# ABILITY TO VISUALIZE CIRCULATING DECOMPRESSION-INDUCED GAS EMBOLI BY PORTABLE TRANSTHORACIC ECHOCARDIOGRAPHY INCREASES WITH INCREASING PRECORDIAL DOPPLER GRADE

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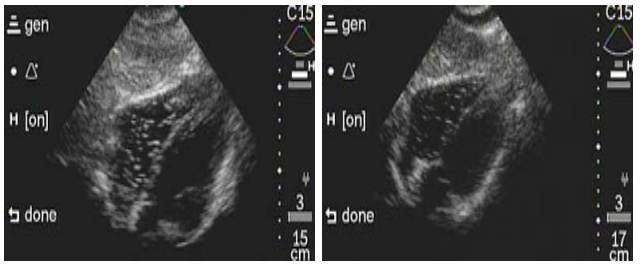
## Introduction

- Decompression is associated with gas emboli (bubble) formation
- Doppler ultrasound provides a surrogate measure of decompression stress through aural identification of bubbles in the blood, typically those leaving the right heart for the lungs
- While the lungs are an effective bubble filter, several avenues exist for left ventricular gas emboli (LVGE) to arise, potentially creating an elevated risk of neurological decompression sickness
- Recently developed, portable two-dimensional transthoracic echocardiographic imaging (TTE) systems facilitate left heart monitoring under laboratory or field conditions
- An unresolved question is whether portable TTE is as sensitive as Doppler to bubble presence

## Methods

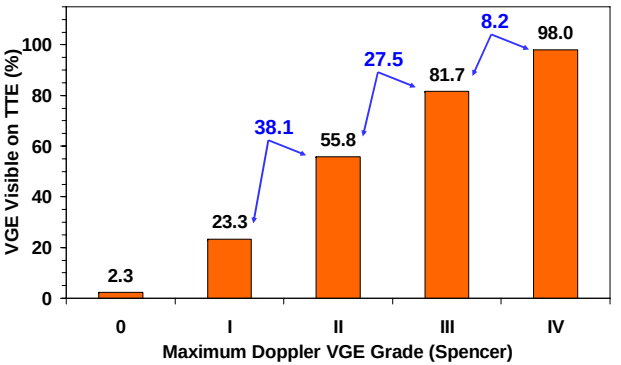
- Subjects exposed to significant decompression stress at altitude in our lab are evaluated with precordial Doppler and, more recently, also with TTE
  - Doppler - TechnoScientific DBM9008
  - TTE - SonoSite SonoHeart Elite
- Doppler scored using the 0-IV grade Spencer scale
  - providing a secondary measure of decompression stress (our normal study endpoint for decompression stress is symptoms of decompression sickness)
- TTE scans were conducted as a safety measure focused on the left heart
  - the clearest of three standard views achieved for each individual was used
    - apical, parasternal or subcostal
  - the presence of LVGE resulted in immediate compression of the subject to ground level
  - the presence/absence of right heart bubbles was recorded if that field was also interpretable
    - grading scales for right bubbles were not employed
- This study compared monitoring periods for which both precordial Doppler and right heart TTE data were available
- Chi squared testing assessed differences in TTE-identified bubbles across non-zero Doppler grades
  - significance was accepted at $p<0.05$

## Results




Clear TTE scans showing bubbles in right heart (left side of visible hearts)

- A total of 2734 records were reviewed
  - non-zero scores: 575 Doppler (21%); 383 TTE (14%)
- The ability to identify bubbles with TTE progressively increased with increasing non-zero Doppler grades
  - I = 34/146; II = 126/226; III = 125/153; IV = 49/50




The percentage of cases in which bubbles (identified with Doppler) were observed in the right heart with portable TTE increased as a function of precordial Doppler grade; values with arrows indicate paired Chi squared contrasts

- All paired contrasts were significantly different
  - I vs. II; II vs. III; and III vs. IV

## Discussion

- TTE view quality is affected by subject differences, thus influencing the view employed
  - **apical** view is good for four chamber imaging, providing a long axis plane generally best for capturing moving bubbles
    - used as a default when reliably clear
  - **parasternal** view is good for left heart imaging but provides only short axis cross-section of right ventricle
    - bubbles in right ventricle tend to be visible for shorter periods and only as flashes when passing through the view plane
  - **subcostal** view can be comparable to apical but generally requires a deeper focal depth, shrinking image size and making discrimination more difficult
    - also harder to get clear view as abdominal fat and overall body size increase

## Note

- Our TTE monitoring has identified two cases of LVGE
  - both were immediately compressed; neither developed symptoms resulting from the exposure

## Future Initiatives

- Compare the agreement between Doppler and each of our three standard views
- Grade right heart bubbles observed with TTE to compare with standard precordial Doppler scores
- Evaluate new TTE imaging devices

## Conclusions

- Portable TTE devices facilitate left heart monitoring during decompression studies not feasible with precordial Doppler
- Portable TTE devices appear to be more able to detect right heart bubbles when precordial Doppler-detected grades are higher
- The relative insensitivity of portable TTE to lower bubble grades indicates that scoring provided by the different technologies may not be fully comparable
  - evolving technologies may improve agreement in the future

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