

INVESTIGATION OF DELAYED RECOMPRESSION TREATMENT FOR LIMITING THE INDUCTION OF DYSBARIC OSTEONECROSIS IN UW SHEEP MODEL

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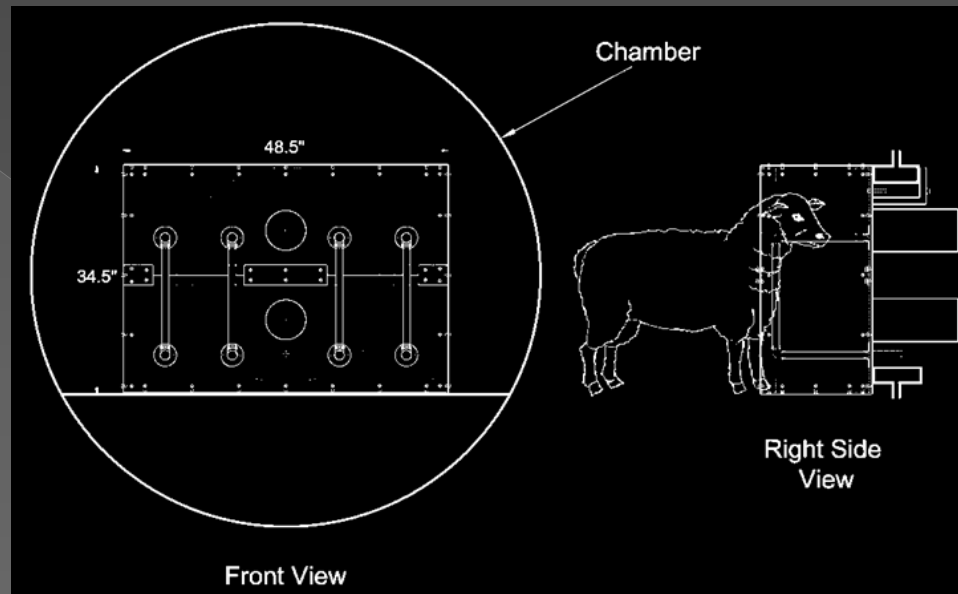
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Introduction

- It was successfully demonstrated that dysbaric osteonecrosis (DON) can be induced using the sheep model of the diver by prolonged compressed air exposures and provocative “dropout” decompressions.
- Dysbaric osteonecrosis may lead to the joint collapse of disabling secondary osteoarthritis.
- We investigated of delayed recompression treatment for limiting the induction in sheep of dysbaric osteonecrosis (DON) in sheep.

UW SHEEP MODEL

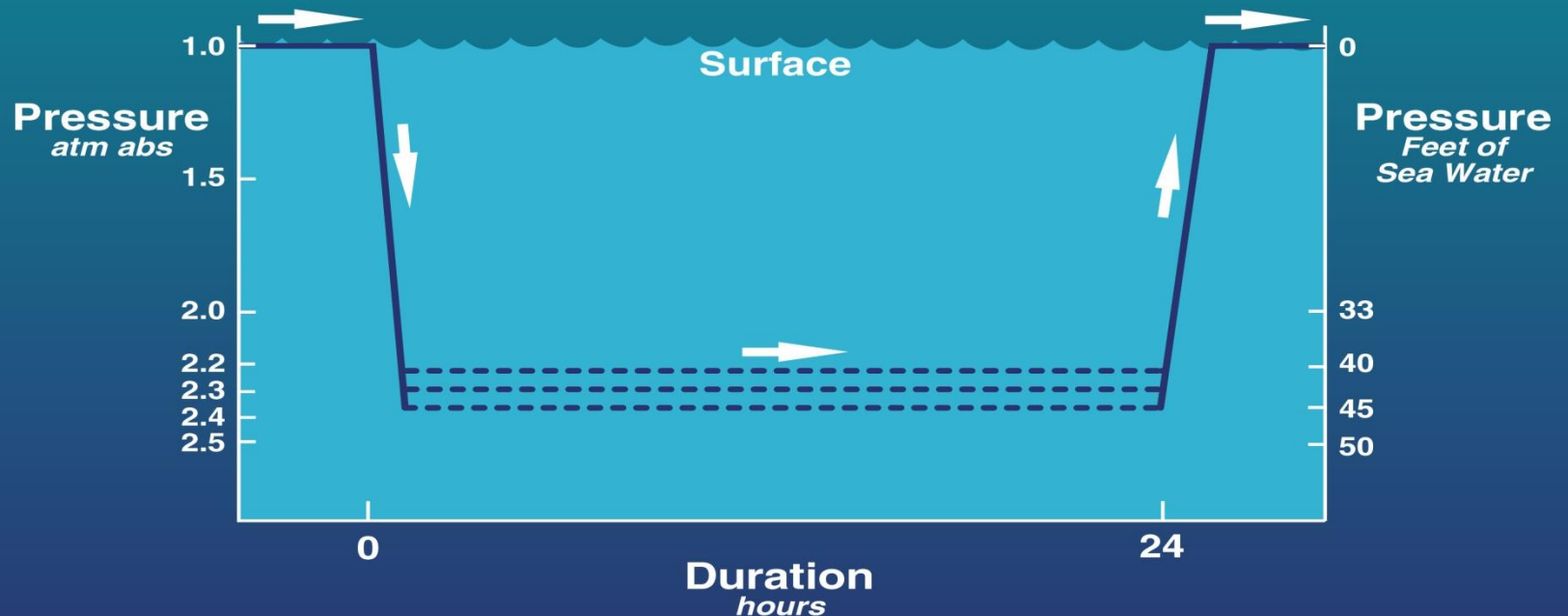


Methods

- Twenty-seven adult female sheep (90.5 ± 15.5 SD kg) underwent dry-air chamber exposures at 2.27 atm abs (43 fsw, 12.8 msw) for 24 hours, then rapid decompression at 30 feet/min (0.9 atm/min) to surface followed by air recompression treatment (Modified USN Table 6) with latencies of 4, 8, 10, or 14 hours.
- One month after decompression, sheep were injected with ^{99m}Tc -methylene diphosphonate (MDP) for bone scans of radii and tibiae to identify “hot spots” signifying long-bone 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.

Dive profile

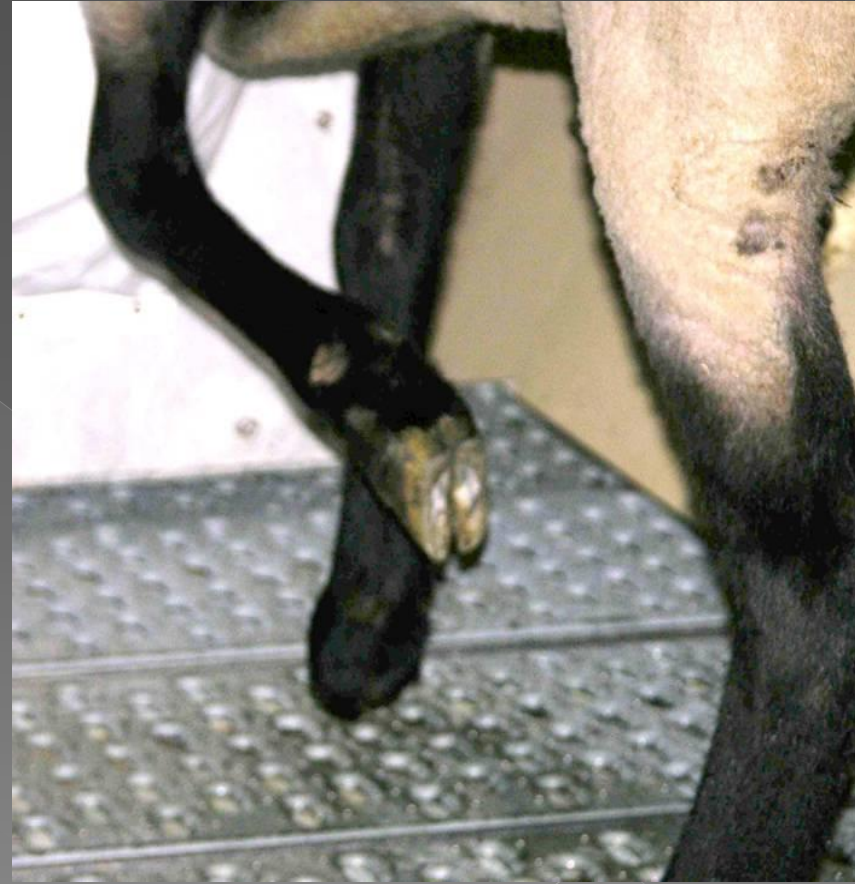
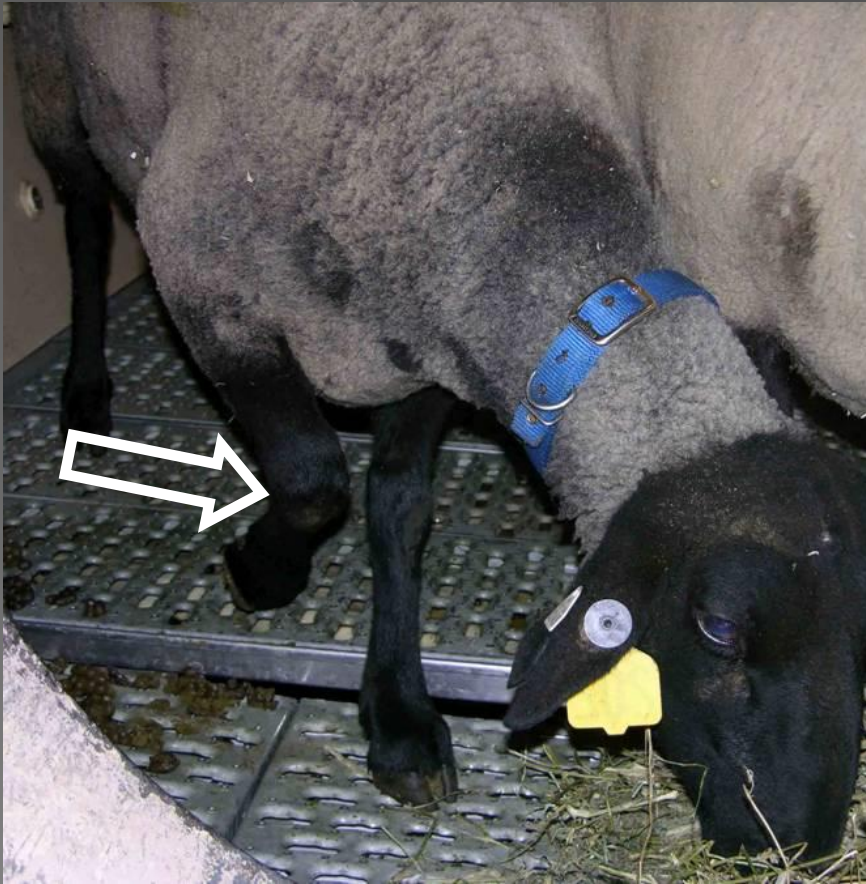
Hyperbaric Exposures Induced Dysbaric Osteonecrosis in Sheep Long Bones



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



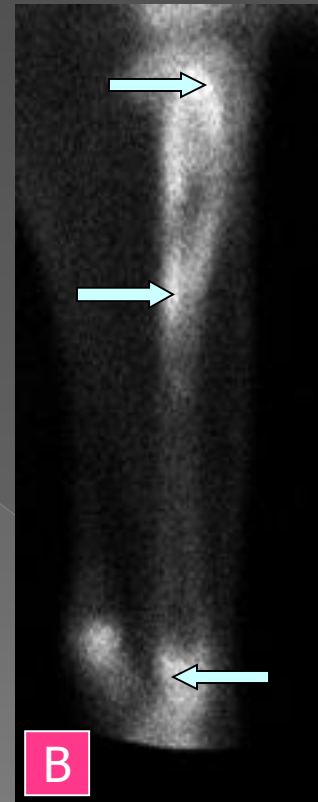
Bone scan of sheep with Tc99m MDP used to detect new bone formation of DON lesions undergoing repair



Results

- Of 27 sheep that underwent recompression in the 4 groups, 12 sheep sustained DON lesions with active remodeling.
- Logistic regression showed that DON occurrence was significantly associated with hours of delayed recompression (Wald $p = 0.015$), with the odds of developing DON about twice as large for each additional hour of recompression delay (odds ratio = 1.99; 95% CI [1.15, 3.45]).
- Based on the logistic model, predicted incidence of DON rose from 4% at 4 hours to 98% at 14 hours, with DON incidence predicted to be 50% at 8.47 hours of delay (95% CI [5.30, 10.52]).

Bone scan. Numerous lesions appeared in medullary sites of long bone diaphyses and metaphyses and some extended into the subchondral bone region

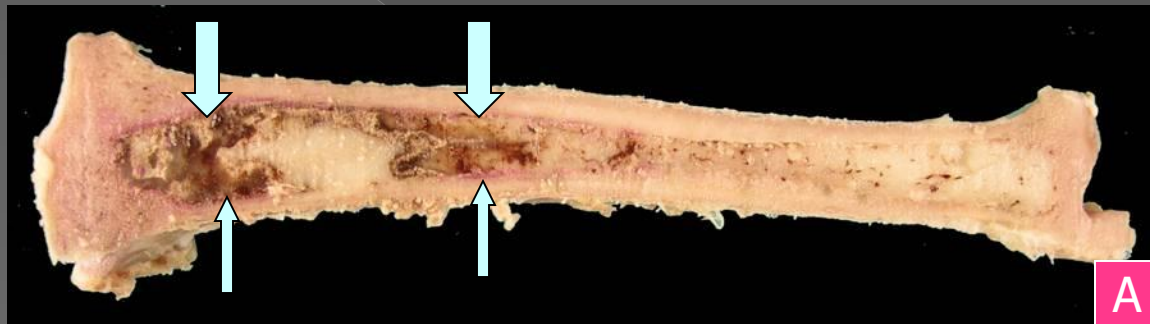


(A) Normal right tibia of Sheep #170 before hyperbaric exposure.

(B) Right tibia of Sheep #170 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

Necrotic marrow fat in the proximal diaphysis was opaque, brown, and dry (wide arrows).



Surrounding the necrotic fat is a band of hyperemic connective tissue and endosteal bony proliferation can be seen in the diaphysis (thinner arrows).



(A) Longitudinally-sectioned affected right tibia from Sheep #170. Clinical signs presented in this limb during 4 hour observation period.

(B) Longitudinally-sectioned left tibia from Sheep #170. The bone appeared normal, and there are no clinical signs of DON.

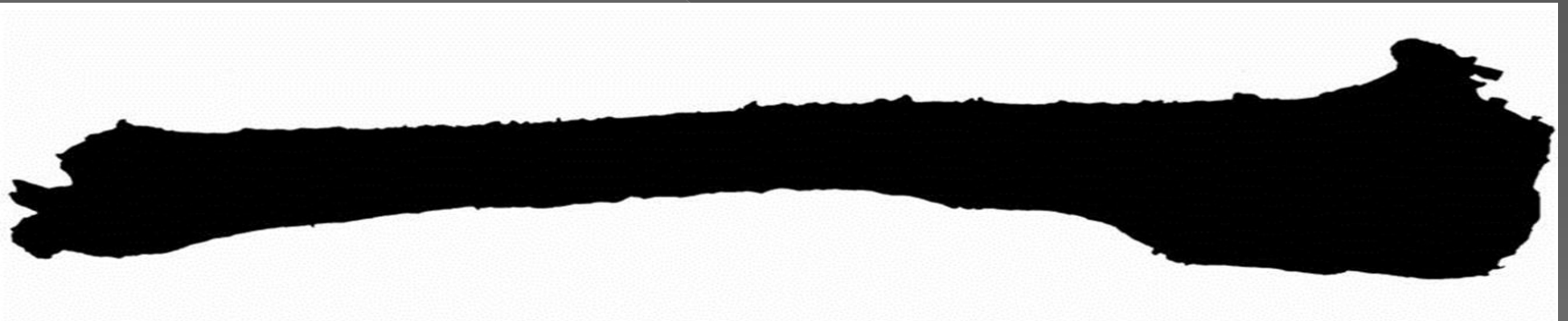
Bone sites using to calculate alizarin deposition



UW sheep model of dysbaric osteonecrosis pathology: extensive bone marrow necrosis and bone remodeling occurred in the right tibia



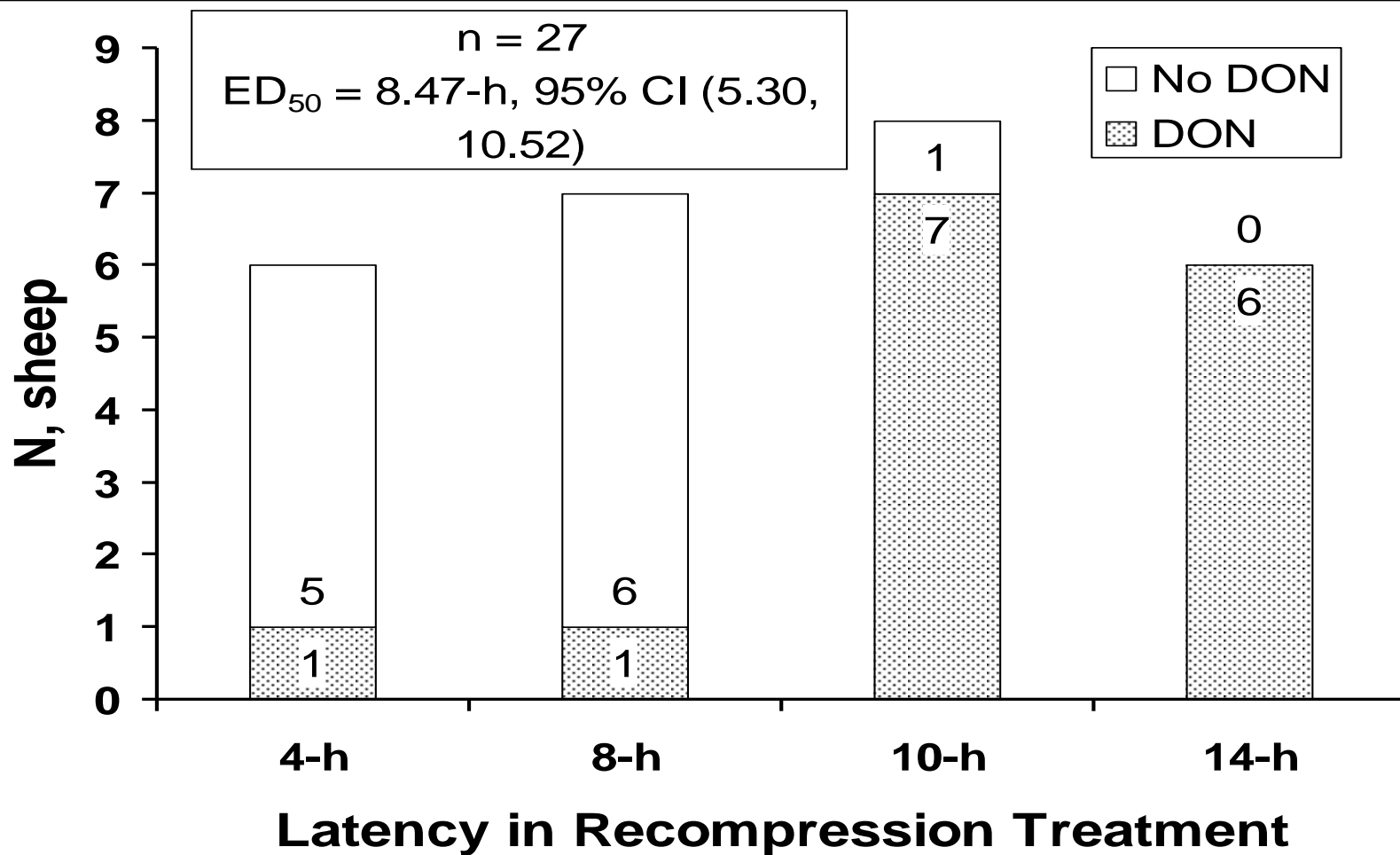
Whole area of bone using Scion Image software



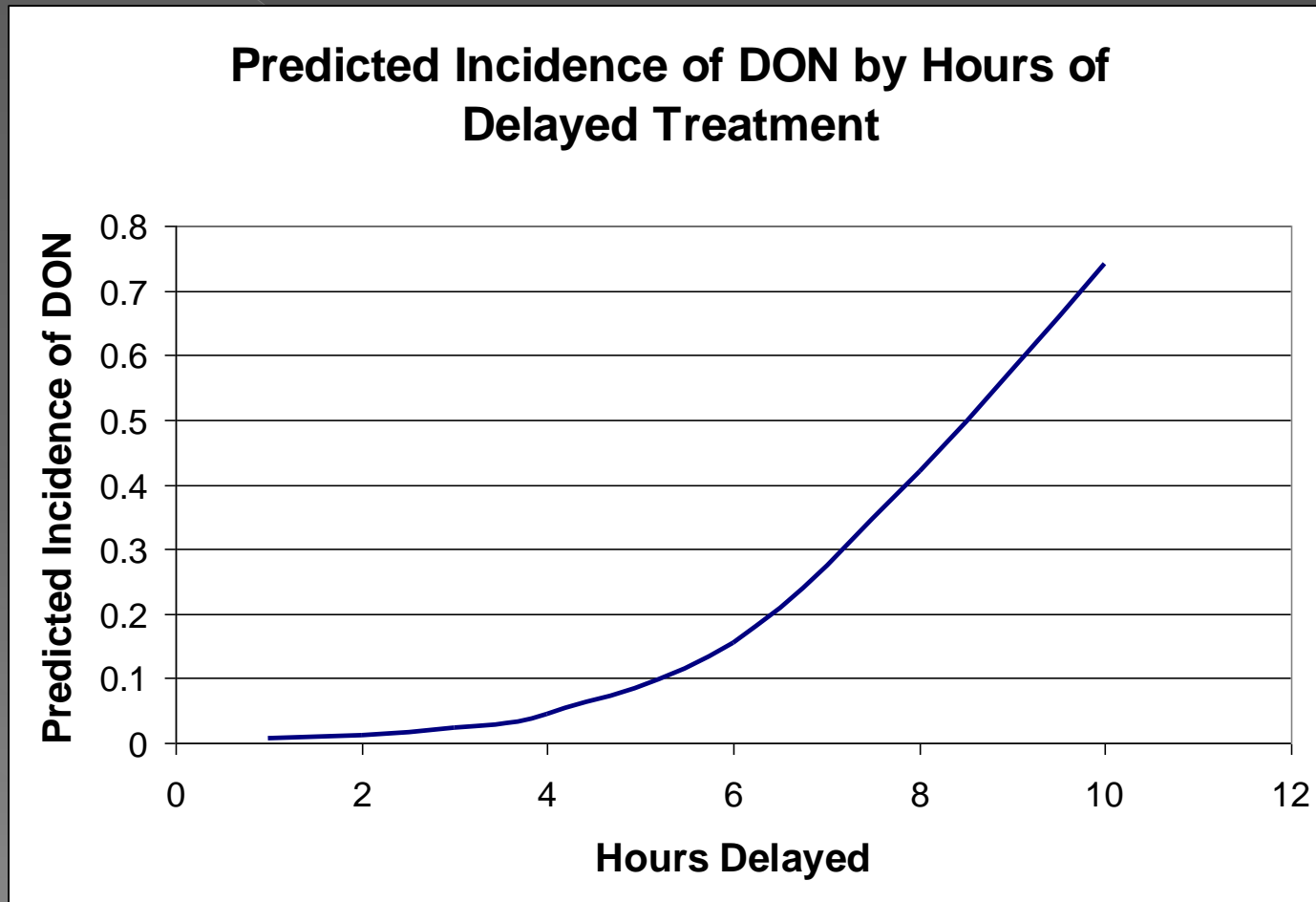
The affected area of bone with alizarin complexone deposition



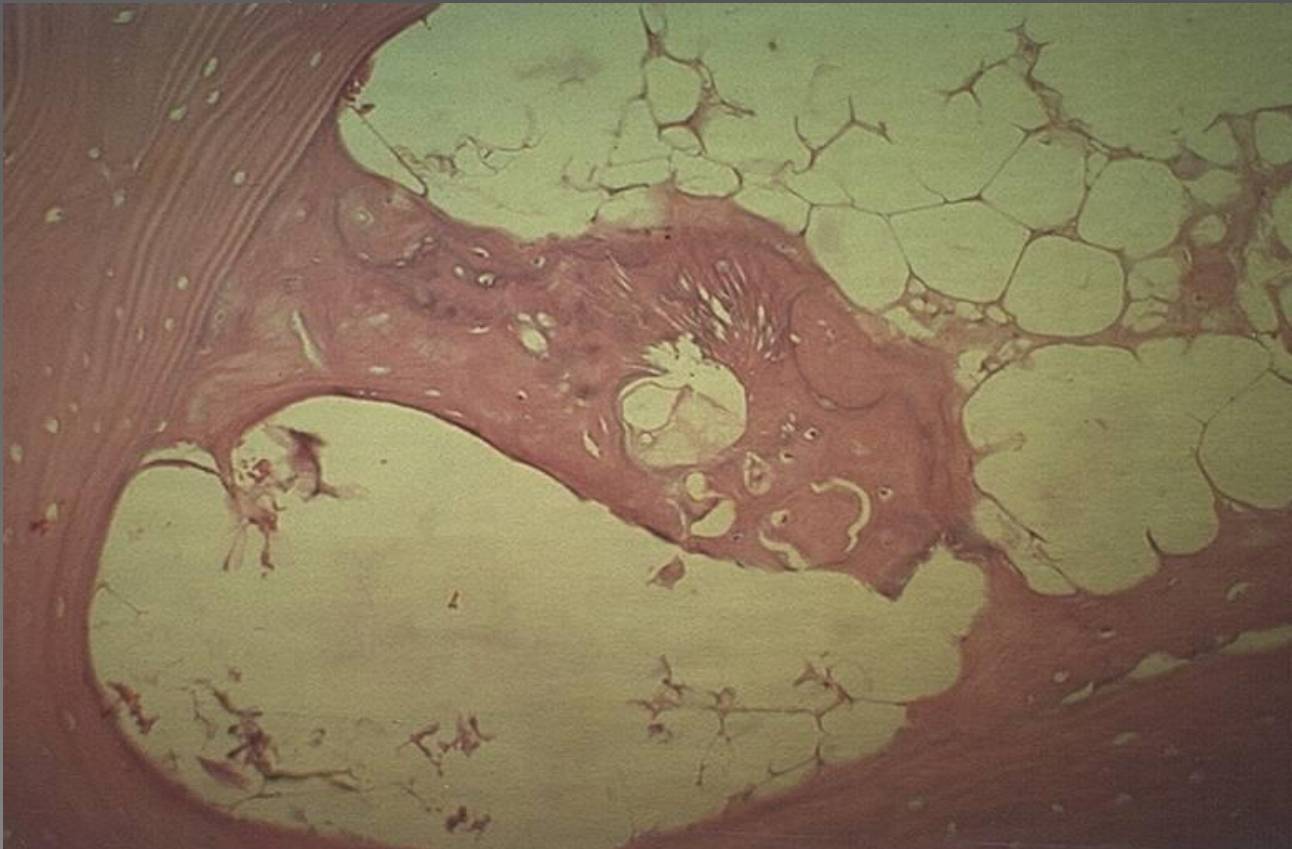
Incidence of DON by latency in recompression treatment



Predicted incidence of DON by latency of recompression treatment



New bone formation



Sheep DON with fatty marrow necrosis and bone repair

Conclusions

- Prompt therapeutic recompression after the hyperbaric exposure effectively prevented the development of DON.
- Delaying recompression treatment of limb bends can markedly elevate the incidence of DON and potentially disabling osteoarthritis in the affected diver.

Acknowledgments

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Thank you for attention!



Apostle Islands National lakeshore
Ice caves, Feb 28, 2015



Frozen air bubbles