HYPERBARIC OXYGEN AND FRACTURE HEALING

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Abstract

Recent medical evidence offers beneficial effects for living systems involving hyperbaric oxygen. New findings imply that past environmental conditions may have better supported life here on Earth. Reviewed here is an investigation in early fracture healing with hyperbaric oxygen exposure. Also, Biblical implications are discussed.

History

Our planet Earth is the most remarkable bubble of life in all the vast and harsh dimensions of the known universe. The specific conditions endowed here are absolutely essential for life support. As J. E. Lovelock (1979, p. 10) astutely observed,

> The climate and chemical properties of the Earth now and throughout its history seem always to have been optimal for life. For this to have happened by chance is as unlikely as to survive a drive blindfolded through rush hour traffic.

Dr. Lovelock, in the book entitled *Gaia*, describes the cybernetic system here on Earth which seeks the continuity of life. He defines Gaia (p. 11) as ". . . a complex entity involving the Earth's biosphere, atmosphere, oceans, and soil . . . which seeks an optimal physical and chemical environment for life on this planet." He theorizes that life must have arisen in an anaerobic atmosphere where there was neither free oxygen nor ozone in the air. The mystery of the appearance of oxygen ". . . held an almost fatal catastrophe for early life" (Lovelock, p. 31). With oxygen,

> . . . the Earth's atmosphere was so curious and an incompatible mixture that it could not possibly have risen or persisted by chance. Almost everything about it seemed to violate the rules of equilibrium chemistry (Lovelock, p. 67).

He states that there is an upper limit for available atmospheric oxygen that would be compatible with continuing existence of life and that with a 15% increase over present conditions, grass in a rain forest would burn (Lovelock, p. 71).

Theories concerning possible original Earth atmospheres in general exclude oxygen. Dr. Urey suggested to Dr. Miller for his classic experiment in 1953 (for which he won a Nobel Prize) to use methane, hydrogen, ammonia and water vapor. The reason for this mixture is, as Klotz (1972, pp. 481-482) states,

> . . . the absence of oxygen prior to this time prevented the oxidation of the relatively simple compounds which could exist in a reducing atmosphere but would have been destroyed in the present oxidizing atmosphere.

Now evidence from the past concerning the presence of oxygen on Earth in a greater quantity than present conditions is coming forward. The problem with oxygen regulation has always been critical as Lovelock (p. 20) acknowledges: "If Gaia does exist, the need for regulation was as urgent at the start of life as at any time since." George F. Howe (1977, p. 176) has noted,

> . . . the sedimentary distribution of carbon, sulfur, uranium and ferrous iron depend greatly upon ambient pressure and should reflect any major change in the proportion of oxygen in the atmosphere or hydrosphere. The similar distributions of these elements in sedimentary rocks of all ages are here interpreted to indicate the existence of a Pre-Cambrian atmosphere containing much oxygen. . . . We find no evidence . . . that an oxygen-free atmosphere has existed at any time during the span of geological history recorded in the well preserved sedimentary rocks.

Also quoted in this article studying the chemical evidence for the presence of oxygen in fossil rocks: ". . . no other conclusion but that oxygen has always been an important constituent of the atmosphere seems possible."

As Cox (1976, p. 121) has noted, the question of oxygen's presence in the atmosphere and the age of the Earth-are related:

> What seemed puzzling, is that, while the oxygen associated with the photosynthetic cycle should be in balance, oxidation of minerals and rocks, etc., would be expected to make the proportion of oxygen in the atmosphere decrease, but there is no evidence that it has decreased.

His note continued,

> . . . it is only in conjunction with a belief in a very old Earth that this matter of the removal of oxygen by oxidation causes any trouble. If it is admitted that the Earth is young, the oxidation need cause no concern.

Recent investigations into air trapped in amber fossil finds have given some unexpected results. This "fossil" air has been reported by geochemist Robert Berner of Yale and Gary Landis of the U.S. Geological Survey to contain tiny bubbles of entrapped atmosphere from the Late Cretaceous, 80 million years old (Bemer, 1988). Their mass spectrometry analysis yields oxygen levels over 30% compared to the 21% found today. The oldest samples studied had the highest oxygen values. However, a debate arose after this announcement. Hopfenburg (1988, pp. 717-718) and Beck (1988, pp. 718-719) disclaimed the idea that amber could be a sealant for ancient air. Perhaps this will be resolved with additional studies as Berner and

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Landis state, "Amber existed three hundred million years ago. We have opened a new field of study" (Anon., 1988, p. 12).

Experience with neonates limits the upper tolerability of humans to higher levels of oxygen. For example, oxygenation above 0.4 atm (100% increase) would lead to retinal hyperplasia and blindness (Smith, 1980, p. 108).

Creation theories about a possible vapor canopy allude to prior elevations in atmospheric pressure. Joseph C. Dillow (1978) wrote about the canopy and ancient longevity. He also talked about the relationship of higher oxygen levels and giantism displayed in the fossil record. Dillow calculated a possible atmospheric pressure of 2.18 standard atmospheres with a vapor canopy.

> If the oxygen tension in the alveolar sacs was doubled due to increased atmospheric pressure, this would increase the oxygen diffusion force and hence enable the animal effectively to deliver more oxygen to its body cells (Dillow, 1978, p. 27).

Hyperbaric Oxygen

Implications toward accelerated wound healing and the effects of the aging process using hyperbaric oxygen have been noted in prior creation literature (Dillow, 1978, pp. 31-32). Hyperbaric oxygen (HBO) exposure at 100% absolute oxygen and two atmospheres of pressure for short periods of time have proven definite therapeutic effects. Increased oxygen tension in the presence of fractures has been shown to stimulate the early appearance of osteoblasts (Niinikoski, 1972, p. 746), accelerate rates of calcium deposition and callus (Coulson, 1966, p. 449), and to augment the tensile strength in healing bone (Yablon, 1968, p. 186). A controlled investigation of rat femur fractures, without internal fixation, concluded that HBO therapy accelerated all phases of bone healing, i.e., subperiosteal new bone formation, cartilage deposition, cartilage to bone transformation, and advanced the overall healing rate by 25% (Heppenstall, 1975, p. 357). Hyperbaric oxygen appears to enhance the development of the fibroblastic collagen framework. This precedes the trailing invasion of vascular branches and the subsequent development of osseous callus deposits.

Acceleration through the stages of bone healing has been shown with hyperbaric treatment in oral and maxillofacial surgery. Studies have also shown enhancement in bone regeneration and have reduced by one-third the time needed for internal fixation (Kerley, 1981, p. 9). HBO is effective in the healing of refractory osteomyelitis probably by improving oxygenation in poorly vascularized bone (Davis, 1986, p. 1210). HBO therapy has proven helpful in many other medical settings (Myers, 1984, p. 83).

The Study

A pilot investigation was performed, analyzing fracture repair in rabbit femurs which had received intramedullary rodding. Surgical exposure, osteotomy, reaming and placement of an intramedullary rod would lend the fracture site avascular of its periosteal and endosteal blood supplies. Thus, it would appear that in this avascular setting bone repair effects of hyperbaric oxygen may prove demonstrable.

Twenty-one same age adolescent male white New Zealand rabbits entered the study. All rabbits received the same treatment and care including general anesthesia, a lateral incision to the midshaft femur, transverse osteotomy using oscillating saw and intramedullary fixation using a Steinmann pin. The animals were weighed and received hemoglobin checks to assure quality of health. All animals were treated the same except for random selection of rabbits to receive hyperbaric oxygen treatment. Twice daily dives in 100% oxygen at two atmospheres were arranged for one hour. Sacrifice analysis was done at 1, 2 and 3 weeks on the fractured femurs. Data for comparison between treated and nontreated groups was obtained through microscopic, radiographic and biomechanical tests.

Results

Microscopic

Animals and specimens handled at one week post fracture were eliminated from the study secondary to technical difficulties and fracture instability. It was noticed that qualitatively less callus was produced in HBO treated fractures. See Table I and Figure 1 for percentage quantization of longitudinal sections through the callus for old bone, new bone (osteoid), cartilage and marrow.

Table I. Longitudinal sections for comparison through fracture sites. Control and HBO-treated specimens were analyzed to show cartilage versus callus differences at two and three weeks.

RABBITS-HYPERBARIC OXYGEN STUDY
(Data reflects the percentage of old bone, callus, and cartilage to the total section area: add marrow to get 100%)

ANIMAL	OLD BONE	CALLUS	CARTILAGE	TOTAL
TWO WEEKS POST FRACTURE				
4008*	16.19%	33.42%	28.71%	78.32
3999*	16.15	27.51	14.88	56.65
4010**	17.03	12.93	24.45	54.40
4005**	14.89	12.27	27.84	55.00
4011**	19.05	15.54	22.56	57.15
THREE WEEKS POST FRACTURE				
4003*	13.89	50.13	17.86	81.88
4000*	11.91	44.29	37.83	94.03
3996**	15.69	55.69	25.43	96.81
4014**	14.25	35.24	20.70	70.19
4002**	26.06	38.35	24.50	86.92

* Controls
**Hyperbaric oxygen test group

For callus formation "osteoid" at two weeks, there was 125% more in the control group. At three weeks, the values were still greater in controls but only 9.5% greater. Cartilage formation percentages differed, being 14% greater in the HBO group at two weeks, but at three weeks there was 15.4% less in the HBO group versus controls. The callus in the treated femurs appeared to be more 'mature.' The woven cartilaginous framework of the osteoid was more compact, and the osteocytic lacunae were smaller around the osteoblast.

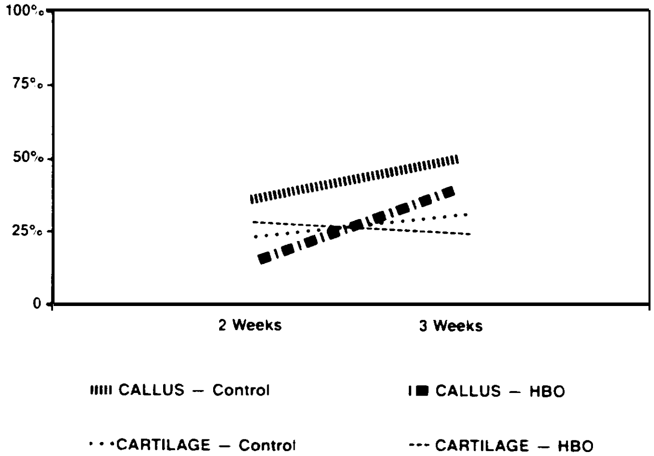

Figure 1. Graphic display of differences in cartilage and callus formation at two and three weeks.

There was less uncalcified osteoid, the width of the spicules were narrow and the orientation of the spicules less random. See Figures 3 and 4 for comparison of microscopic appearance of fracture healing at three weeks.

Radiographic

Little difference was detectable at two weeks between HBO and controlled groups; however, at three weeks, the HBO treated callus appeared qualitatively denser and to a greater extent demonstrated bridging callus across the fracture site. See Figures 5 and 6 for comparison between fracture healing at three weeks. See Table II for radiographic rating at three weeks fracture healing.

Biomechanical

See Figure 2 for graphic comparison between flexoral stiffness of the test samples. Using a 4-point bending stress test, the flexoral stiffness of the fractured femurs was analyzed and compared to its intact contra-lateral femur. Taken as a group, the HBO treated animals displayed greater flexoral stiffness, being 34% greater in treated femurs, versus controls. It is noted that a slight alteration in the four-point bending stress test was necessary due to a proximally placed fracture in one of the HBO treated femurs.

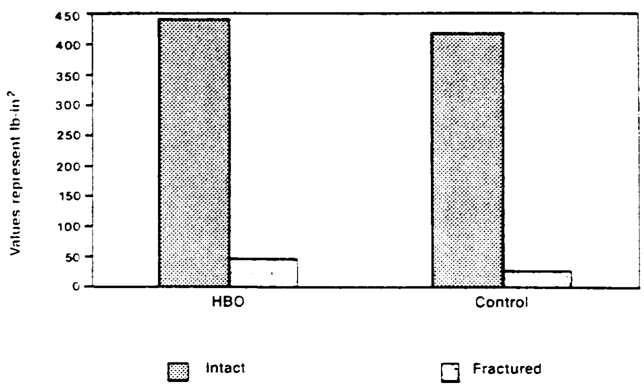

Figure 2. Graphic comparison for flexoral stiffness for control and HBO femurs. Both fractured and intact opposite femurs were tested at three weeks healing time.

Discussion

This pilot study attempted to delineate any major differences in fracture healing of rabbit femurs receiving intramedullary fixation in the presence of hyperbaric oxygen. It is believed that microscopic analysis allows an assumption of more advanced maturity in the fracture callus, a greater percent in early appearance of cartilage, and conversion of cartilage to osteoid. Radiographic analysis appears to demonstrate a greater density representing compaction of the calcified osteoid spicules. The biomechanical analysis appears to demonstrate advancement in fracture healing toward greater stiffness.

Admittedly, one weakness of this pilot study is the small number of samples. Of concern also is the lack of uniform appearance of the fractured femurs in that specimens showed variable degrees of comminution. In a subsequent analysis, careful steps will attempt to obtain a reproducible model that eliminates these variables and also uses sample numbers worthy of significant biostatistical analysis. However, the general assumption appears to be valid that hyperbaric oxygen may 'effect' the fracture callus toward accelerated stages of development.

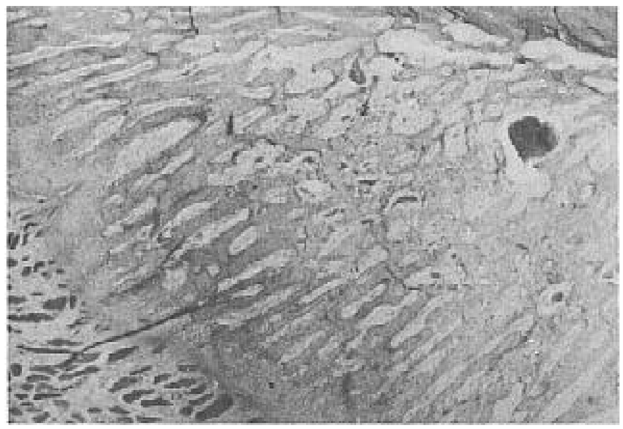

Figure 3. Control photomicrograph showing central cartilage and radiating spicules of osteoid fracture healing.

Conclusion

In a subsequent study, it is intended to produce solid evidence that HBO provides beneficial accelerated healing potential to fractures. It is hoped that this will prove to be of benefit in the human setting. It is possible that hyperbaric oxygen treatment could more quickly return people to their pre-morbid (pre-fracture) status. Such a benefit could considerably decrease hospital stay and cost, loss of time from work, the number of follow-up physician visits, the need for immobilization, casts, internal and external fixation, etc., and enhance early return to work or sports.

The possible pre-Flood condition of increased oxygen levels and atmospheric pressure have been discussed. Certainly, upper limits in each condition to sustain life are known (Smith, 1980, p. 12). Modern understanding regarding possible pre-Flood conditions is certainly inadequate. Lovelock (p. 107) has an explanation:

> Biblical teaching that the fall was from a state of blissful innocence into the sorrowful world of the

Figure 4. HBO photomicrograph showing central cartilage and radiating spicules of osteoid at the fracture site.

flesh and the devil through the sin of disobedience is hard to accept in our contemporary culture.

Yet, perhaps such possible beneficial effects as HBO demonstrate that a proper exposure to these "Eden-like" conditions may allow more effective cellular physiology. It is curious from an evolutionary scenario, starting with the reducing atmosphere and building the atmospheric oxygen level to the present 21%, why leukocytes, (which supposedly have never seen any oxygen conditions above 21%) are better phagocytic killers of bacteria at elevated oxygen tensions (Mader, 1981, p. 45). Similarly, for osteoblasts exposed to elevated oxygen levels as Shaw (1967, p. 74) notes, ". . . the most extensive and and uniform osteogenesis was observed in the explants grown in the gas mixture containing 35% oxygen." Could it be that the cellular machinery "remembers" or was designed originally for elevated oxygen levels?

Additional studies will hopefully clarify some of these issues. Imagine optimal conditions for terrestrial life including the beneficial effects of a combined stronger magnetic field, a vapor canopy, elevated oxygen levels, and elevated atmospheric pressures. Knowing more about the past world conditions can only help us become better stewards of our present earth. Curiously, Lovelock concludes in his book *Gaia* (p. 145), with this statement,

Figure 5. HBO x-ray of healing fracture at three weeks. Notice the fluffy bridging ossification.

Table II. Radiographic rating for healing callus. Scale: No callus, 0; small amount, 1; moderate amount, 2; profuse, 3; bridging, 4; osseous bridging, 5.

Results

Radiographic

three weeks	callus	ossification
4000	2+	1+
4003	2+	2+
4000*	4+	3+ bridging
4014*	2+	2+
3996*	4+	3+

*HBO

There is, for example, a fresh awareness of the concept of Christian stewardship whereby man, while still allowed dominion over the fish and the fowl and every living thing, is accountable to the gods for good management of the Earth.

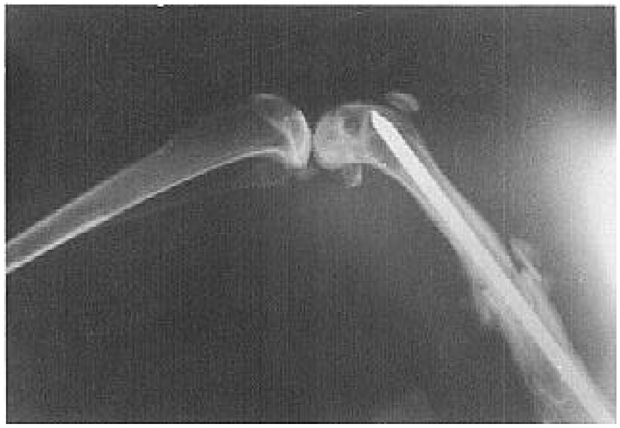

Figure 6. Control x-ray at three weeks healing. Notice the lesser abundance of ossified bridging callus.

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FUNCTIONAL PROTEINS: CHAOS OR LOGOS**

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Abstract

The purpose of this paper is to explore whether undirected, randomized energy through physicochemical laws (Chaos) could make functional proteins necessary for cellular life. Both downhill and uphill work are explained. These two types of work are further explained as thermal entropy work and configurational entropy work. The four requirements for making a single functional protein of living systems areas follows: use of only left-handed amino acids, use of only peptide bonds, linking of amino acids in correct order and prevention of other organic molecules joining the chain. Random methods (Chaos) violate all these requirements. Therefore, the correct three-dimensional structure of functional proteins cannot be developed by undirected physiochemical laws which do not perform configurational entropy work. It is clear that there needs to be an outside intelligent agent (Logos) to fulfill these requirements. An unbiased observer would have great difficulty denying the rationality of inferring from the complexity of functional proteins and a living cell the activity of a "Logos" which is the prime component of the creation model.

Introduction

Evolutionism and creationism disagree on how life began. Evolutionism claims all non-living and living matter can be explained only by natural causes, i.e., the laws of chemistry and physics. It claims these physiochemical laws explain not only how all things work, but how they came into being in the very first prebiotic soup of chemicals. These physiochemical laws operate solely by random methods (Chaos).

Creationism claims that although physiochemical laws are valid to explain how chemicals function today, they cannot explain how non-living complex chemicals and living cells and organisms originated in the first place. In order for matter and energy to organize itself into self-directing functional units, they must have a designed program with an uphill energy conversion system (configurational entropy work). This designed program with its uphill energy conversion system must be imposed on matter from an outside creative force (Logos). For example, the blueprint of an automobile is not contained within the steel, aluminum, chrome and vinyl materials. There is no spontaneous urge for these materials to develop into engines, frames, bodies and interior by random methods (Chaos). The design and programmed operation of these components were ordered by automotive engineers and skilled craftsmen (Logos). Likewise in the first living cell, the basic unit of living structure, i.e., a functional protein, must be developed. If functional proteins can be developed solely by physiochemical forces acting randomly (Chaos), then evolutionism would be a true explanation of life. But if a simple flow of energy through a system of matter cannot organize chemicals into a functional protein, then evolutionism could not explain the origin of life. If it can be shown that to organize amino acids into a functional protein a selecting, sorting and sequencing program with an uphill energy system is required, then the creation model which includes a creative force (Logos) would be the logical explanation for the origin of life. It is the purpose of this paper to explore whether undirected, randomized energy through physiochemical laws (Chaos) can make even one functional protein. It will discuss the two types of thermodynamic work and how physicochemical forces (Chaos) fail to perform configurational entropy work. It will show how the Logos of the creation model must be required to originate and make functional proteins.

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Discussion

Easterbrook (1988, p. 32) stated: "Nobody has any idea what makes chemicals start living. The origin of life is perhaps the leading unknown of contemporary science." Wickramasinghe (1988, p. 611) bluntly observed:

> One is inevitably faced here with a situation where there are few empirical facts of direct relevance and perhaps no facts relating to the actual transition from organic material to material that can even remotely be described as living.

These quotes demonstrate the immense problems associated with explaining how chemicals organize themselves into living entities. The question this paper will try to answer is how, when no life existed, did functional proteins, the building blocks of DNA and organelles, come into existence which today are absolutely essential to living systems yet which can only be formed by those systems?