

## **Hyperbaric Oxygen in Exceptional Acute Blood-Loss Anemia**

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Hart GB, Lennon PA, Strauss MB. Hyperbaric oxygen in exceptional acute blood-loss anemia. *J Hyperbaric Med* 1987; 2(4):205-210.—Intermittent exposures to hyperbaric oxygen (HBO) were used in treating 26 patients (20 females, 6 males; average age 42.5 yr  $\pm$  21) with exceptional blood-loss anemia; 18 (69%) survived. Six of the patients who died arrived for treatment in a decerebrate or decorticate neurologic state. The admitting hematocrits (Hct) and hemoglobins (Hb) were higher in the survivors (Hct 13.6%, Hb 4.7 g/dl) than in those who died (Hct 10.5%, Hb 3.8 g/dl). HBO was discontinued in the survivors when they no longer suffered from hypoxic sprue, postural hypotension, and usually when the Hct was 22% or greater and the Hb was 7 g/dl or greater. We conclude that HBO may be useful in the treatment of acute blood-loss anemia when applied early.

*blood loss, anemia, shock, hyperbaria, oxygenation, life support*

### **Introduction**

Acute blood loss anemia occurring in patients who for medical or religious reasons cannot or will not accept blood transfusions is defined for the purpose of this report as *exceptional blood-loss anemia*. This problem seems to be somewhat worse in areas where there are large numbers of AIDS patients, because many people undergoing procedures that could result in a significant loss of blood are refusing transfusions.

Lambertsen et al. (1) observed that the vital organs require only 6 vol% oxygen at rest to support their respiratory needs. Boerema et al. (2) revealed that piglets, whose circulating blood was replaced with an acellular perfusate, could be supported with hyperbaric oxygen for short periods without apparent neurologic damage. Attar and colleagues (3) showed hyperbaric oxygen that (HBO) could be used in animals to improve survival from hemorrhagic shock. Sporadically, HBO has been reported as successful in a limited number of cases (4, 5).

Recently, the FDA's Blood Products Advisory Committee unanimously agreed that the perfluorocarbon oxygen transport fluid Fluosol-DA 20% was not ready for release (6). Other reports have noted adverse effects, such as retention of the drug and morphologic changes in certain organs (7-9); the latter of these authors (9) demonstrated long-term alterations in the reticuloendothelial system. A more recent study (10) of a select group of patients suggests that perfluorocarbons are unnecessary in moderate anemia and ineffective in

severe anemia. A satisfactory "artificial blood" has yet to be found, and as the amount of oxygen delivered to the tissues is the primary determinate of irreversible shock (11), HBO may support the vital functions for short periods of time.

This report deals with our experience over the past 17 yr (1970–1987). Our experience suggests that HBO is a valuable asset in the treatment of exceptional blood-loss anemia.

## Method

The patients were treated in the first 5 yr (1970–1975) at the Naval Hospital, Long Beach, CA, and thereafter (1975–1987) at Memorial Medical Center, Long Beach, CA. Three of the patients included herein were the basis of an earlier report (5).

The patients were studied in a prospective fashion inasmuch as those who were referred for HBO were given this treatment. No attempt was made to provide controls because we considered it unethical to deny these moribund patients the potential benefit of HBO.

Lost volume was replaced with artificial plasma expanders and balanced saline solutions. High molecular weight dextran was used early until the advent of Hetastarch, which is preferred at this time because it has fewer reactions and a longer half life. The fluids were given in sufficient amounts to maintain the serum osmolality and osmolarity, as well as maintaining the central venous pressure at 10 cm of water. Approximately 1500 ml of 5% dextrose in water is administered daily to replace the insensible water loss.

Generous doses of hemetemics (vitamin Bs, vitamin C, and iron compounds) were administered i.v. or orally or both. Hyperalimentation was commenced i.v. or orally and was timed where possible with the HBO treatments (particularly if by the oral route). Antibiotics were given to those who had some manifestation of a bacterial infection. Vasopressors were used when volume alone did not restore the blood pressure to above 80 mmHg systolic.

The lower extremities (where feasible) were wrapped with elastic bandages to the mid thigh, using moderate pressure. These were removed and reapplied at 4-h intervals.

Hyperbaric oxygen was administered in a repetitive fashion, according to any or all of the following indications:

- Shock—systolic blood pressure below 90 mmHg or pressures maintained with vasopressors.
- Disorientation to coma.
- Ischemic changes of the myocardium demonstrated on the ECG.
- Ischemic gut as demonstrated by sprue-like diarrhea.

The first treatment administered was most frequently a 90-min exposure at 2.0 atmospheres absolute (ATA) oxygen. The treatments described below were performed after the hypoxic state was present for at least an hour and were

usually of an hour duration. The time interval of 1 h of hypoxia was elected arbitrarily as a possible stimulus to the erythropoietic system. The patients in this series were treated in a monoplace chamber.

Laboratory studies of blood samples were held to a minimum and usually limited to finger stick or microsampling techniques. Radiographs were taken as indicated by the associated problems and most were with a portable technique.

Each patient was monitored by ECG, and blood pressures were followed with intravascular lines. Five of the patients with disorientation or hypoxic gut or both did not have intraarterial lines for monitoring.

## Results

Twenty-six patients (20 females and 6 males, average age  $42.5 \text{ yr} \pm 21$ ), were referred for HBO as an adjunct to other care for their exceptional blood-loss anemia. Twenty-two (85%) (17 females and 5 males) were Jehovah's Witnesses and refused blood transfusions due to religious convictions. Three (2 females and 1 male) had major blood typing incompatibilities making it impossible to type and cross-match blood for transfusions. One woman had refused a blood transfusion due to the religious beliefs of her husband, but on awakening in the chamber from her coma readily agreed to receiving whole blood.

The causes of the anemia were as follows: 7 suffered hemorrhaging from severe traumatic injury; 7 bled massively after childbirth, ruptured tubal pregnancy, or cesarean section; 3 had lost blood from the gastrointestinal tract (2 from peptic ulcers and 1 from the large bowel); 3 bled from infected arteriovenous shunts (for hemodialysis); 2 had significant blood loss at elective operation; 3 had anemia from hemolysis of a type not determined at the time of treatment; and 1 had anemia due to hemochromatosis.

Seventeen (65%) arrived in classical shock (systolic blood pressure less than 80 mmHg or pressures maintained with vasopressors); 21 demonstrated some mental confusion to deep coma; 9 had ischemic gut presenting as a sprue; and all patients showed some degree of myocardial ischemia and respiratory distress at the commencement of treatment.

There were 8 deaths, 7 female and 1 male, average age  $37 \text{ yr} \pm 21$ . Six died surrounding their first treatment, 3 of these had cardiac arrest at the referring hospital or en route to the hyperbaric chamber area; 6 were decerebrate on arrival; and 1 had no neurologic response. One of the decerebrate patients survived the blood-loss anemia and remained in a vegetative state until death occurred 2 mo. later from hepatorenal failure. One patient died unexpectedly at night of an anaphylactic reaction presumed to be from the iron dextran. The deaths are listed in Table 1.

The mean hematocrit (Hct) of all patients ( $n = 26$ ) at arrival was  $12.9 \pm 4.4\%$ . The survivors ( $n = 18$ ) originally had a Hct of  $13.65 \pm 4\%$ , and Hct for

**Table 1: Causes of Deaths Among the 8 Patients Who Died**

Patient	Age <sup>a</sup>	Sex	Cause of Blood Loss	HBO Rx	Cause of Death
LW	59	F	dyscrasia + hemolysis	1	hypoxic arrest
AG	24	F	C-section	20	hepatorenal
LH	20	F	trauma	7	anaphylaxis
DT	34	F	trauma	1	hypoxic arrest
DY	22	F	ruptured tubal	1	hypoxic arrest
KB	15	M	SS crises + DIC-hemol	1	hypoxic arrest
VD	74	F	trauma	2	hypoxic arrest
EB	48	F	postop lami	4	hypoxic arrest

<sup>a</sup>Average age 37 yr  $\pm$  21.

**Table 2: Hemoglobin and Hematocrits**

Group	Hematocrit, %	Hemoglobin, g	Reticulocyte, %
<i>n</i> = 28	12.9 $\pm$ 4	4.4 $\pm$ 1.6	2 $\pm$ 1.6
<i>n</i> = 18*	13.6 $\pm$ 4	4.7 $\pm$ 1.3	2.4 $\pm$ 1.7
<i>n</i> = 8**	10.5 $\pm$ 5	3.8 $\pm$ 2.2	1.8 $\pm$ 1.4
After HBO			
<i>n</i> = 18	22.9 $\pm$ 4.9	7.7 $\pm$ 1.6	8.4 $\pm$ 2.75

\* = Survivors.    \*\* = Deaths

the patients who died was 10.5  $\pm$  5% (Table 2). The heart rate before HBO was 124.45  $\pm$  18/min. (*Note:* One was excluded from this statistical averaging because she had required continual cardiac massage to arrive at the treatment area with electrical activity on the monitor. A trial of HBO was unsuccessful.) The heart rate after 30 min of HBO (*n* = 25) was 98  $\pm$  14/min. The average systolic blood pressure before HBO was 108  $\pm$  23 mmHg while the diastolic was 46  $\pm$  24 mmHg. The average systolic blood pressure of those arriving with intravascular lines (*n* = 18) was 122  $\pm$  16 mmHg, improving to 138  $\pm$  21 mmHg with HBO.

The survivors averaged 9.6  $\pm$  5 d of HBO treatments, and those who died averaged 2.6 d. There was an average of 5  $\pm$  3 treatments on the first day. The average HBO treatment lasted 66 min. The average chamber time the first day was 273  $\pm$  116 min. Two survivors had over 30 h of HBO in the first 72 h. HBO was discontinued on the survivors when there were no signs of ischemia, with an average Hct of 22.9  $\pm$  4.9%, a Hb of 7.7  $\pm$  1.6%, and a reticulocyte count of 8.4  $\pm$  2.7% (Figs. 1 and 2).

## Discussion

This study confirms our hypothesis that intermittent exposures of HBO are a valuable adjunct to the treatment of acute blood-loss anemias in those who

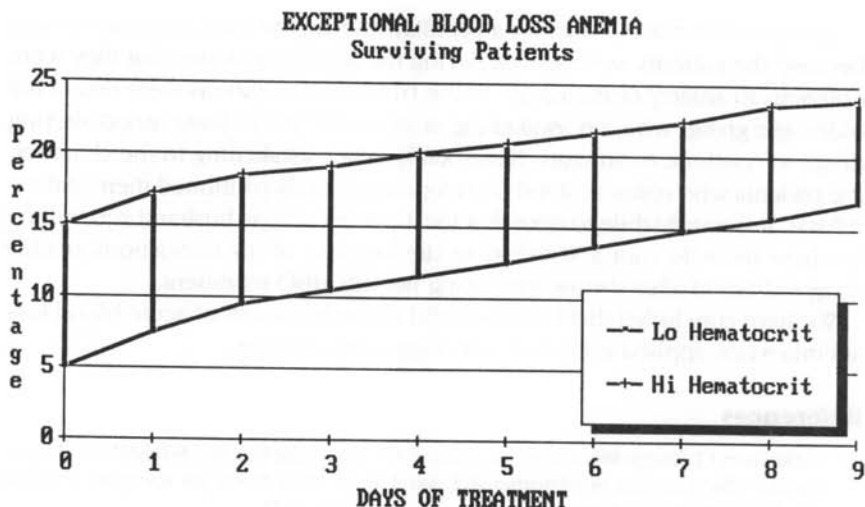


FIG. 1—Range values (highest and lowest) of reticulocyte count: 0 = baseline before HBO; 1 to 9 = days after beginning HBO.

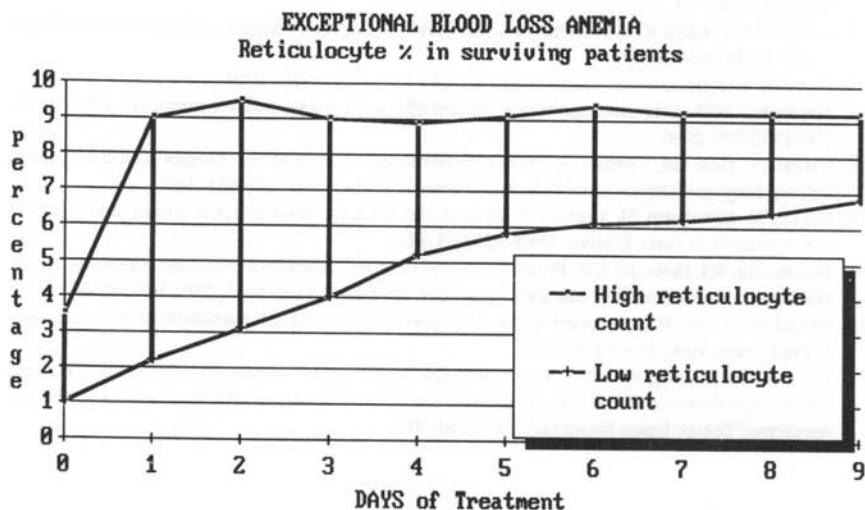


FIG. 2—Range values (highest and lowest) of hematocrits: 0 = baseline before HBO; 1 to 9 = days after beginning HBO.

cannot receive transfusions. No instance of pulmonary or central nervous system oxygen toxicity occurred in this group, most likely due to the low intravascular  $PO_2$ . The most frequent complication noted in this condition was barotrauma (50%), which probably is a reflection of the numbers of treatments per day plus many of the patients being unable to follow commands until they reached pressure.

Confinement anxiety was not a problem during the early treatment phase because the patients were so sick during the initial exposures that they were oblivious to anxiety or the nature of the HBO; the exceptions were two of the older age group who, on awakening at pressure had to have mood-altering drugs to continue treatments. Remarkably, when awakening in the chamber, the patients who refused blood on religious grounds continued their zealous refusal. It is worthwhile to note that the 1 patient whose husband was willing to allow his wife (not a Witness) to die because of his convictions readily accepted blood after she awoke during her 4th HBO treatment.

We have concluded that HBO is useful in the treatment of acute blood-loss anemia when applied early and with a vigorous regimen.

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