

# THE EFFECT OF INTERRUPTION ON OXYGEN PRE-BREATHE TREATMENT AND THE INDUCTION OF DYSBARIC OSTEONECROSIS IN UW SHEEP MODEL

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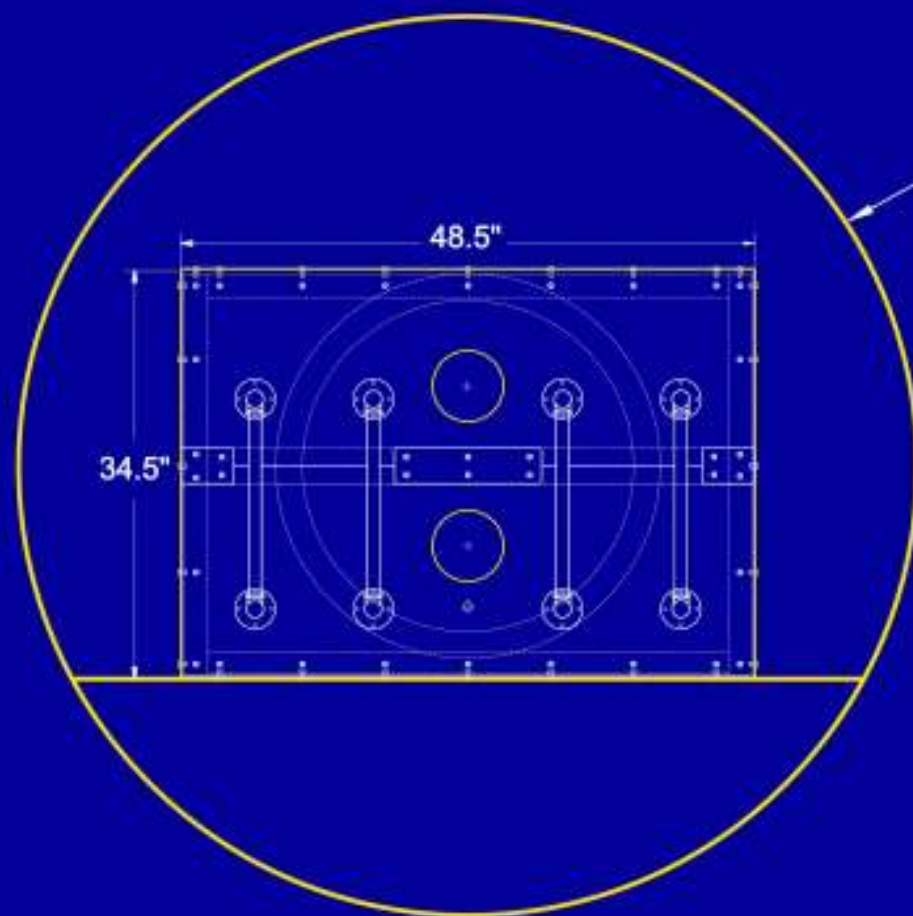
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# Background

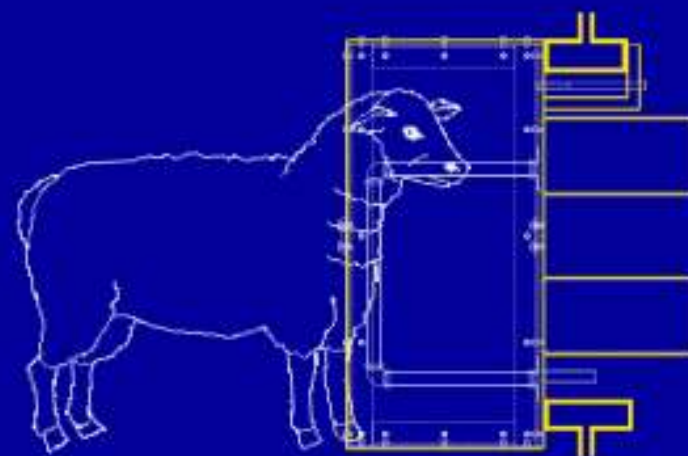
- Previous studies in sheep showed “oxygen pre-breathes” of 1-3 h from 60 fsw (2.8 ATA) saturation dives significantly reduced decompression sickness (DCS).
- An engineering limitation necessitated interruption prior to “drop-out” decompression.
- This study explores the effect of interruption of a 3-h oxygen pre-breathe with subsequent 1-h air break.

# UW SHEEP MODEL



Front View

Chamber



Right Side  
View

# UW SHEEP MODEL



UW O<sub>2</sub> delivery system used to evaluate emergency decompression to surface pressure.

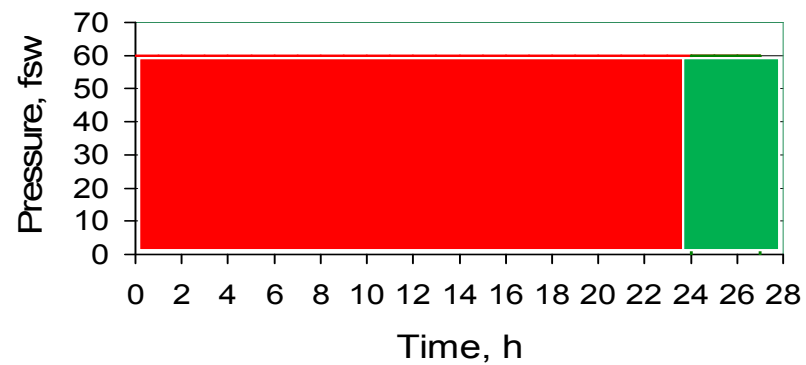


# Materials and methods

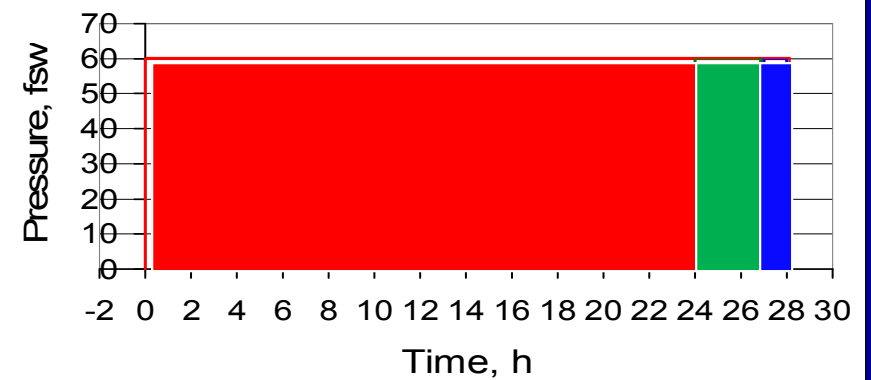
- Ten adult sheep underwent dry chamber air exposure at 60 fsw (2.8 ATA) for 24 hours, followed by an O<sub>2</sub> (88-92%) pre-breathe for 3-h before “dropout” decompression at 30 feet/min (0.9 atm/min) to surface.
- Another ten sheep underwent the same procedure with a 1-h air break before decompression. Upon surfacing, the animals breathed ambient air and were observed for 4-hours for signs of DCS.
- One month later, <sup>99m</sup>Tc-methylene diphosphonate (MDP) bone scans of the radii and tibiae were used to monitor “hot spots” of remodeling dysbaric osteonecrosis (DON) lesions.
- During bone scans, alizarin complexone fluorochrome was administered IV to visualize DON repair.
- One week later, sheep underwent necropsy for observation of DON pathology.

# Decompression profiles

**3-h O<sub>2</sub> Pre-breathe**



**3-h O<sub>2</sub> Pre-breathe + 1-h Air**





# **Doppler ultrasound probe detection of circulating bubbles in the decompressed sheep at the precordium**



**Sheep with a flexed limb, the classic sign of limb bends associated with DON in the decompressed UW sheep**





**Bone scan of sheep with Tc99m MDP used to detect new bone formation of DON lesions undergoing repair**



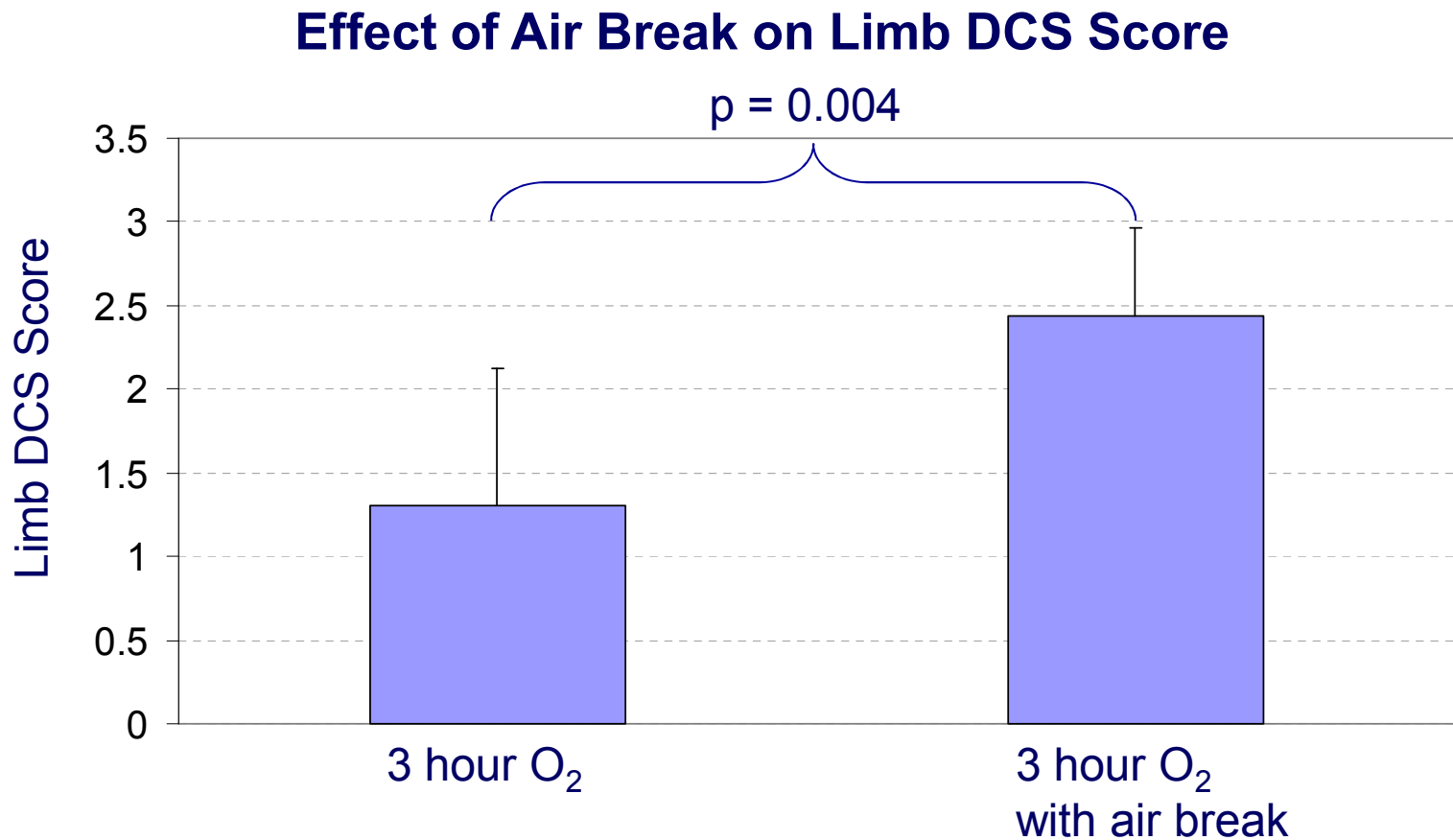
**Alizarin complexone flurochrome injection to visualize DON repair when sheep underwent necropsy to observe potential DON pathology**



# Results

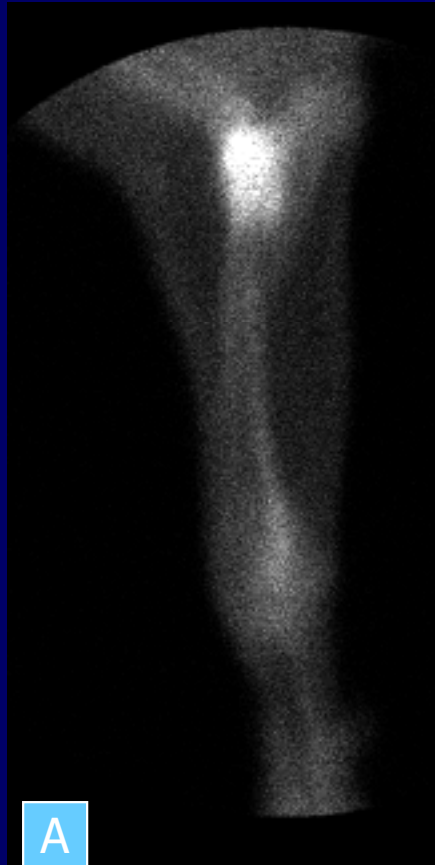
- All sheep survived accelerated decompression. Respiratory DCS developed in three animals in the air break group, but only one in the group without an air break.
- All ten sheep in the air break group developed limb bends within 10 min of surfacing.
- However, in the group without an air break eight animals developed limb bends, typically within 120 min of surfacing.
- Bone scans and confirmatory gross pathology showed significantly higher incidence and severity of DON in the group with an air break (average score 2.44 vs. 1.3,  $p = 0.004$ ).

**There were no significant differences between 3hrs oxygen plus 1 hour air vs 3hrs oxygen in terms of average bubble score at surface or one hour or of rate of RDCS. However, Limb DCS was significantly lower in the 3hrs O<sub>2</sub> group (average score 1.3 vs. 2.44,  $p = 0.004$ ).**



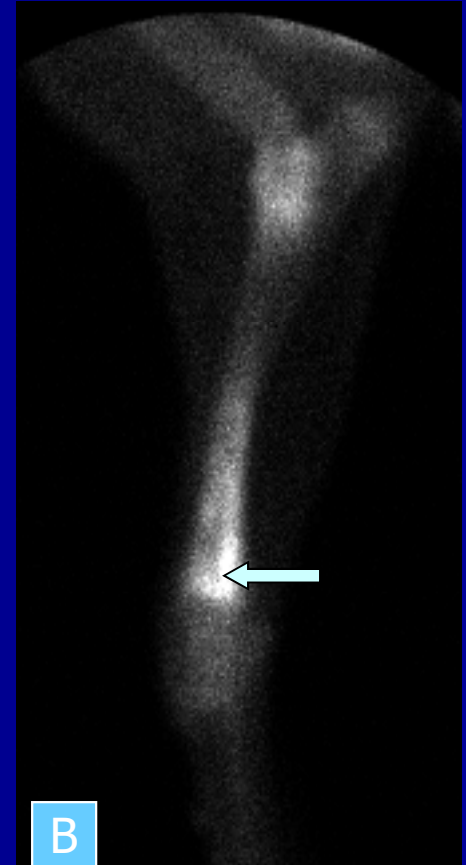
## Bone scan.

Numerous lesions appeared in medullary sites of long bone diaphyses and metaphyses.



(A) Normal left radius of sheep before hyperbaric exposure.

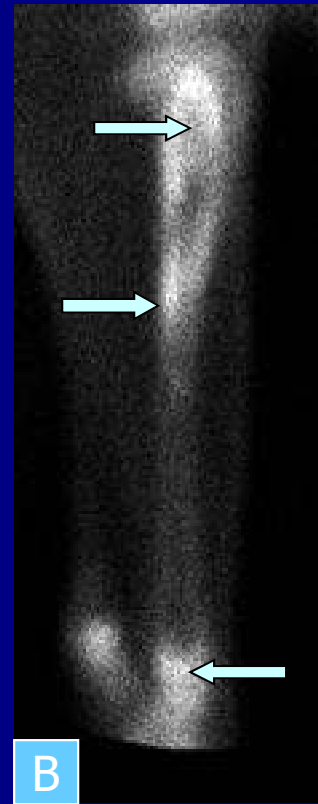
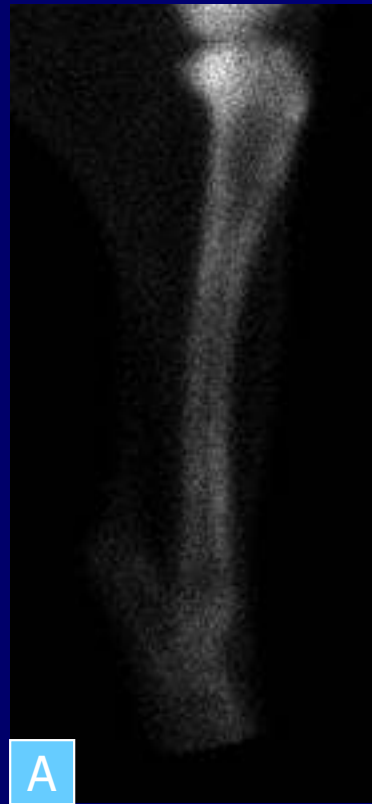
(B) Left radius of sheep after hyperbaric exposure.





## Bone scan.

Some lesions extended into the subchondral bone region.



(A) Normal right tibia of sheep before hyperbaric exposure.

(B) Right tibia of sheep after hyperbaric exposure. Tibial lesions were first observed at two sites in this sheep at 5 weeks after its hyperbaric exposure, suggestive of DON in this study. The arrows show regions of prominent endosteal and medullary activity.

# Gross examination of sheep after hyperbaric exposure followed by 3-h oxygen pre-breathe and 1-h air break



Right femur



Right humerus

# Gross examination of sheep after hyperbaric exposure followed by 3-h oxygen pre-breathe and 1-h air break



Right radius



Right tibia

# Gross examination



3-h O<sub>2</sub> + 1-h air break



3-h O<sub>2</sub>



# Gross examination of sheep after hyperbaric exposure followed by 3-h oxygen pre-breathe



Longitudinally-sectioned affected right tibia. Clinical signs presented in this limb during 4 hour observation period.



Longitudinally-sectioned left tibia. The bone appeared normal, and there were no clinical signs of DON.



# Conclusions

- This study strongly suggests that 3-h O<sub>2</sub> pre-breathing of emulated submarine escape and rescue will enhance survival and reduce DON in the UW sheep model of the decompressed human.
- Decompression-induced bubble formation likely slows N<sub>2</sub> gas tissue washout and may lead to pathogenic tissue ischemia and osteonecrosis.
- Interruption of O<sub>2</sub> pre-breathing prior to dropout decompression appears to decrease the protective effect of the O<sub>2</sub> pre-breathing for both respiratory DCS and DONs in sheep undergoing an accelerated decompression profile following a simulated saturation dive.

# Acknowledgments

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# Thank you for attention!



A girl sheep is called a Ewe. Sheep eat grass, weeds, and grain.