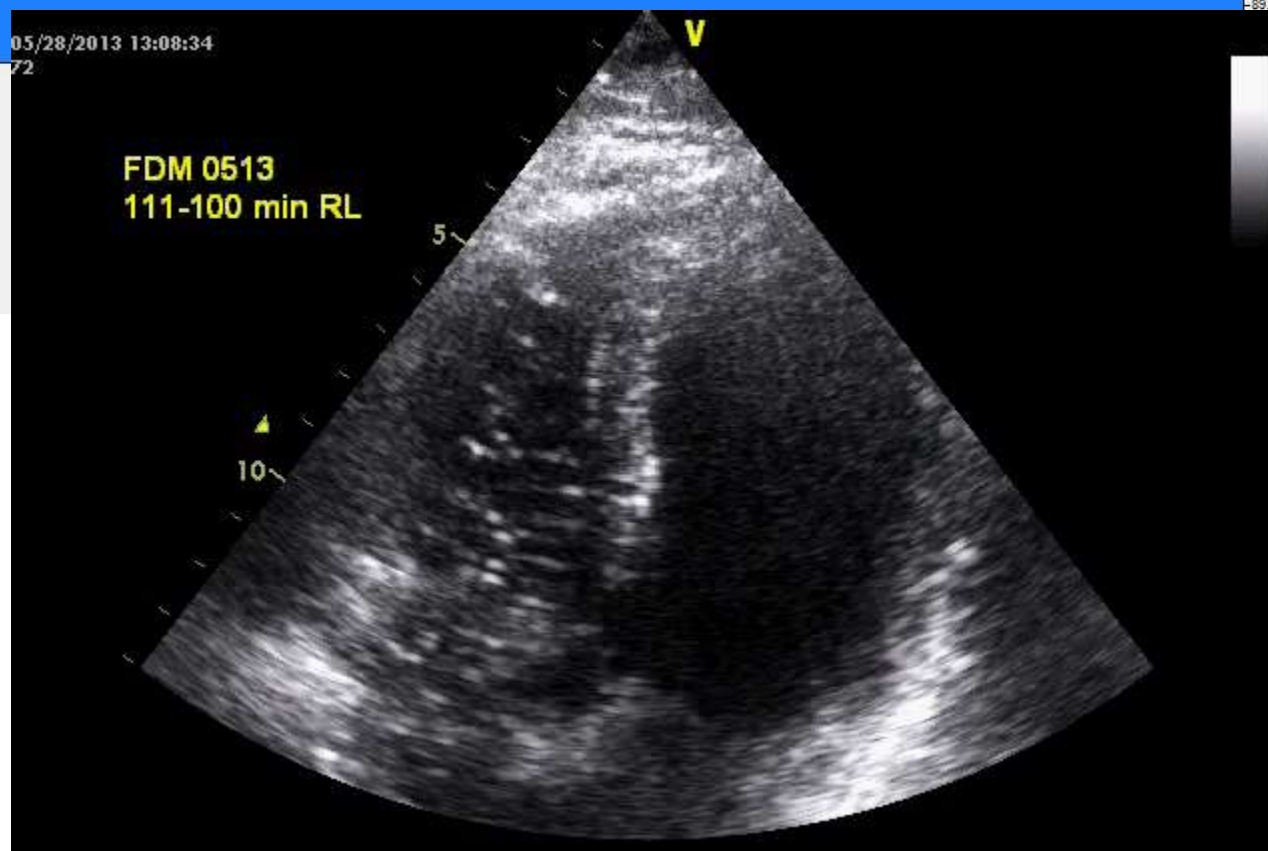


Dive Profile | Dive Information | Data | Gas Management | Log Book

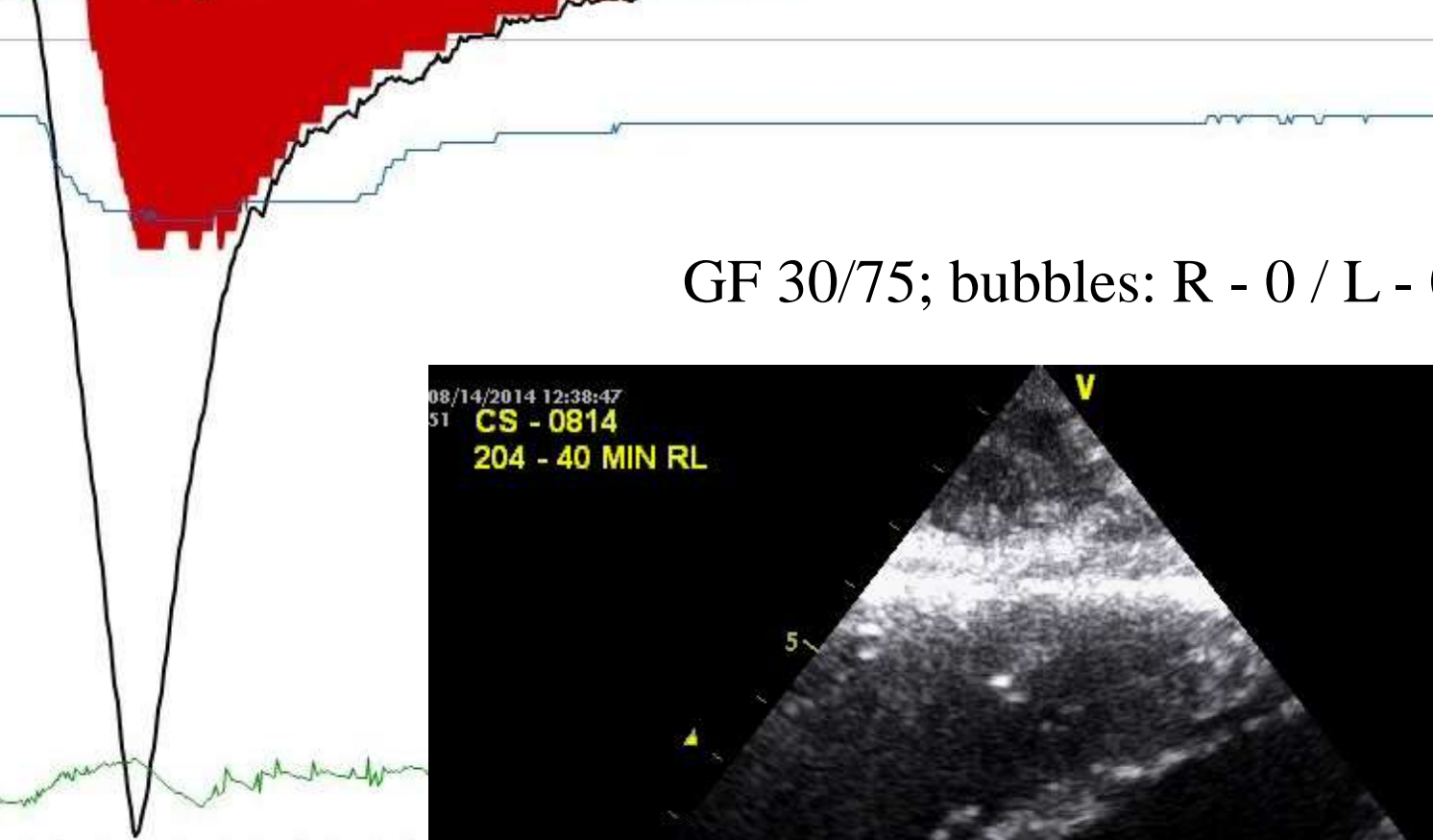


GF 10/75; bubbles R - IVc⁰ / L - II

Alarms	Controller	Alarms	Display
Cell Warning	<input type="radio"/>	Fast Ascent	<input type="radio"/>
Low Battery	<input type="radio"/>	Ceiling Violation	<input type="radio"/>
Low Oxygen	<input type="radio"/>	CNS Exposure	<input type="radio"/>
High Oxygen	<input type="radio"/>	OTU Exposure	<input type="radio"/>
No Alarm	<input type="radio"/>	Scrubber 2nd Warning	<input type="radio"/>
Alarm	<input checked="" type="radio"/>	Scrubber 1st Warning	<input type="radio"/>
No Alarm Masked	<input type="radio"/>	CO2 Warning	<input type="radio"/>
Alarm Masked	<input checked="" type="radio"/>	Dive Start	<input type="radio"/>



295 fsw (90 msw)



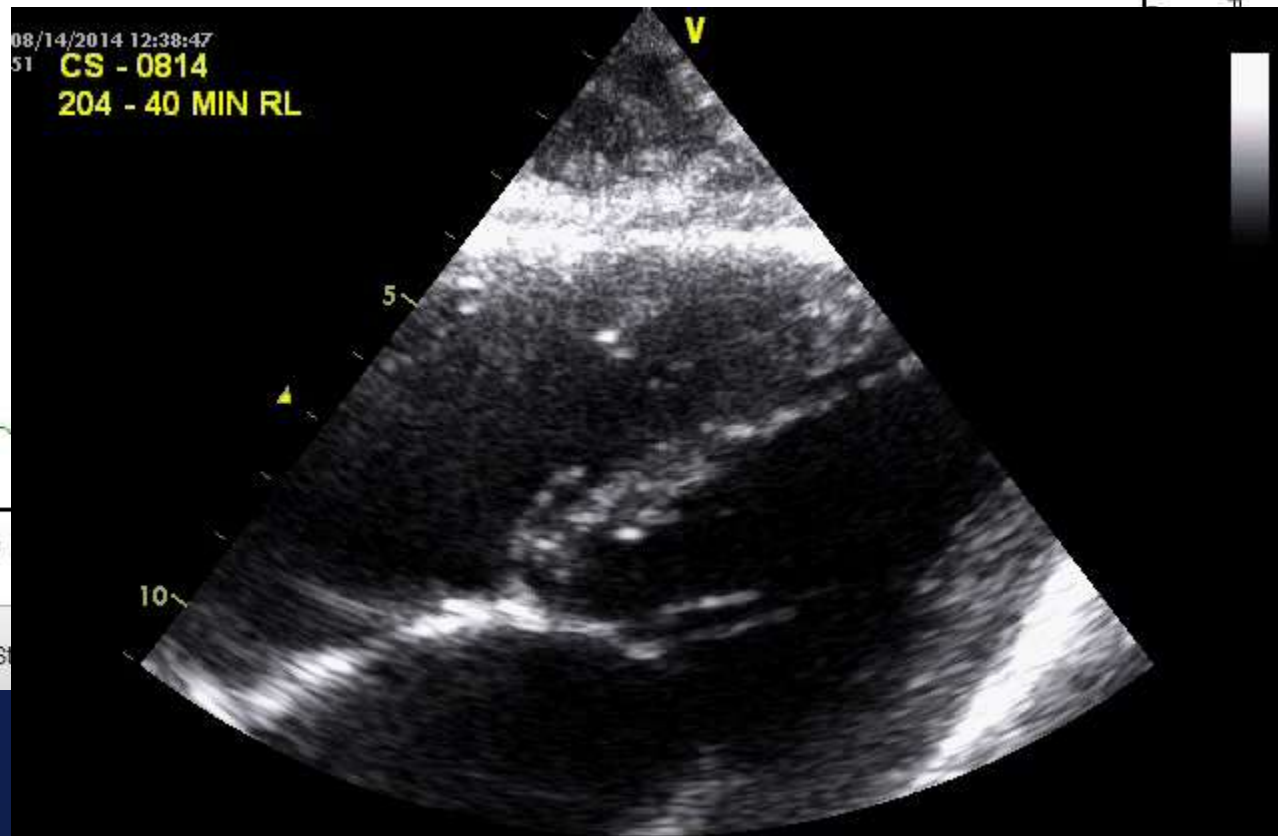
Depth (ft)

GF 30/75; bubbles: R - 0 / L - 0

08/14/2014 12:38:47
51 CS - 0814
204 - 40 MIN RL

515 fsw (157 msw)

515 fsw (157 msw)



DISCUSSION

- ◆ Recreational-technical divers are extending their diving range, increasingly beyond the zone where decompression algorithms have been adequately tested
 - decompression safety may be overestimated
- ◆ The frequency of LVGE in diving is likely underestimated
 - improvements in ultrasound technology almost certainly explain the recent increase in observations

LIMITATIONS

- ◆ As an observational study, divers controlled their own exposures and decompression procedures
 - increased conservatism following high bubble scores would lead to an underestimate of typical unmonitored exposures

CONCLUSIONS

- ◆ Relatively high decompression stress warrants further evaluation of procedures of recreational-technical divers

ACKNOWLEDGMENTS

- ◆ We thank Divetech and Spree Expeditions Inc. for provision of facilities enabling our research

