DAN Research Project

2009 – February until May

Introduction

- DCS without bubbles
- Bubbles without DCS
- Endothelial dysfunction without DCS
- Endothelial dysfunction with or without bubbles
- What is the cause of bubbles production ?
- What is the cause of endothelial dysfunction ?

Introduction

- Is there a link between bubbles and endothelial dysfunction ?
- How can we reduce bubbles ?
- How can we reduce endothelial dysfunction ?

Materials and methods

- Population :
  - ✓ Diver 3* CMAS, AOW Padi or licence agreeing to dive under 30 m
  - ✓ Age between 25 – 45 yrs
  - ✓ Weight within 70 – 80 kg
  - ✓ Height between 169 – 187 cm

  } BMI btw 22 – 25

  - ✓ Non – smoker
  - ✓ Experience of more than 50 dives, no DCS
  - ✓ Good health, good physical condition, sport 2-3 times a week

Materials and methods

Materials and methods

- No dive during 72h before Saturday (from Wednesday)
- No intensive physical activity during 48h before Saturday
- Normal meals : not too fat and not too thin

Materials and methods

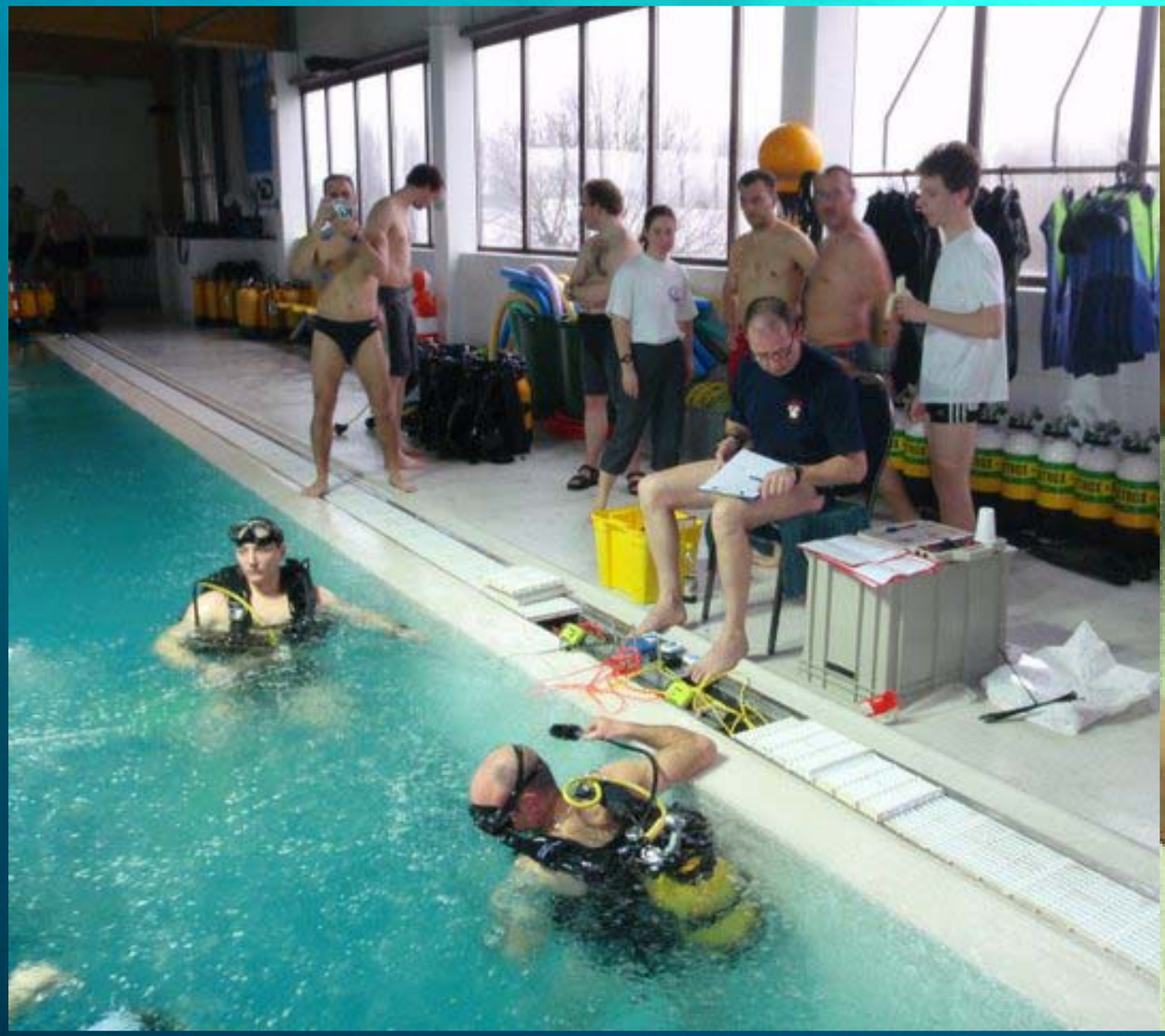
Picture : www.nemo33.com

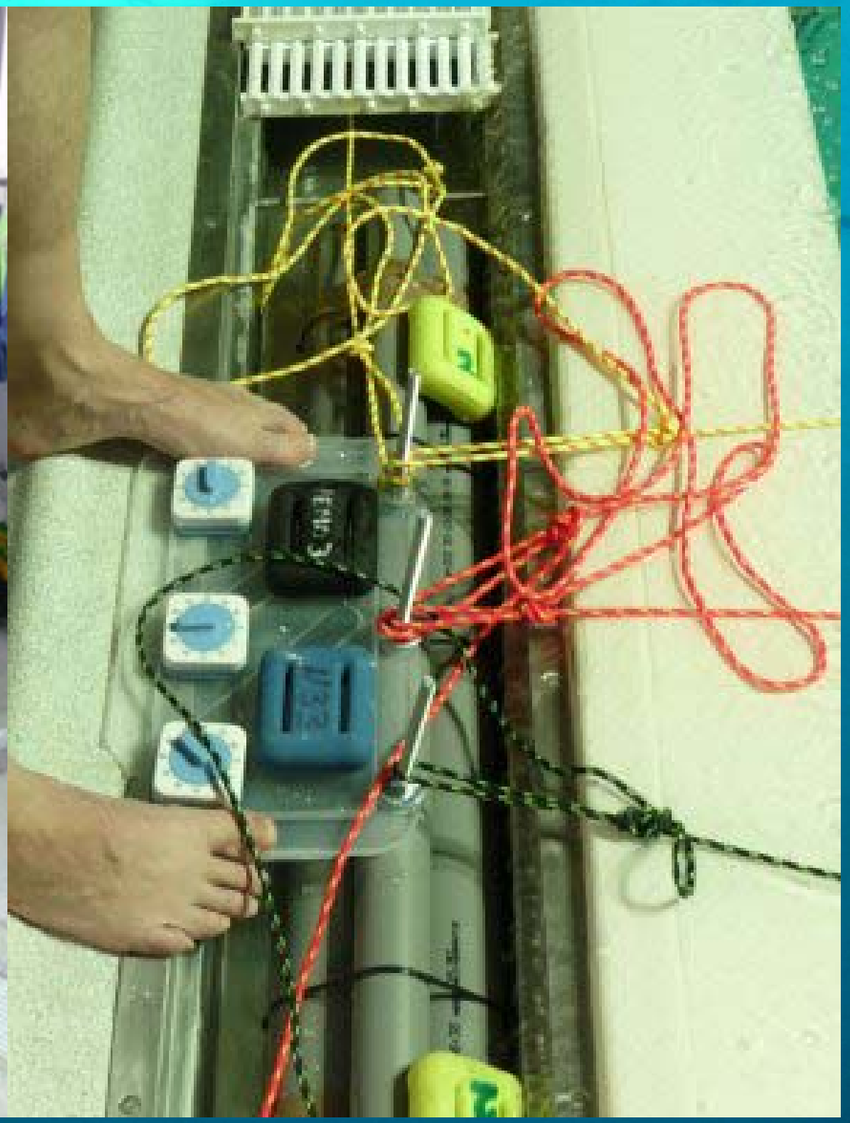
- Nemo 33 – Brussels
- 12 Saturdays between 21/02/09 and 16/5/09
- The divers had to attend minimum 9 saturdays of the 12
- From 12h → 18h

- Thank you John for access to the pool !

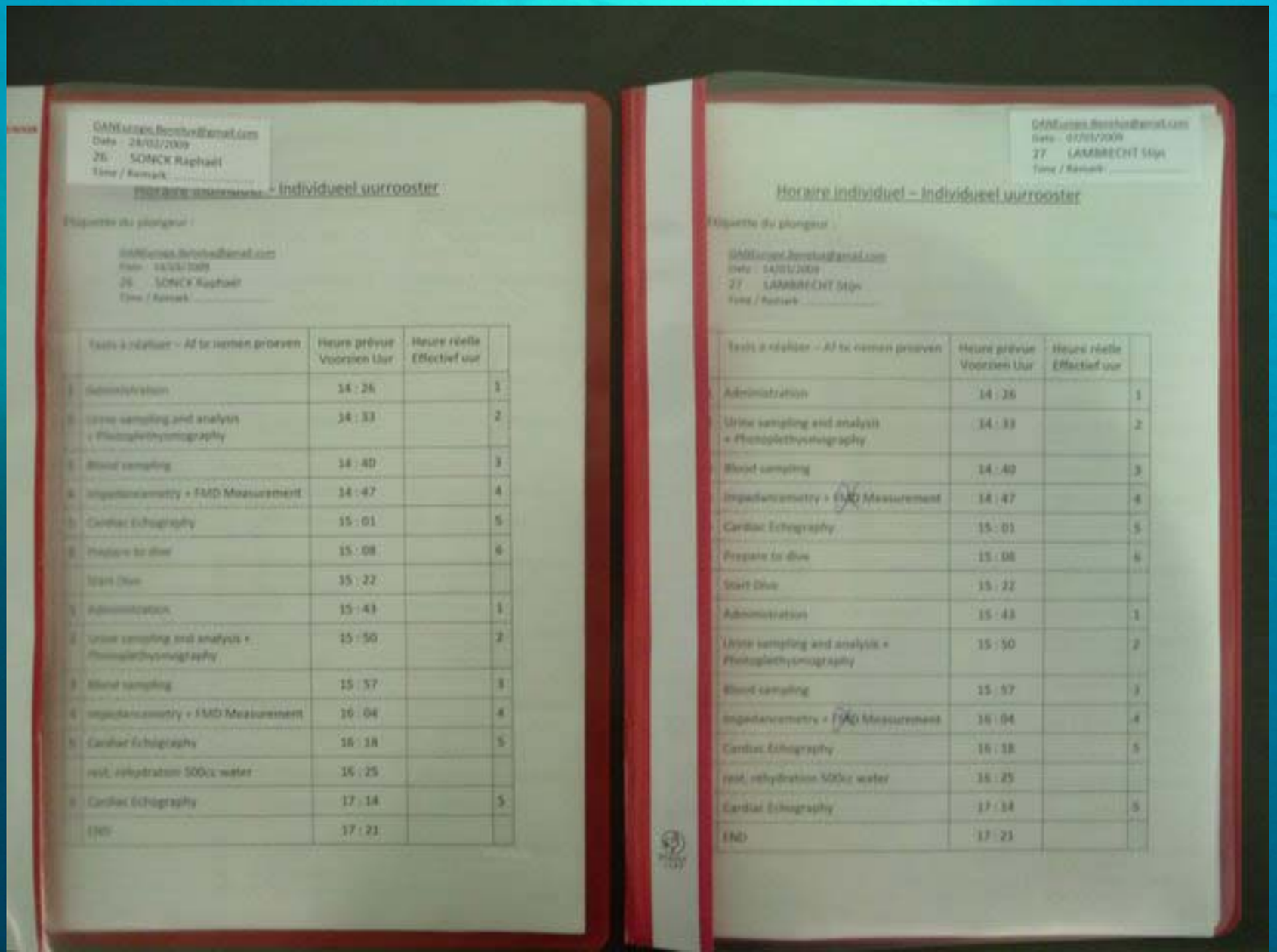
Materials and methods

Dive profile : 33 m – 20 min without computer





Materials and methods



Horaire individuel – Individueel uurrooster

	Tests à réaliser – Af te nemen proeven	Heure prévue Voorzien Uur	Heure réelle Effectief uur	
1	Administration	14 : 26		1
2	Urine sampling and analysis + Photoplethysmography	14 : 33		2
3	Blood sampling	14 : 40		3
4	Impedancemetry + FMD Measurement	14 : 47		4
5	Cardiac Echography	15 : 01		5
6	Prepare to dive	15 : 08		6
	Start Dive	15 : 22		
1	Administration	15 : 43		1
2	Urine sampling and analysis + Photoplethysmography	15 : 50		2
3	Blood sampling	15 : 57		3
4	Impedancemetry + FMD Measurement	16 : 04		4
5	Cardiac Echography	16 : 18		5
	rest, rehydration 500cc water	16 : 25		
5	Cardiac Echography	17 : 14		5
	END	17 : 21		

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5	Cardiac Echography	17 : 14		5
	END	17 : 21		

Materials and methods

- Urine density and impedancemetry

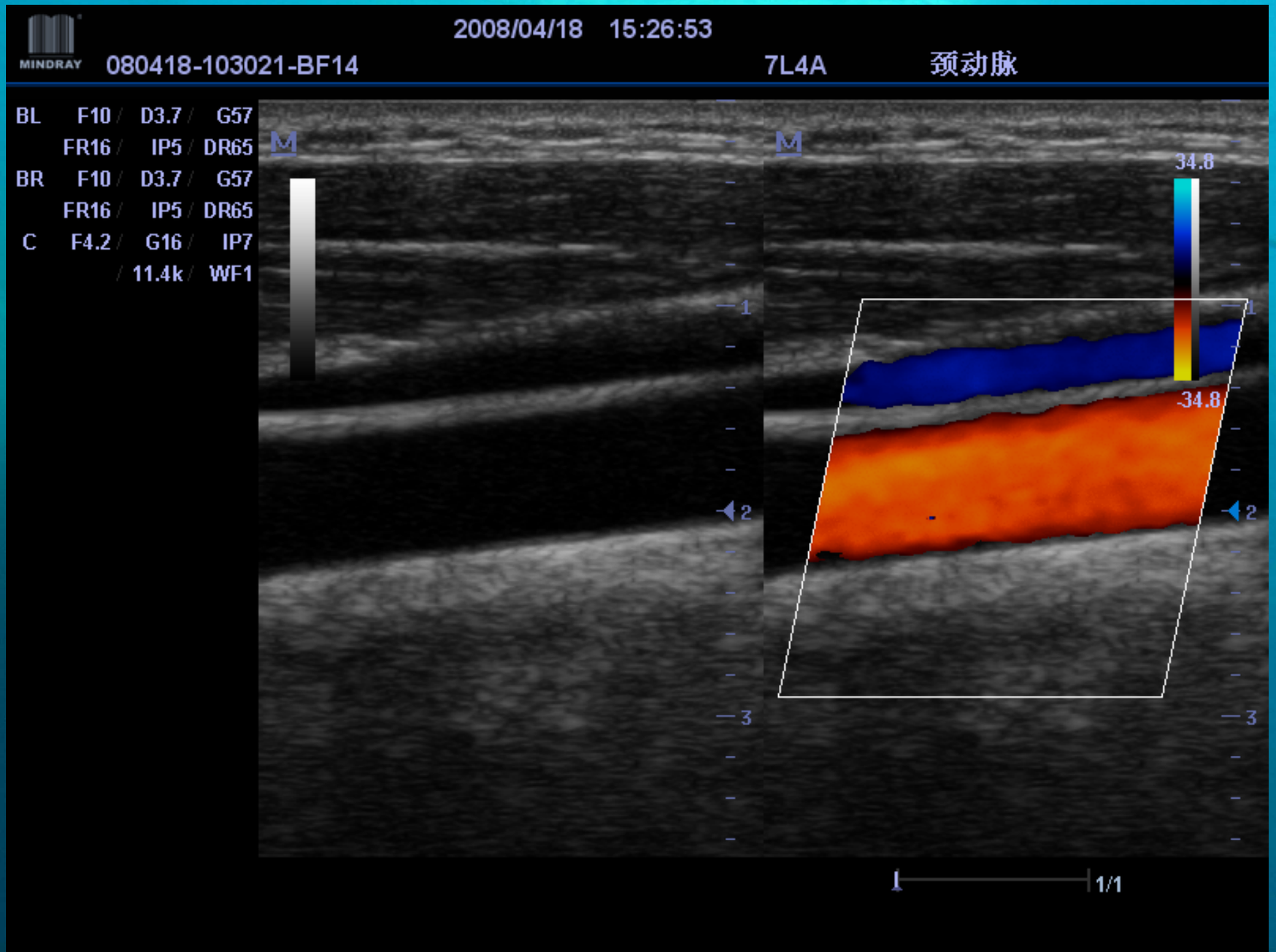
Materials and methods

- Blood sampling :
  - ✓ Hb
  - ✓ Hct
  - ✓ WBC
  - ✓ Platelets
  - ✓ Cholesterol
  - ✓ TG
  - ✓ LDL
  - ✓ HDL
  - ✓ CV risk

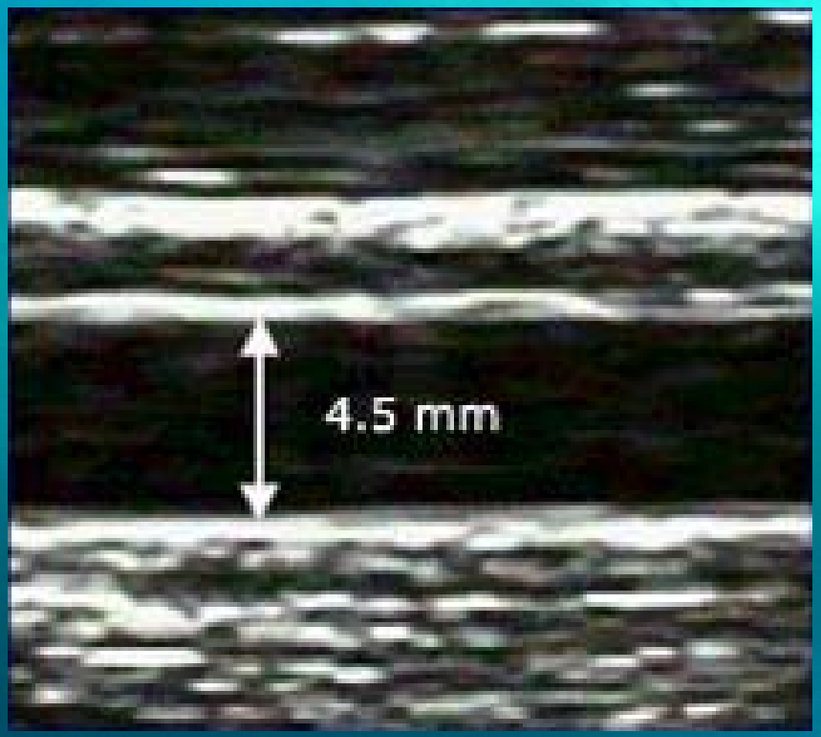
Materials and methods

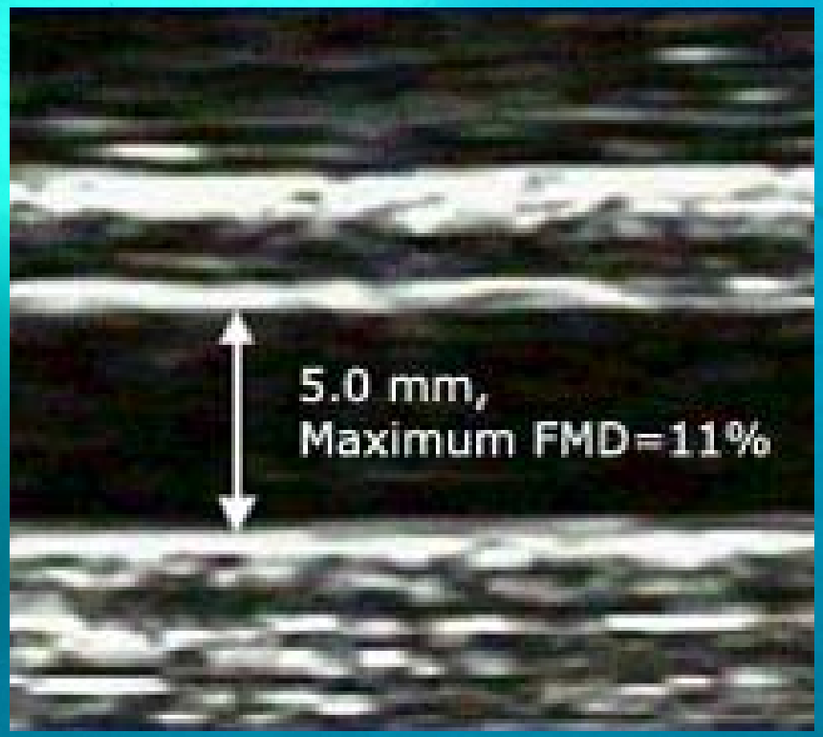
- Flow Mediated Dilation :

Flow Mediated Dilation



Flow Mediated Dilation



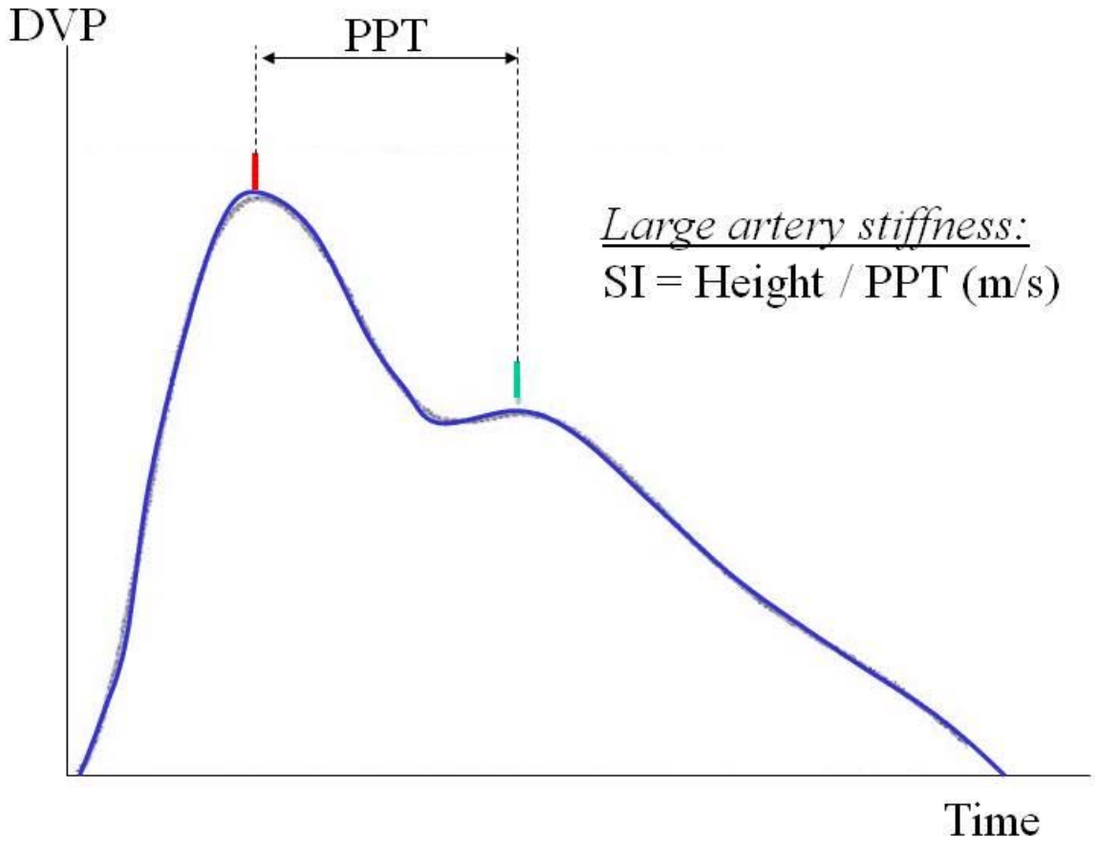


FMD = Diameter post occlusion / Diameter pre occlusion (%)

Materials and methods

- Photoplethysmography

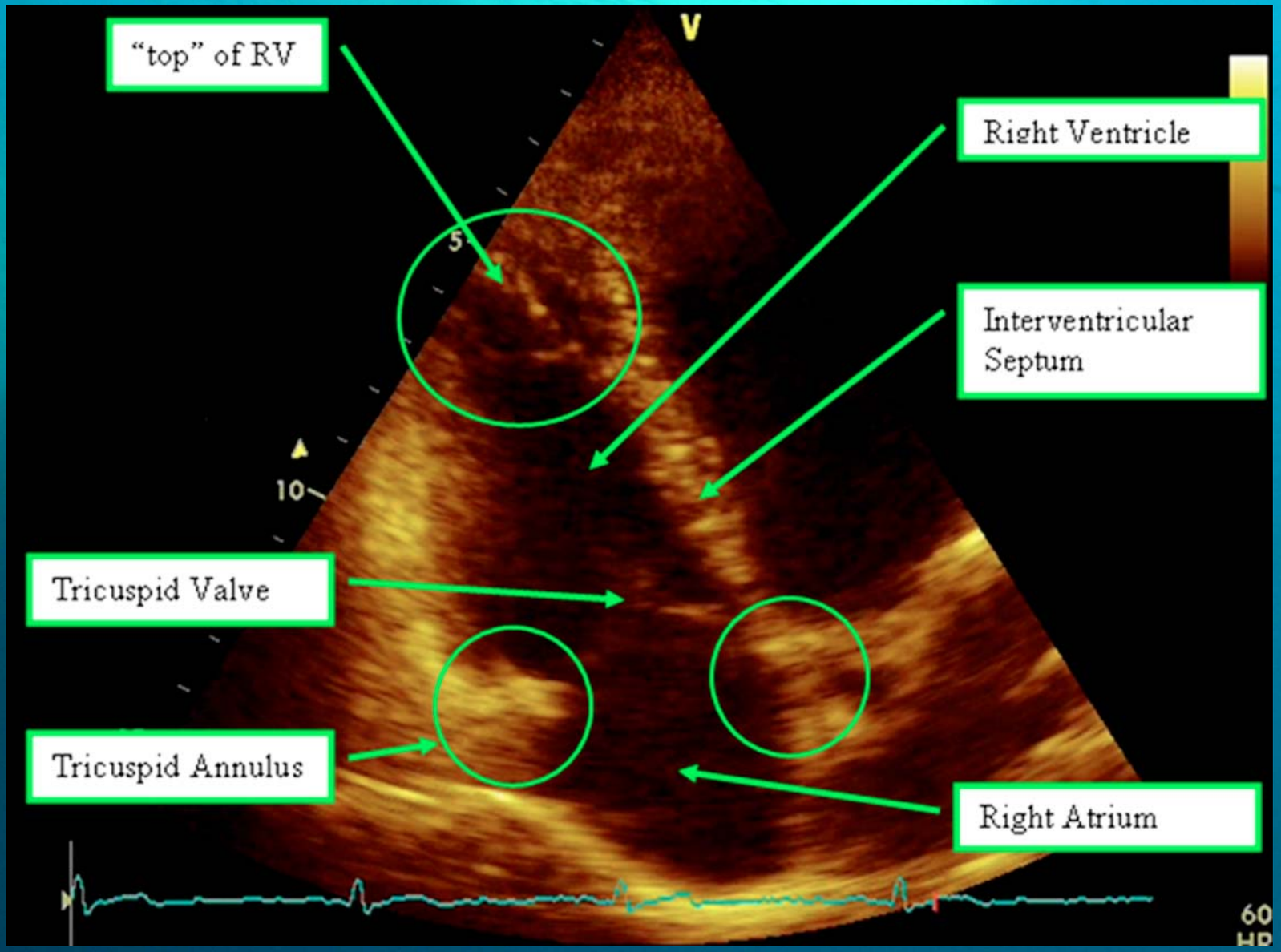
Photoplethysmography



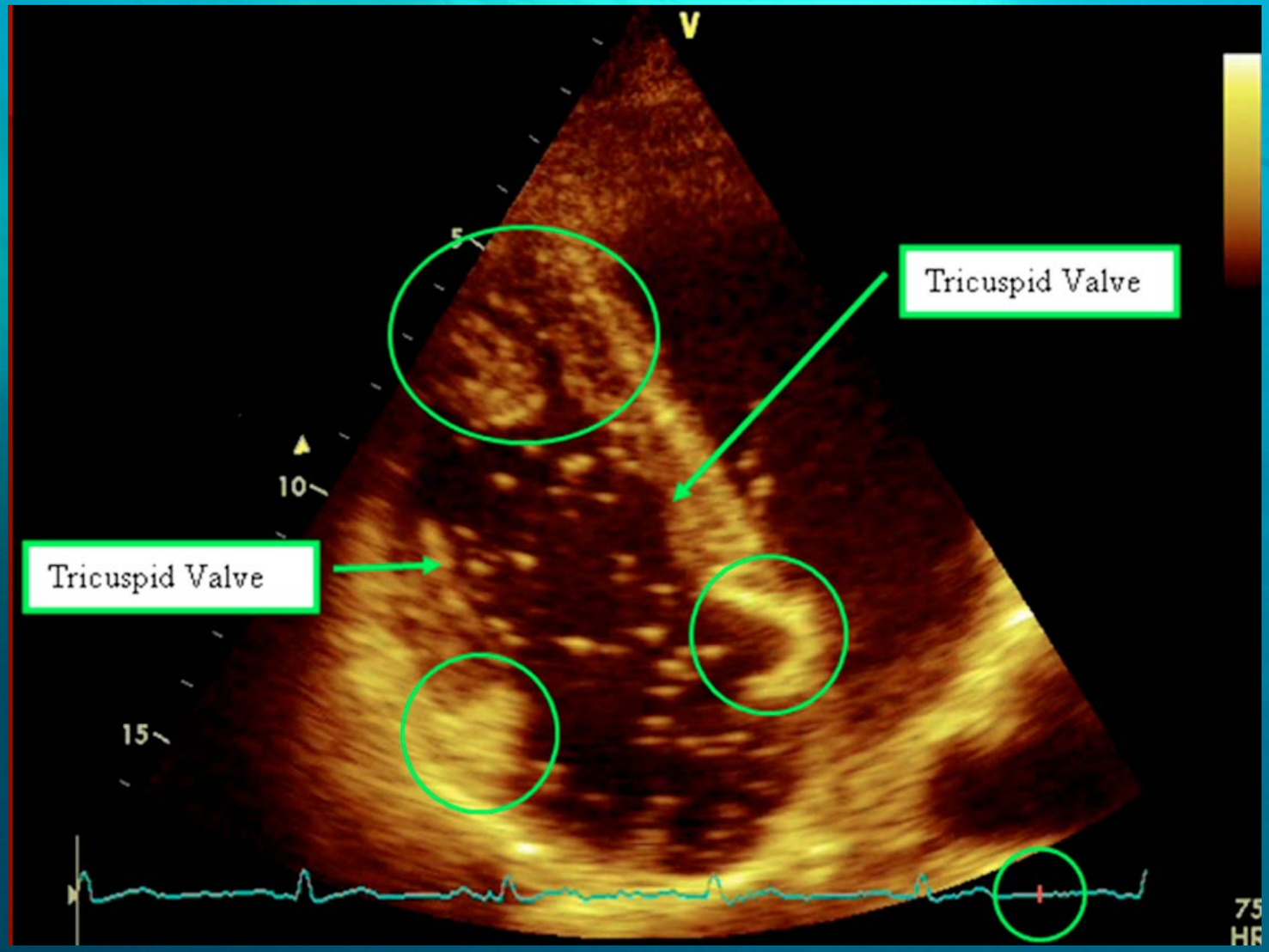
Materials and methods

- Bubbles detection :

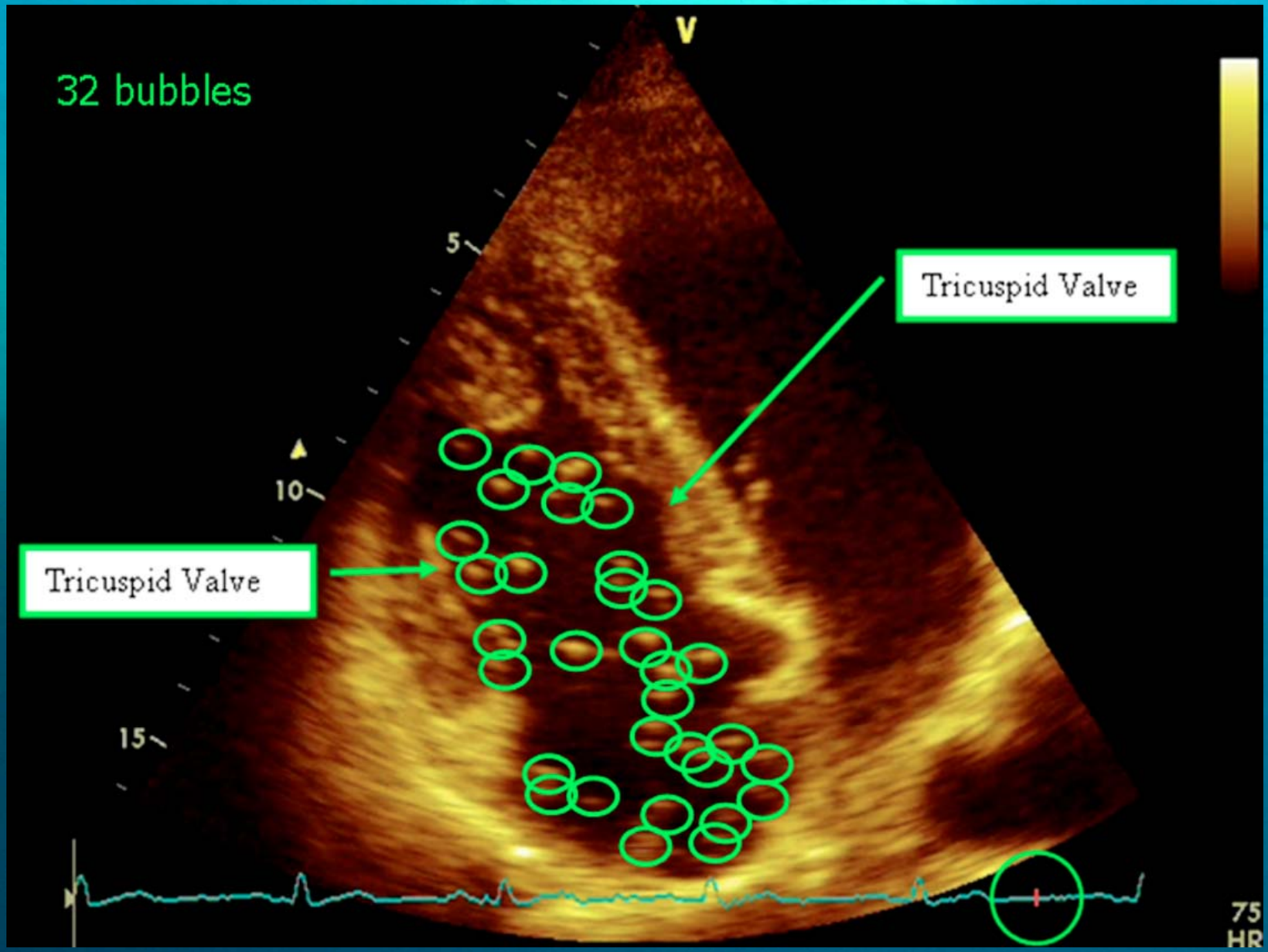
Materials and methods



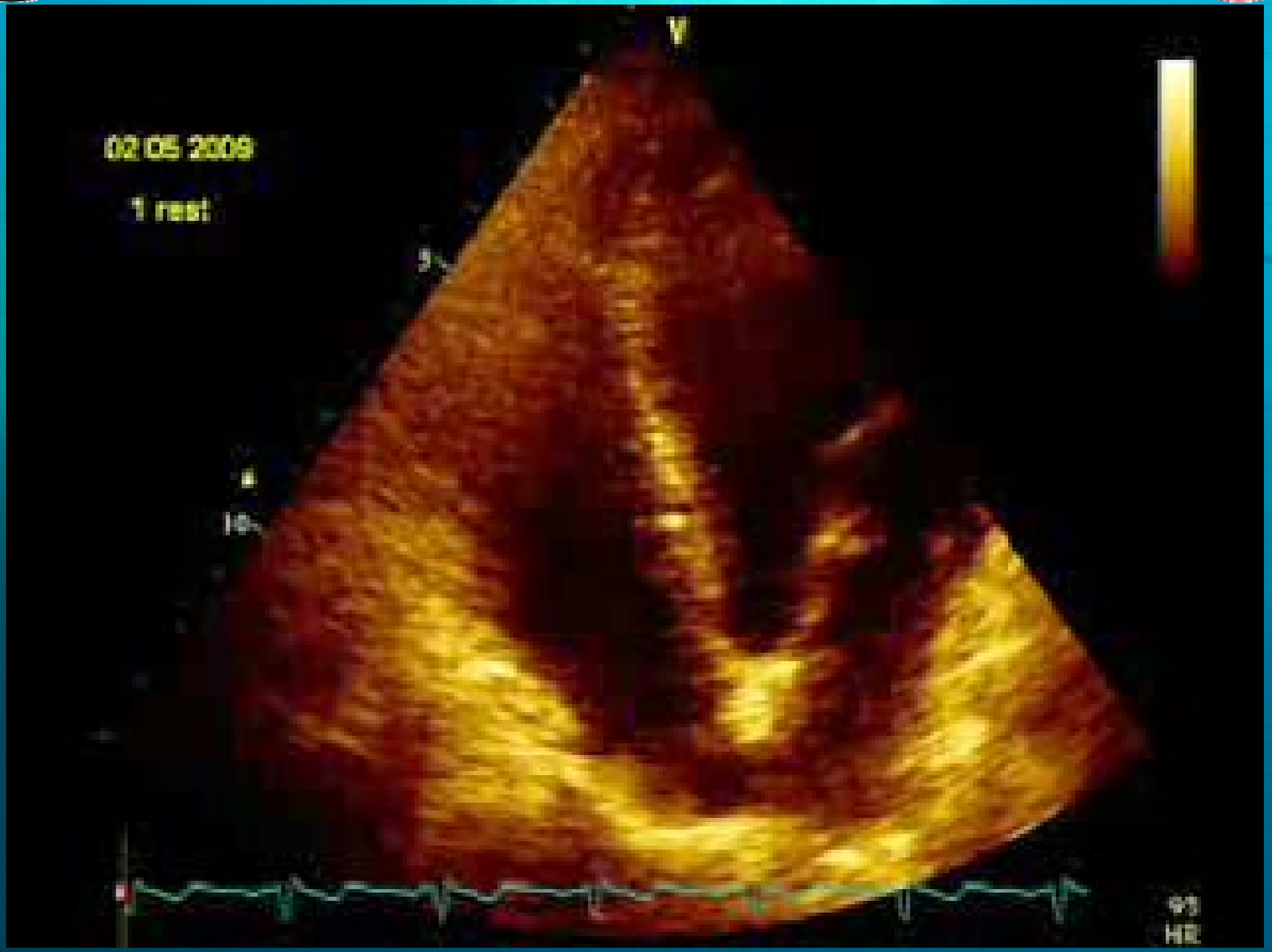
Materials and methods



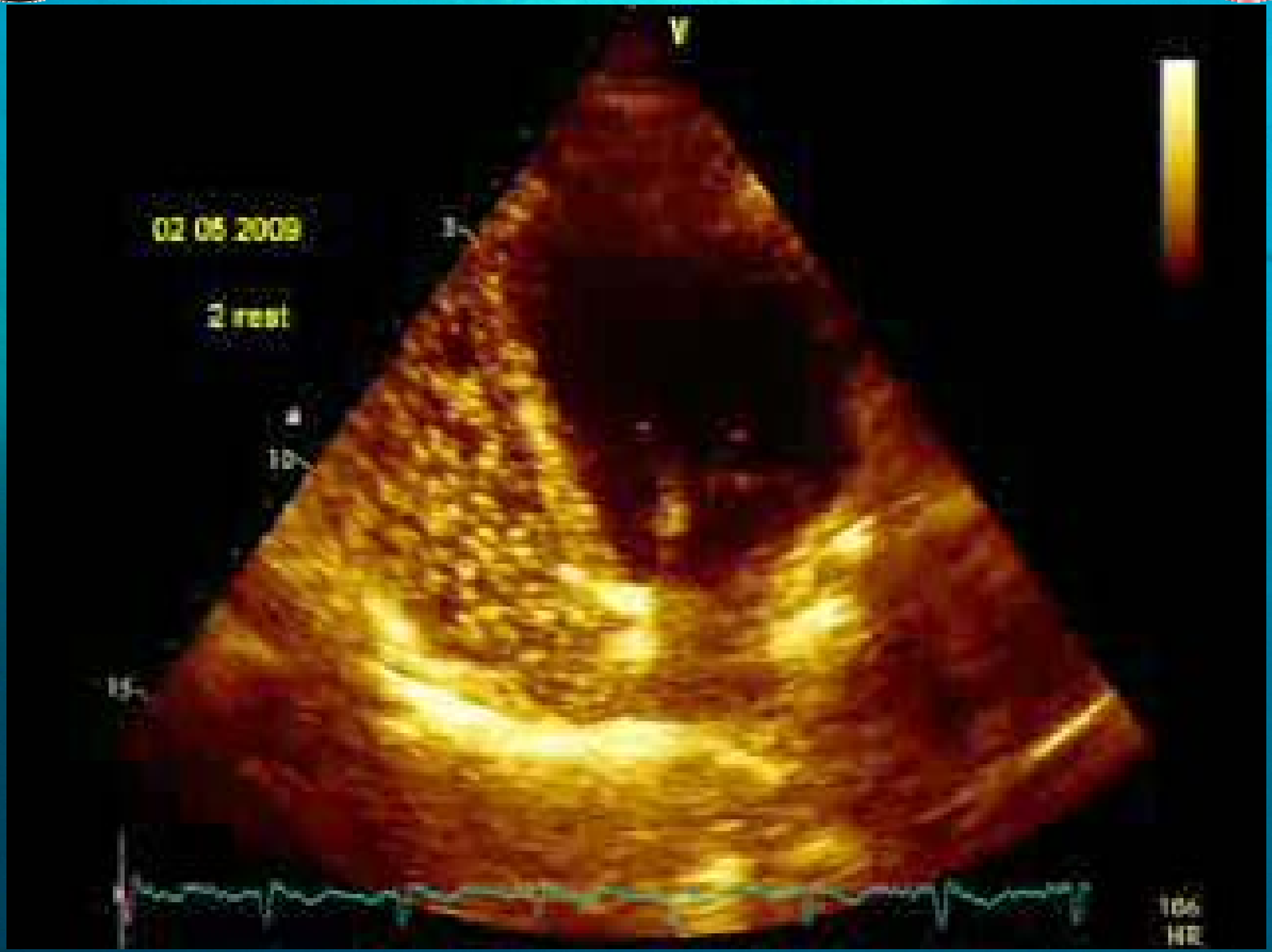
Materials and methods



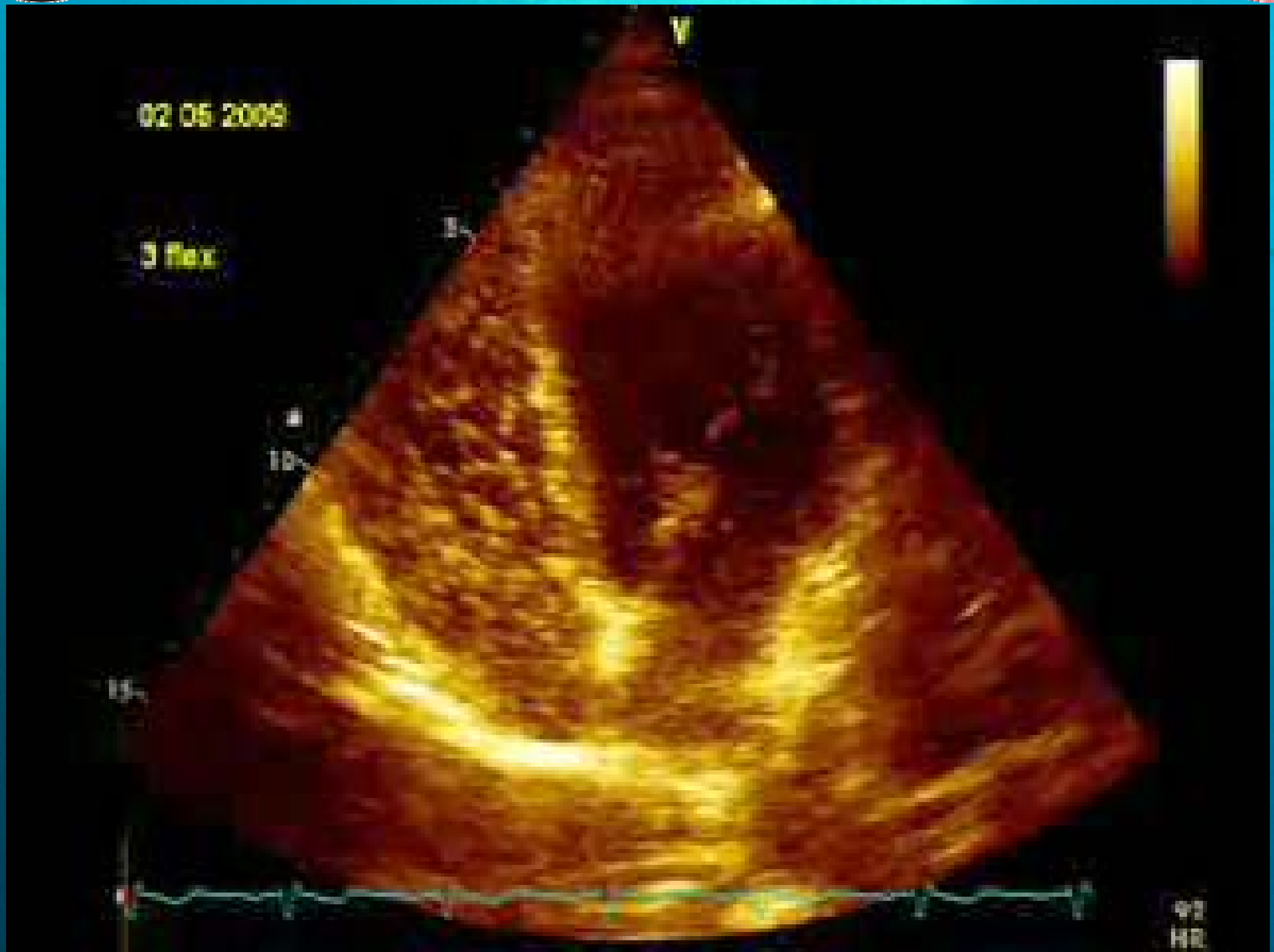
Pre dive



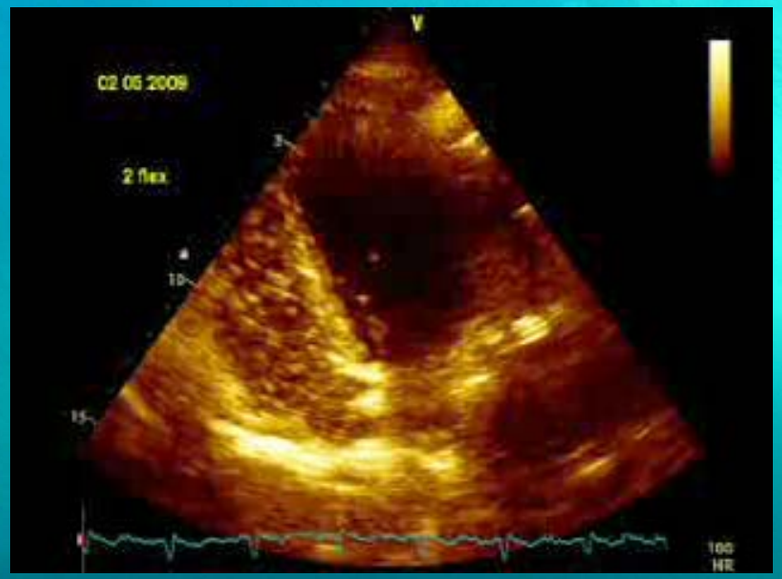
35 min post dive

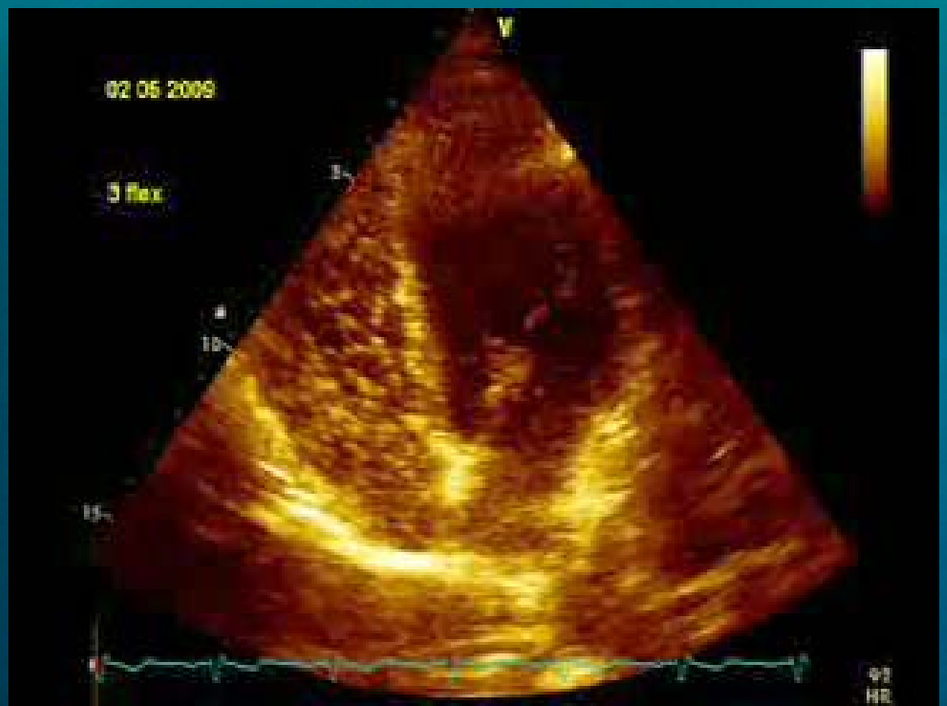


1h30 post dive



Materials and methods



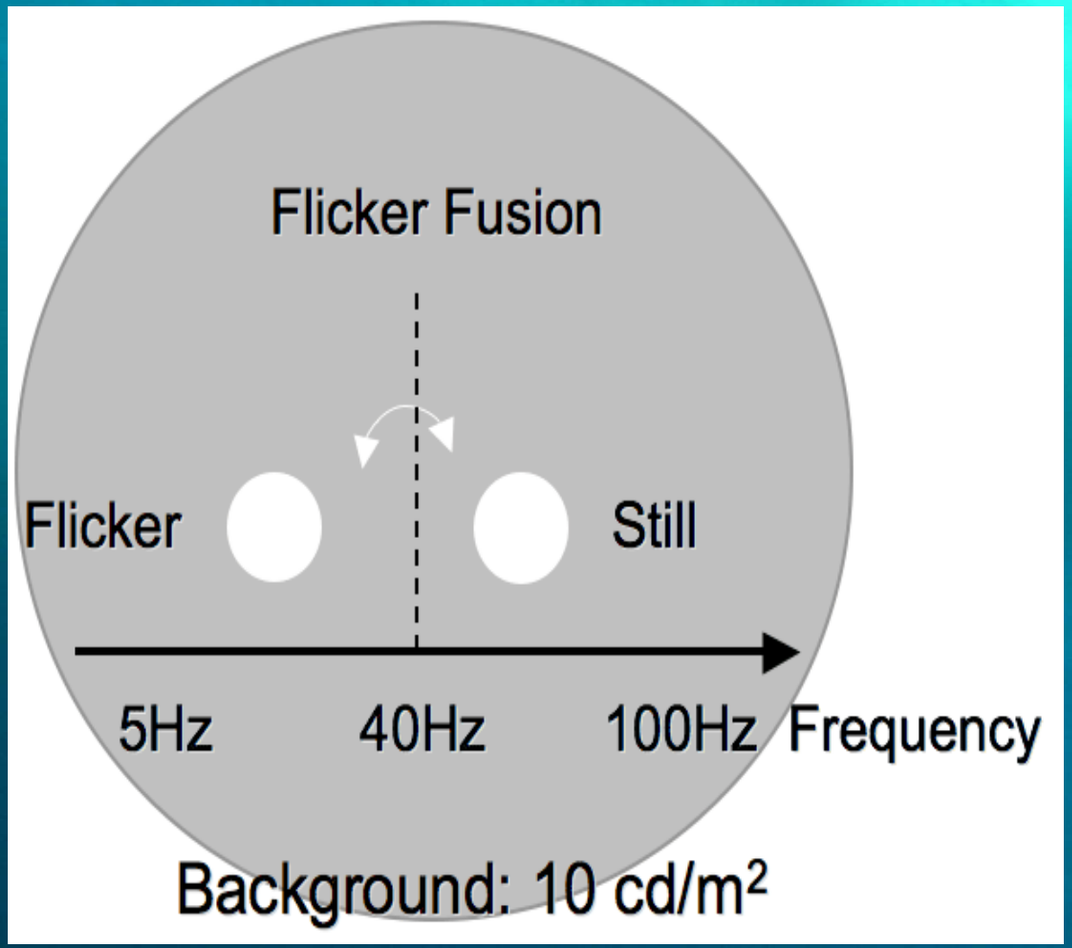


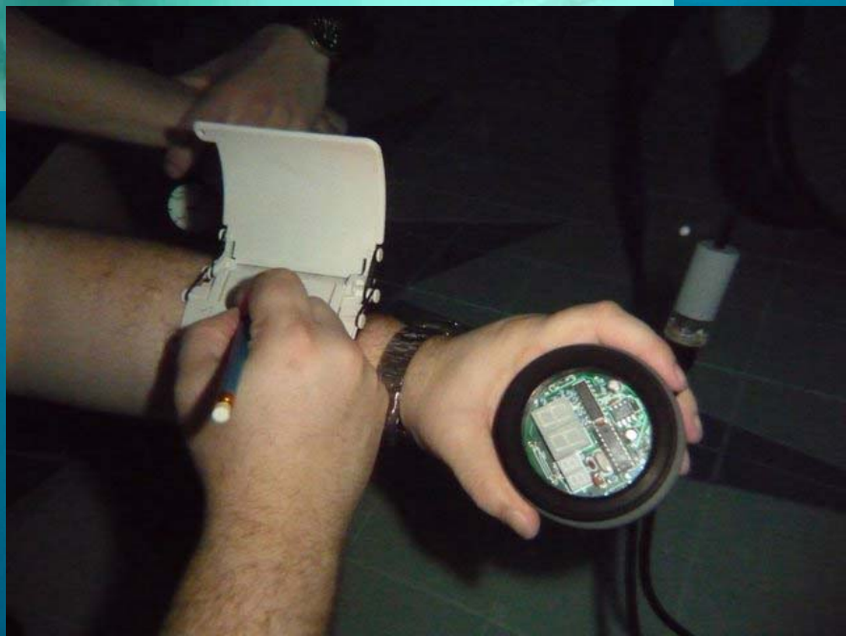
- 198 dives
- 1 echo pre-dive
- 4 echos post-dive
- 10 beats

= 9.900 pictures to analyse

Materials and methods

- Flicker test

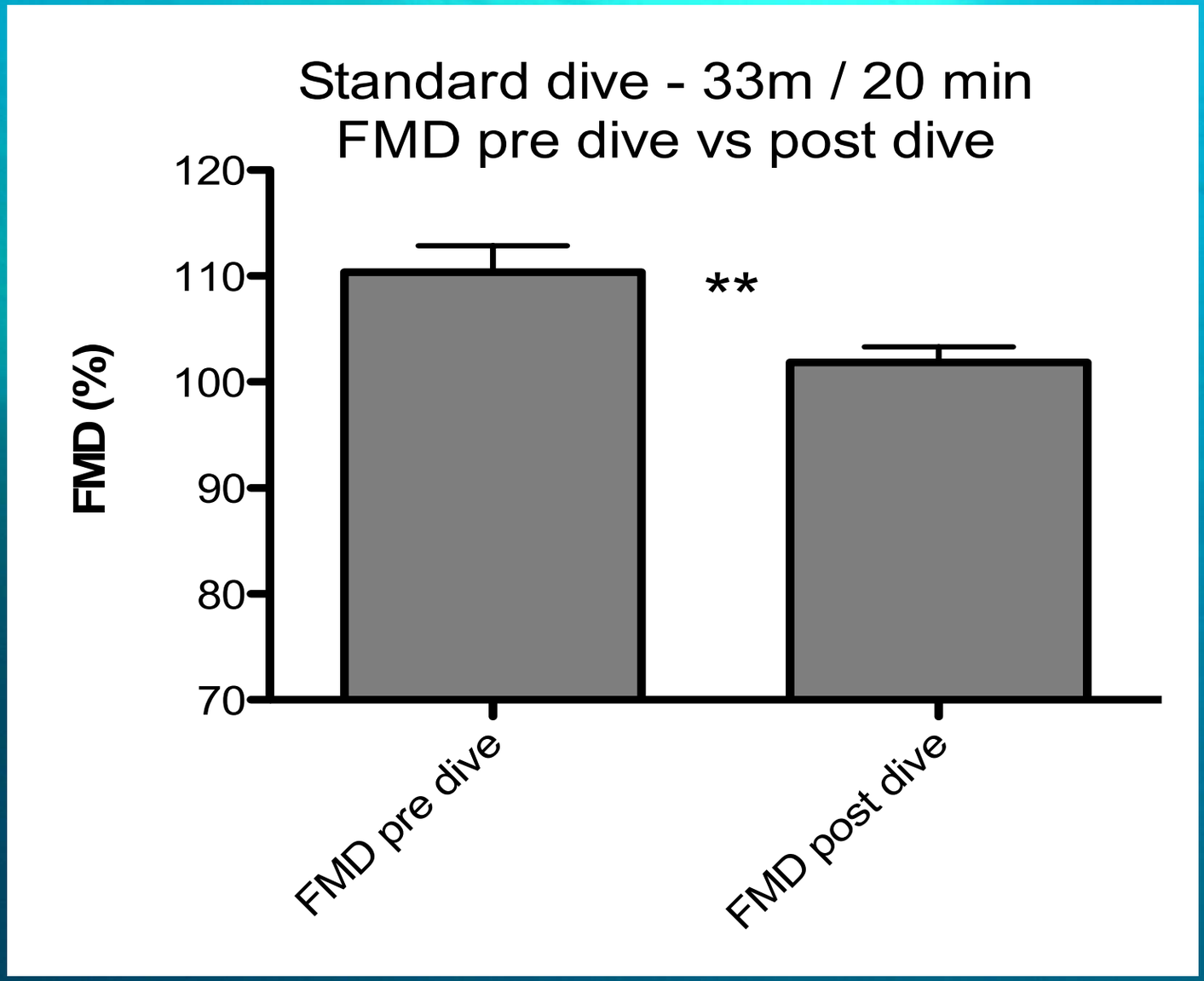




Results and discussion

1. FMD
2. Bubbles
3. Flicker test
4. Pre-conditioning

Results : FMD


Standard dive - 33m / 20 min
FMD pre dive vs post dive
FMD (%)
120
110
100
90
80
70
**
FMD pre dive
FMD post dive

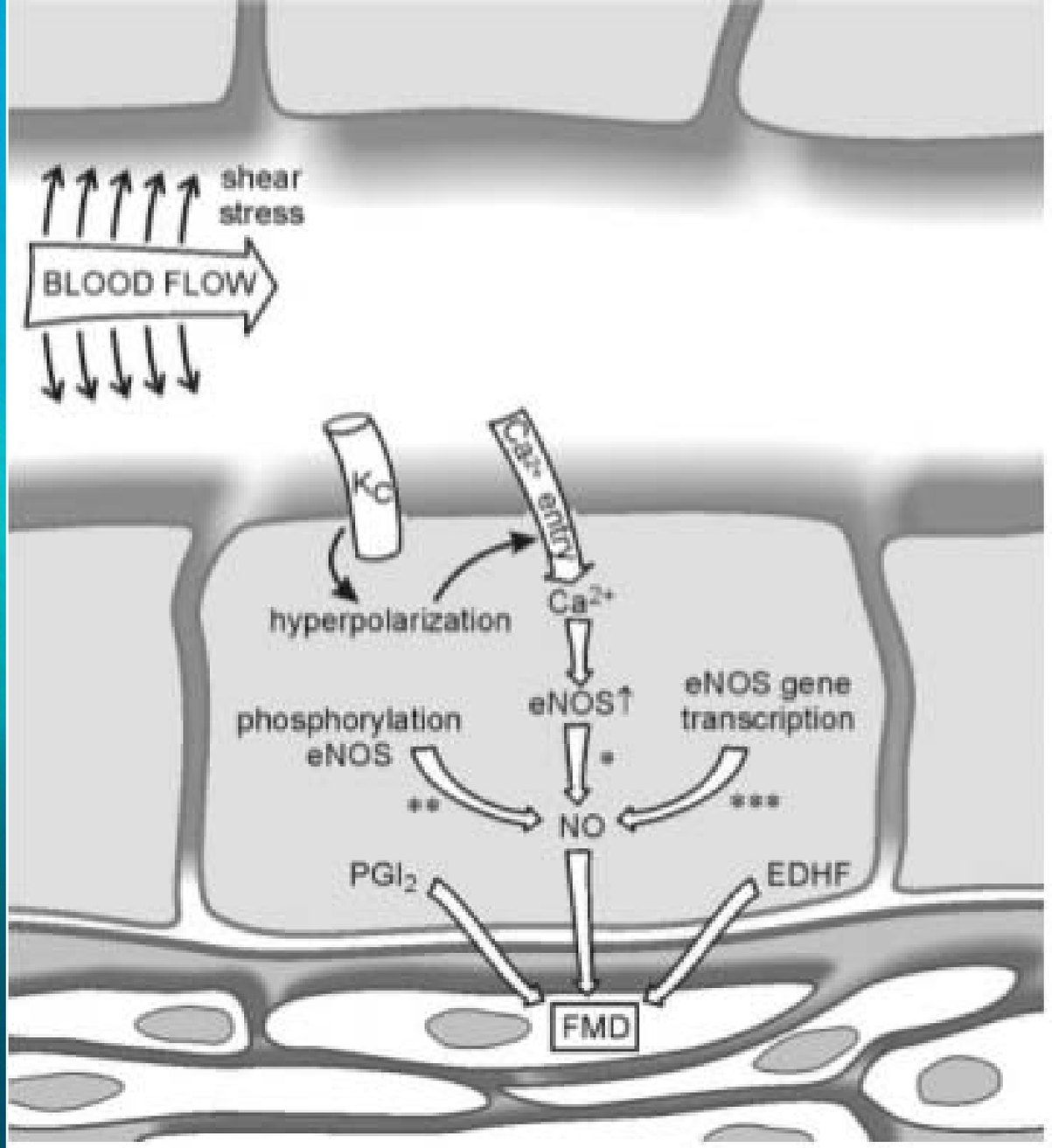
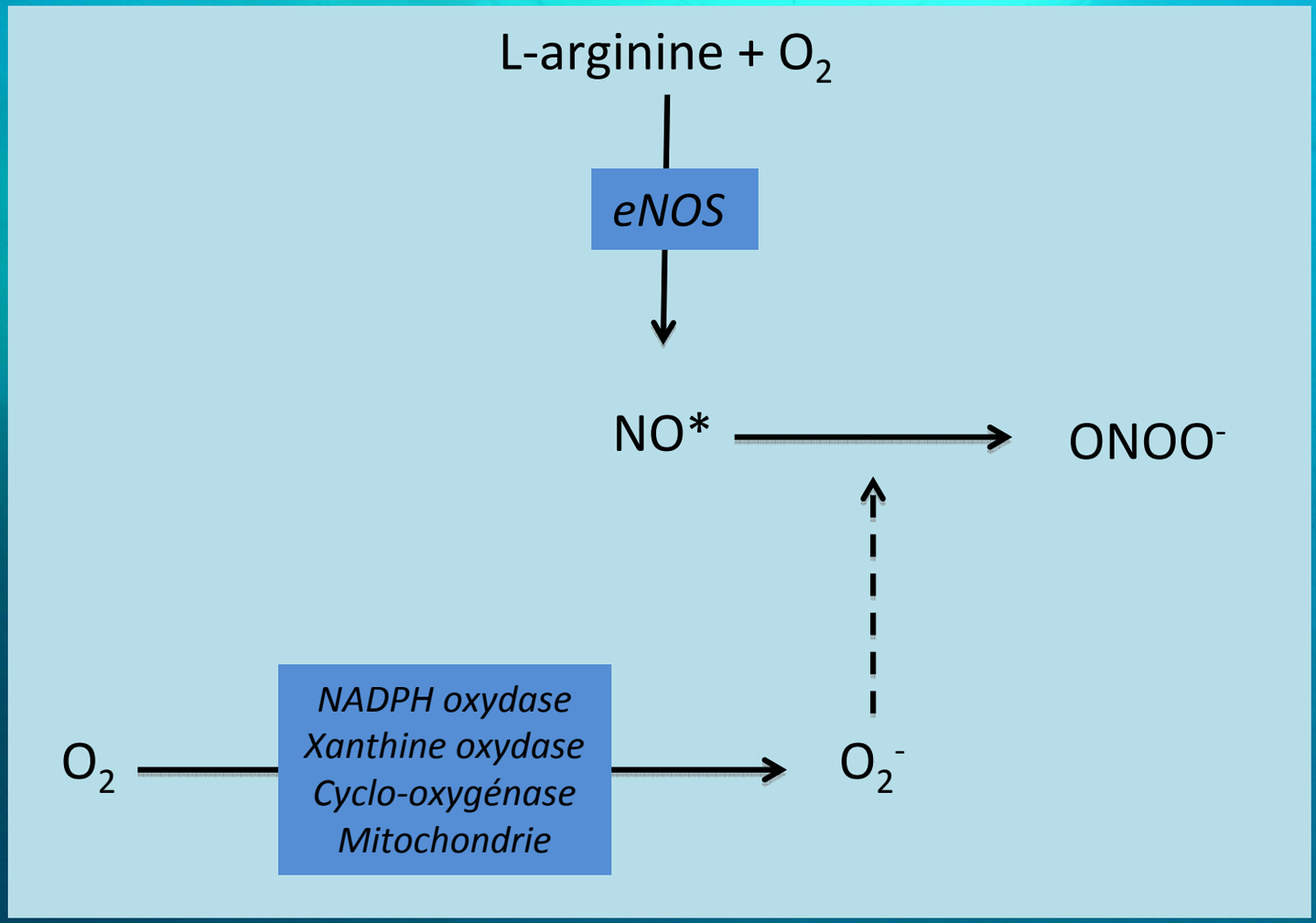


FIGURE 1. The genesis of FMD, in response to different changes in shear stress. * = very short-term changes; ** = changes taking place over slightly longer periods (minutes); *** = changes taking place over a longer time (many minutes or hours). PGI_2 = prostacycline; EDHF = endothelium-derived hyperpolarizing factor; Kc = calcium-activated potassium channel.

FMD


L-arginine + O_2
eNOS
NO*
$ONOO^-$
O_2
NADPH oxydase
Xanthine oxydase
Cyclo-oxygénase
Mitochondrie
O_2^-

FMD - Mechanisms

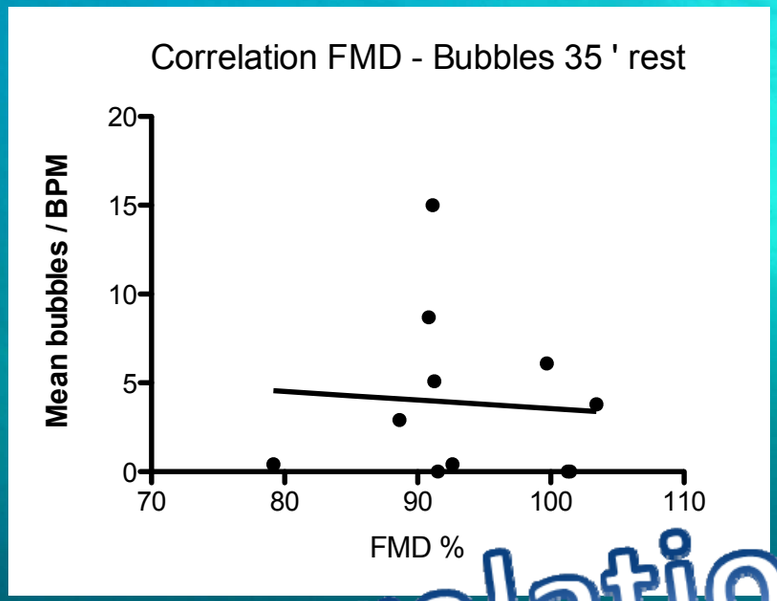
- Arterial dysfunction induced by diving
  - ✓Higher oxygen levels reduce NO ?
  - ✓Bubbles damaging endothelium ?
    NB need to be on arterial side !?
  - ✓Microparticles (MP) damaging endothelium ?
    Venous MPs may pass pulmonary filter; MPs may be produced by arterial endothelium ?
  - ✓Other unknown factor ?

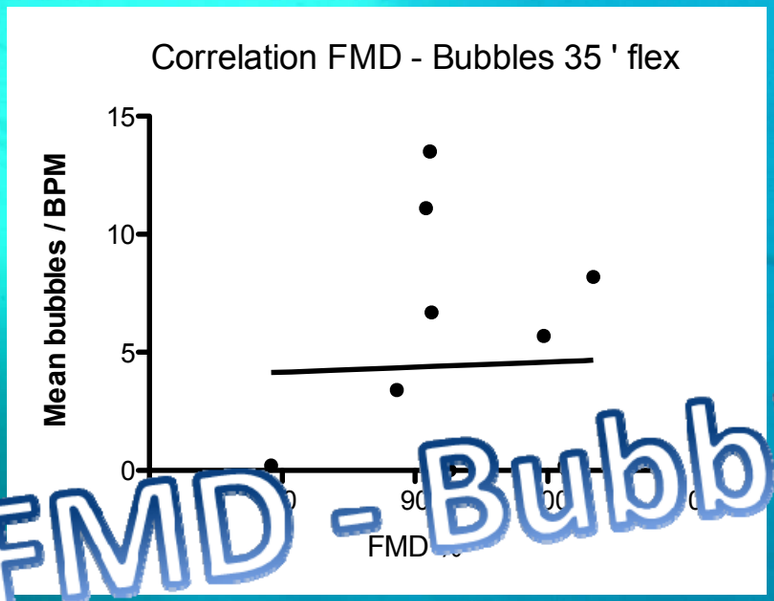
Other unknown factor ?

- Weight
- BMI
- Urine density
- WBC, platelets
- Cholesterol, TG
- LDL, HDL, CV
- Impedancemetry

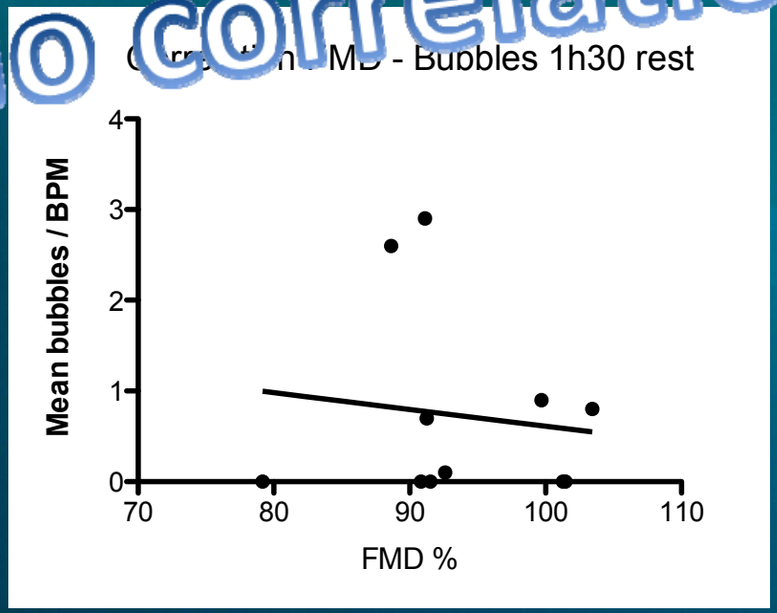
No significant difference between 1/3 inf. and 1/3 sup. of FMD

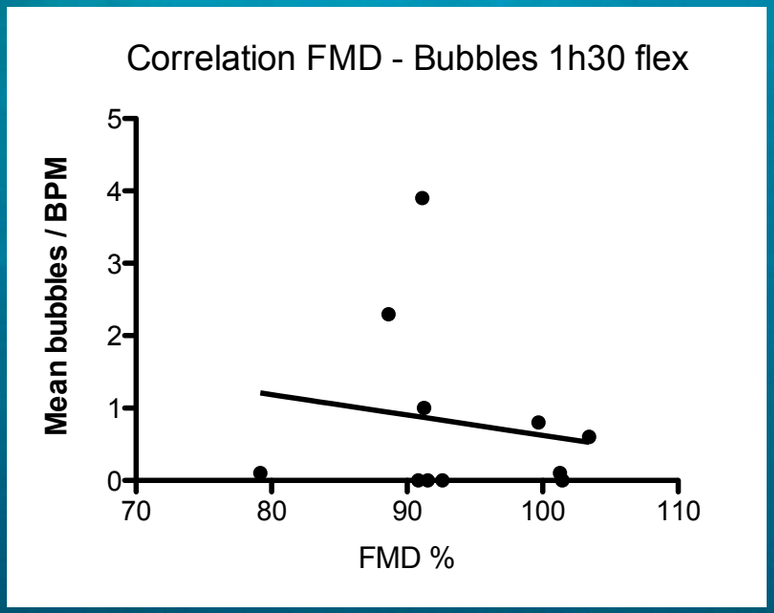
Correlation FMD – bubbles ?





No correlation FMD - Bubbles

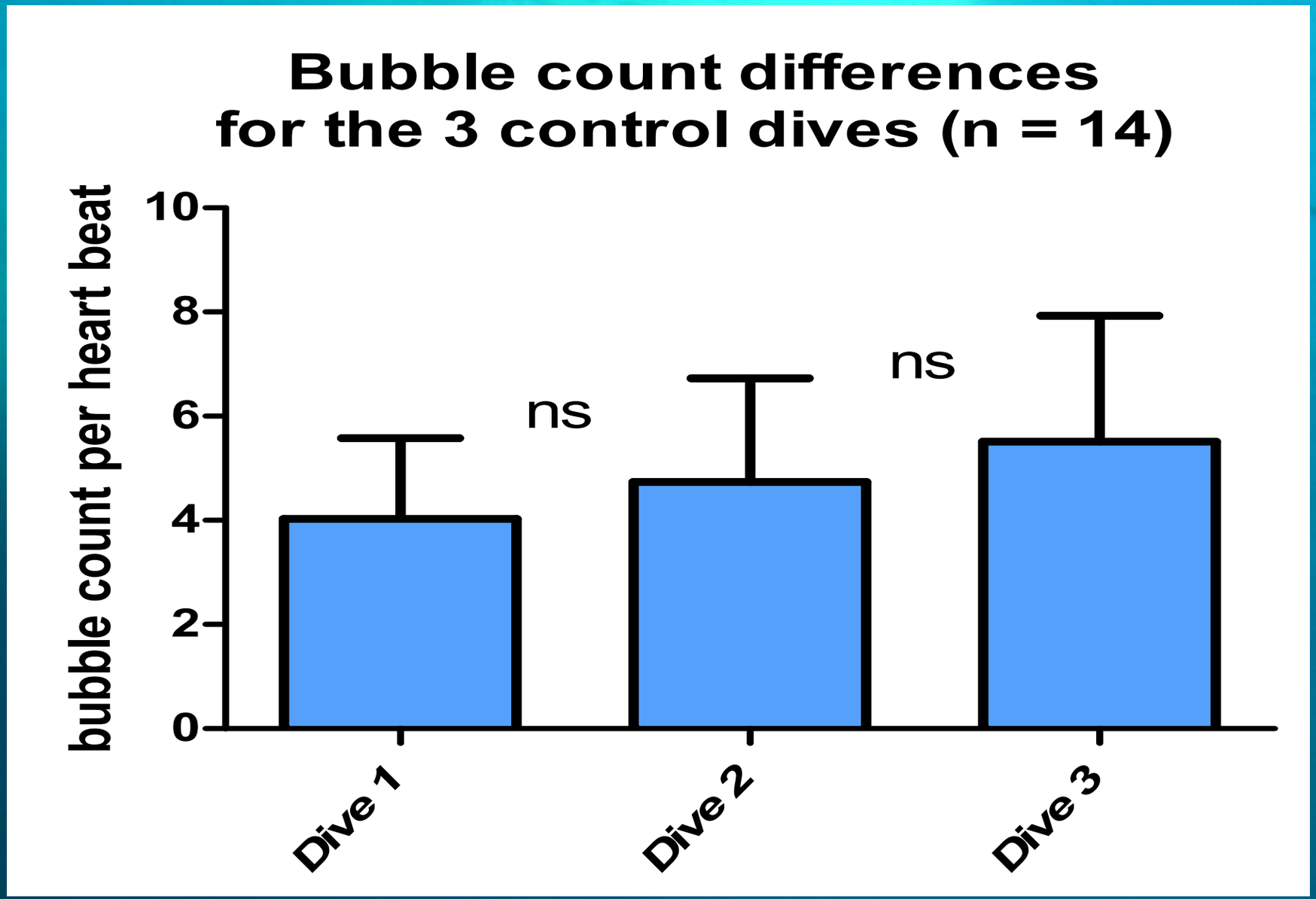




Results : bubbles

- Three « standard » dives (with no pre-dive intervention)
- 14 of the 24 divers were « bubbling »
- Stability of « bubblers »

Bubble counts



Biometrics

- Weight
- BMI
- Urine density
- WBC, platelets
- Cholesterol, TG
- LDL, HDL, CV
- Impedancemetry

No significant difference between « bubblers » and « non-bubblers »

NB: to be confirmed

Results : flicker

- Increase of 4.0 ± 5.1% at 33msw
- Decrease of 6.5 ± 4.3% after 15minutes at depth
- 30 minutes after surfacing : decrease of 3.7 ± 8.2%.

SURPRISING !
Nitrogen narcosis persisting after the dive ?

To be further investigated