Decompression Sickness (DCS) Below 18,000 Feet: A Large Case Series

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Disclosure Information

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I have no financial relationships to disclose.

I will not discuss off-label use and/or investigational use in my presentation.

The opinions expressed are mine only and do not represent DoD or Air Force positions.
Methods

• Source Material
  – Literature 84 cases
  – Unpublished 20 cases
    • Davis Hyperbaric Laboratory 7 cases
  – TOTAL 111 cases

• Descriptive Analysis
Results

• Source of Exposure
  – Aircraft = 39
  – Chamber = 69
  – Parachute = 3

• Mean Age = 26 (aircraft = 30 & chamber = 24)

• Gender
  – Male = 80
  – Female = 13
  – Unknown = 18
Results

[Bar chart showing cases of DCS at various exposure altitudes, differentiated by types I and II and cases of unknown.]
Results

• DCS
  – Type I = 74 (joint*, skin)
  – Type II = 20 (eye, chokes, neurologic)
  – Unknown = 17

• Therapy
  – GLO = 8
  – TT5 = 5
  – TT6 = 24
  – TT8 = 2 (USAF experimental table → 33 ft)
  – None = 50 (1940s = 41; 1960s-1980s = 9)
  – Unknown = 21
Results

• Residual
  – Joint pain = 3 (knee, shoulder)
  – Neurologic = 2 (tingling, numbness)

• Recurrence
  – Joint pain = 1 (knee)
  – Neurologic = 1 (ulnar nerve)

• Tailing Treatments (6)

• Treatment Complications (2)
Results

• Risk Factors
  – No prebreathe (n = 101, 95%)
  – Exercise (n = 103, 76%)
    • AFRL Altitude Research Database, p < 0.05
  – Prior exposures (n = 91, 74%)
  – Duration at altitude (n = 88)
    • Range = 5 - 414 minutes
    • Mean time to symptoms = 83 minutes
Implications of Case Series-1

- Low Altitude DCS may not be uncommon
- Anecdotal cases routinely discussed
- Bubble Data
  - Webb & Pilmanis
  - Olson & Krutz
- Case Series
ADRAC Model of DCS Risk
18,000 Ft --- No Prebreathe

Pilmanis et al; ASEM; 2004;75:749-759
Incidence of Low Altitude DCS

- Houston (1947) \( \rightarrow \) \( \frac{2}{387} = 0.5\% \) \( (6/387 = 1.6\%) \)
- Smedal (1948)
  - 5,000 ft \( \rightarrow \) \( \frac{6}{240} = 2.5\% \)
  - 6,000 ft \( \rightarrow \) \( \frac{4}{22} = 18.2\% \)
  - 10,000 ft \( \rightarrow \) \( \frac{23}{71} = 32.4\% \)
- Smead (1986) \( \rightarrow \) \( \frac{1}{31} = 3.2\% \) \( (15,000 \text{ ft}) \)
- Dixon (1986) \( \rightarrow \) \( \frac{1}{88} = 1.1\% \) \( (16,500 \text{ ft}) \)
- AFRL database \( \rightarrow \) \( \frac{7}{424} = 1.7\% \) \( (16,500 \text{ ft})^* \)
Implications of Case Series-1

• Bubbles form below 18,000 feet
  – Bubbles evolve and grow below 18,000 feet
  – VGE and DCS may not be rare

• Issue
  – Cannot discount symptoms and DCS
  – Definitive treatment indicated (may need HBO)
Implications of Case Series-2

• Operational Air Force
  – U-2 operates up to 29,500 ft (soon to 15,000 ft)
  – AC-130 operates unpressurized to 18,000 ft
  – CV-22 operates unpressurized to 20,000 ft
  – Training chambers operate up to 25,000 ft

• Issue
  – Cannot discount VGE effects and DCS
  – Altered/aborted missions & long term health impacts
  – New Research
    • Microparticles (MPs) --- encapsulated membrane fragments (Thom et al)
    • White Matter Hyperintensities (WMHs) --- rMRI (Jersey et al; McGuire et al)
  – **Future**: pre/post-flight HBO for high decompression stress missions
    • Denucleates, denitrogenates, counters MPs & WBCs (Arieli et al; Thom et al)
Implications of Case Series-3

• Aeromedical Evacuation flies ≤ 8,000 ft
  – VGE in normals = 28% (AFRL Database ≥ 10,250 ft)
  – Patients are not normals
    • Altered perfusion
    • Turbulent flow
    • Anesthetic gases
    • Transfusions infuse bubbles (macro)
      – Warming releases dissolved gas (85% inert)
    • Transfusions introduce MPs (Pritts et al*, Thom et al)
      – Proinflammatory (WBC activation with vascular/lung injury)
      – Abated with recompression (may have a gas component)
Implications of Case Series-3

• Aeromedical Evacuation flies ≤ 8,000 ft
  – VGE, warmed blood gas evolution, and MPs

• Issue
  – Cannot discount “second hit” during AE
  – Cabin altitude restriction a cogent countermeasure
  – **Future:** pre/post-flight HBO (?? USAF TT8 ??)
    • Compresses bubbles, oxygenates, counters MPs & WBCs
      (Thom et al; Arieli et al)
Conclusion

- Low Altitude DCS exists
  - May be more frequent than thought
    - Treat like any altitude DCS
  - May be operationally relevant
    - VGE, MPs, WMHs
  - May be very relevant to AE
    - VGE, transfusion bubbles, MPs
    - “Second hits” and post-flight complications and CARs
- FUTURE: pre/post-flight HBO
Questions

--- Thank you very much
References

8. Manton A. Three incidents of decompression illness at the RAF Centre of Aviation Medicine. Aerospace Medical Association Annual Scientific Meeting; Atlanta, GA; 13-17 May 2012.
17. AFRL Altitude Research Database