Clinical Application of Hyperbaric Oxygen

I. Boerema

W. H. Brummelkamp

N. G. Meijne

CLINICAL APPLICATION OF HYPERBARIC OXYGEN

PROCEEDINGS OF THE FIRST INTERNATIONAL CONGRESS
AMSTERDAM, SEPTEMBER 1963

EDITED BY

I. BOEREMA, W. H. BRUMMELKAMP AND N. G. MEIJNE

Department of Surgery, University of Amsterdam, Wilhelmina Gasthuis, Amsterdam

ELSEVIER PUBLISHING COMPANY

AMSTERDAM / LONDEN / NEW YORK

1964

ELSEVIER PUBLISHING COMPANY
335 JAN VAN GALENSTRAAT, P.O. BOX 211, AMSTERDAM

AMERICAN ELSEVIER PUBLISHING COMPANY, INC.
52 VANDERBILT AVENUE, NEW YORK, N.Y. 10017

ELSEVIER PUBLISHING COMPANY LIMITED
12B, RIPPLESIDE COMMERCIAL ESTATE
RIPPLE ROAD, BARKING, ESSEX

LIBRARY OF CATALOG CARD NUMBER 64-15300

WITH 147 ILLUSTRATIONS AND 65 TABLES

PREFACE

The use of hyperbaric oxygen drenching in surgery was introduced in our clinic as far back as 1956. The first results were reported during two meetings in Zürich and Stockholm (1956). Although the receipt of the results was very encouraging, no surgery clinic used the method following those communications.

The method attracted much interest after our publication in 1961 in *Surgery* where we reported the construction of a large hyperpressure chamber and described the results of the treatment of a series of patients suffering from anaerobic infections.

Publications in *Time* (June 1962) on the treatment of two cases of tetanus in a chamber, and in the same journal of February 1963 on open heart surgery aroused the interest of the scientific world.

In the proceedings of this first international congress on the clinical application of hyperbaric oxygen the real progress in this fascinating field is reflected. We trust that the publication of so many papers on clinical and experimental research will open new avenues for the use of hyperbaric oxygen drenching in the treatment of our patients.

I. BOEREMA

CONTENTS

2. CARDIOVASCULAR SURGERY UNDER HIGH ATMOSPHERIC PRESSURE

3. TANK BUILDING PROBLEMS AND SAFETY MEASURES

4. PHYSIOLOGICAL AND PHARMACOLOGICAL PROBLEMS

5. MISCELLANEOUS REPORTS

6. CLOSING REMARKS

7. GENERAL SUMMARY

OPENING

I. BOEREMA

Mr. Burgomaster of Amsterdam, Mr. Dean of this University, Mr. President of this Medical School, Mr. Manager of this University, Ladies and Gentlemen.

At this first international congress on hyperbaric oxygenation we will discuss an old problem, the influence of an increase in the relative and absolute pressures of the gases of the ambient atmosphere on diseases of living beings.

Incidentally, overpressure has been studied in animals and man for several centuries, especially in Holland and England, but more extensive studies could be made when in France it was found that a caisson was a valuable help in building pillars for bridges and in other underwater works. This dates back to Triger a little over a century ago; the work in the tank was mostly done by physiologists on normal animals or normal human beings, in the last few decades in the first place by Bean, Behnke, Lambertsen, Lanphier and others. However, already before Triger medical men, first of all Pravaz of Lyons, were investigating the influence of hyperbaric pressure on diseases and its value as an aid in surgery.

In the course of time different principles have been tested. First of all the direct influence of hyperbaric oxygen on the lungs themselves, in cases of asthma, bronchitis, tuberculosis.

Secondly the mechanical principle; Pravaz tested it in the reduction of a dislocated hip; Paul Bert, in 1879, advised to use it in the reduction of a strangulated hernia. In our days this mechanical principle was taken up experimentally by Troell and clinically by Wangensteen and his coworkers Cross and Lovelace. In their work however, a more physiological principle also comes up for the first time, for it was thought that hyperpression applied in cases of ileus, in addition to compressing the gases in the distended bowel, would increase the absorption of these gases in the bowel in a considerable degree. Wangensteen used a small caisson; it was difficult to place a patient inside accompanied by doctors. Maybe for this reason the experiments were not continued.

A third principle was a physical one. According to Henry's law the solubility of the gases in the blood is directly proportional to the pressure of the gases in the alveoli. By increasing the partial and absolute pressures of oxygen in the respired oxygen the whole body could be drenched with this gas. Gray introduced this experimentally, and was soon followed clinically by Churchill-Davidson in patients with cancer who were X-rayed while inhaling pure oxygen at three atmospheres.

The physical principle of what we have called hyperbaric oxygen drenching was

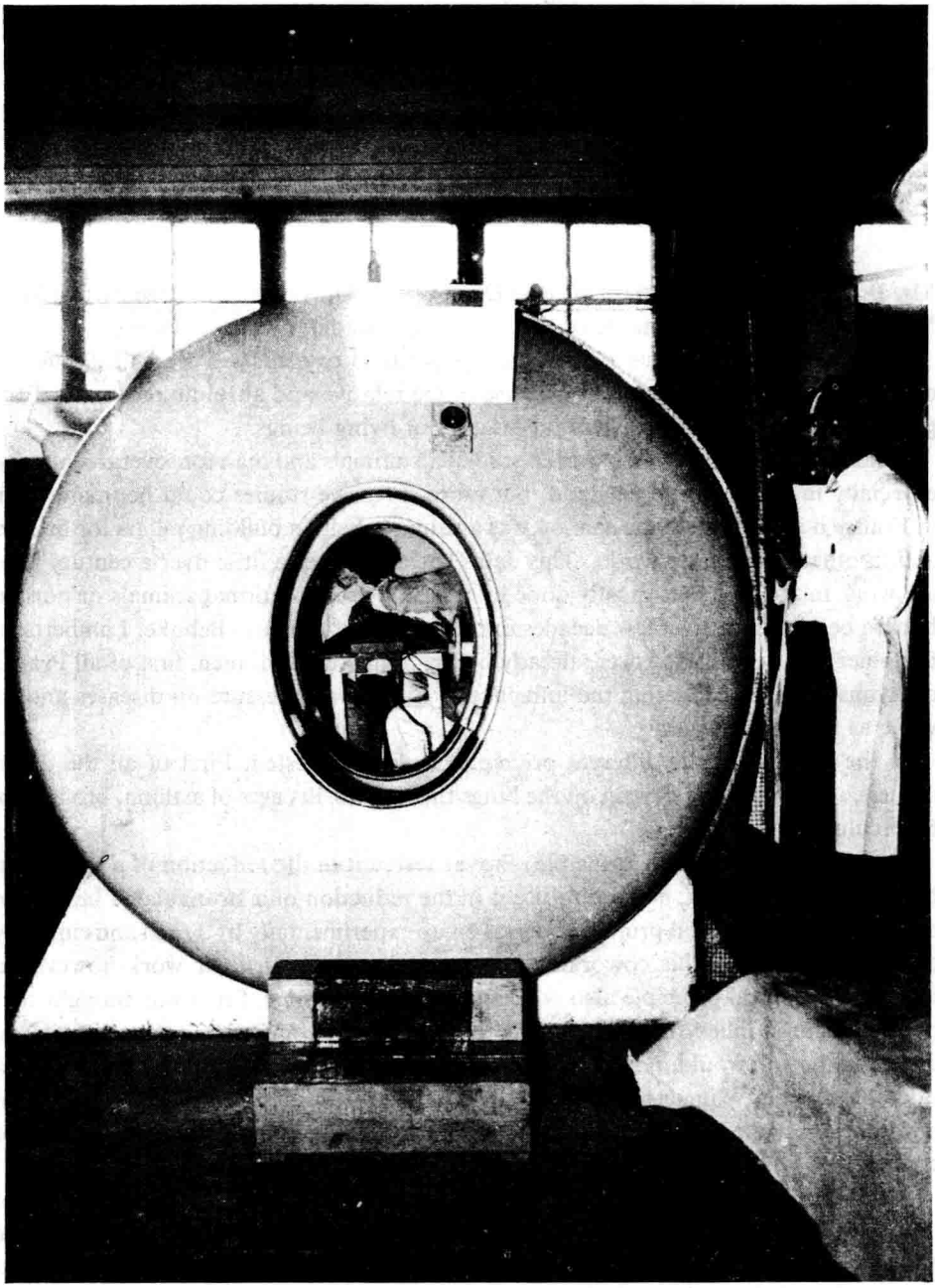

Fig. 1. Caisson of the Royal Dutch Navy.

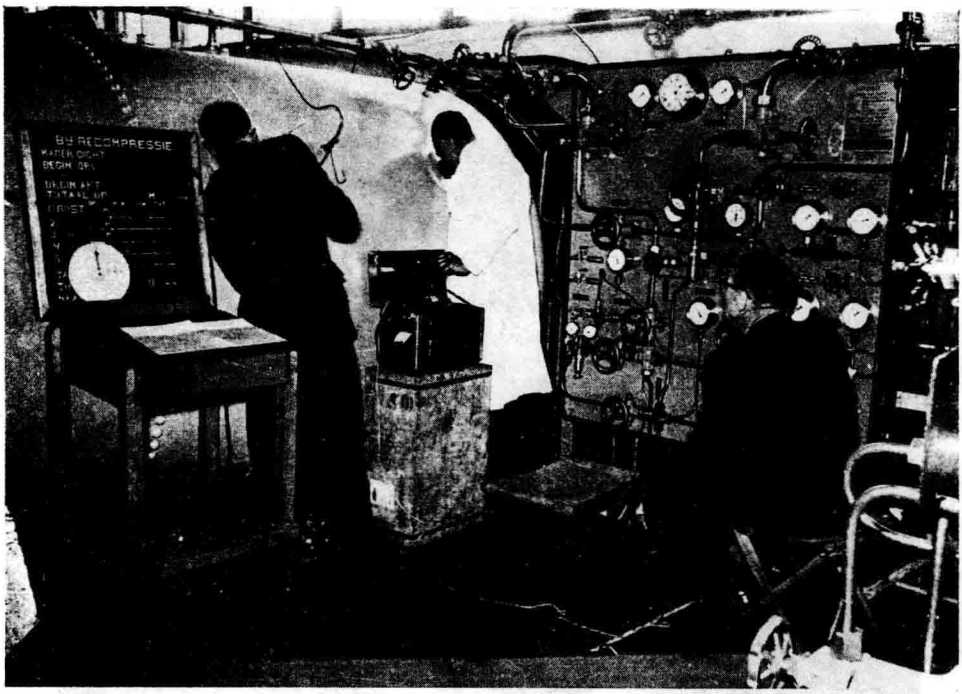

Fig. 2. Caisson of the Royal Dutch Navy. Control panel.

introduced by me and my coworkers in operative surgery in 1956, first of all as an aid to cardiac surgery. My communications at the European Congress of Cardiovascular Surgery in Zurich and at the European Congress of Cardiology in Stockholm in that year were characterized by two remarkable points.

The first point was that the communications were received with an unexpected, tremendous enthusiasm by the large audience, consisting of over one thousand medical men from all the countries of the European continent, England, Scotland, and the United States. Newspapers brought it in headlines; it was broadcasted in different languages.

The second remarkable thing was that in spite of this great enthusiasm, there was a great hesitation in following my work. Immediately some work was done in France, but no publications followed; in Minneapolis Hunter already in 1957 showed me a perfect design for a large tank for surgery; it was never built. The first publications of surgeons who had followed my idea came from Glasgow, two years later. Then it was quiet again; but suddenly it burst out, probably after the communication in "Surgery", when we emphasized that hyperbaric pressure was not only a new help in cardiac surgery, but was also very valuable as a therapeutic measure; indeed a miraculous help in anaerobic infections.

These two points, on the one hand the surprising enthusiasm and on the other hand the slowness with which our principle was followed in practice by others were the

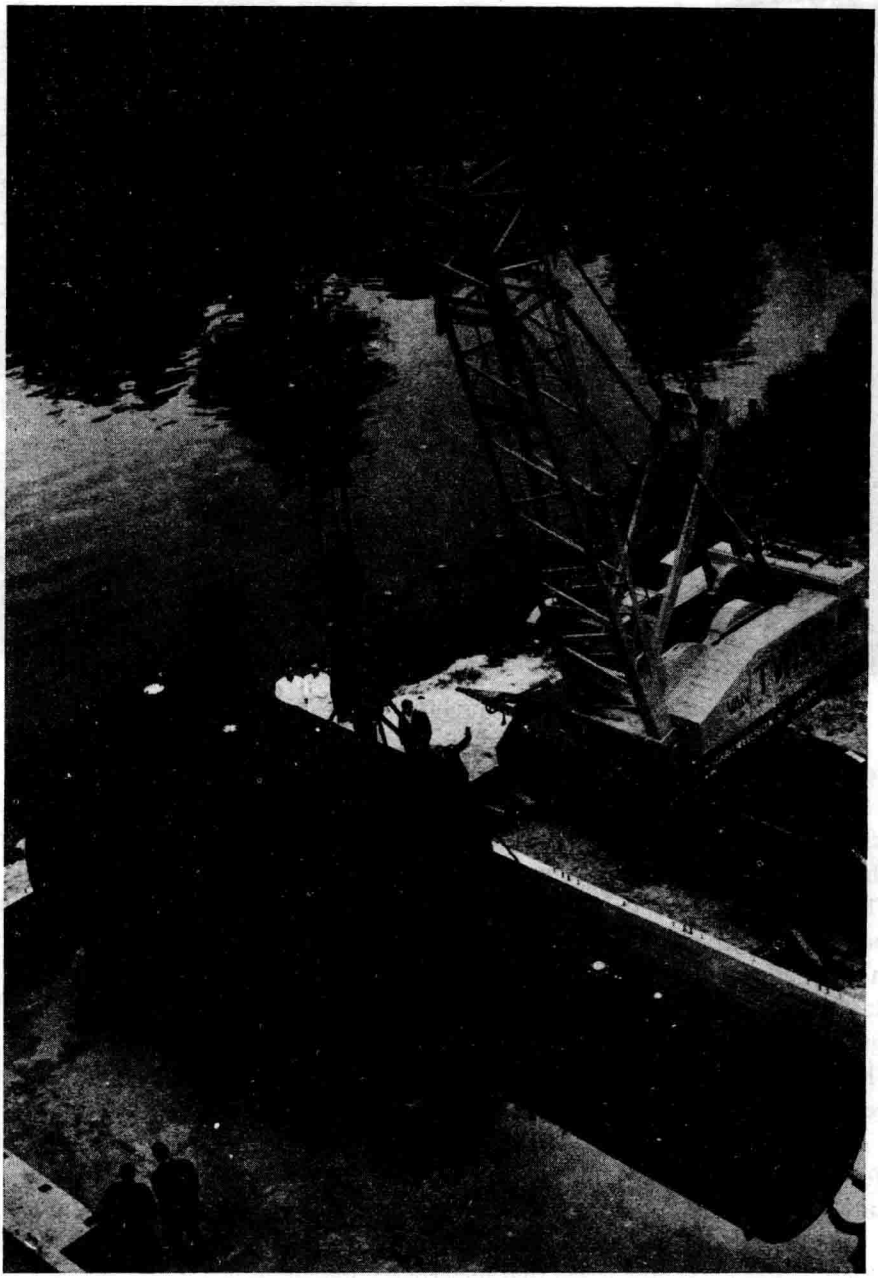

Fig. 3. Caisson of the Wilhelmina Gasthuis, Amsterdam.

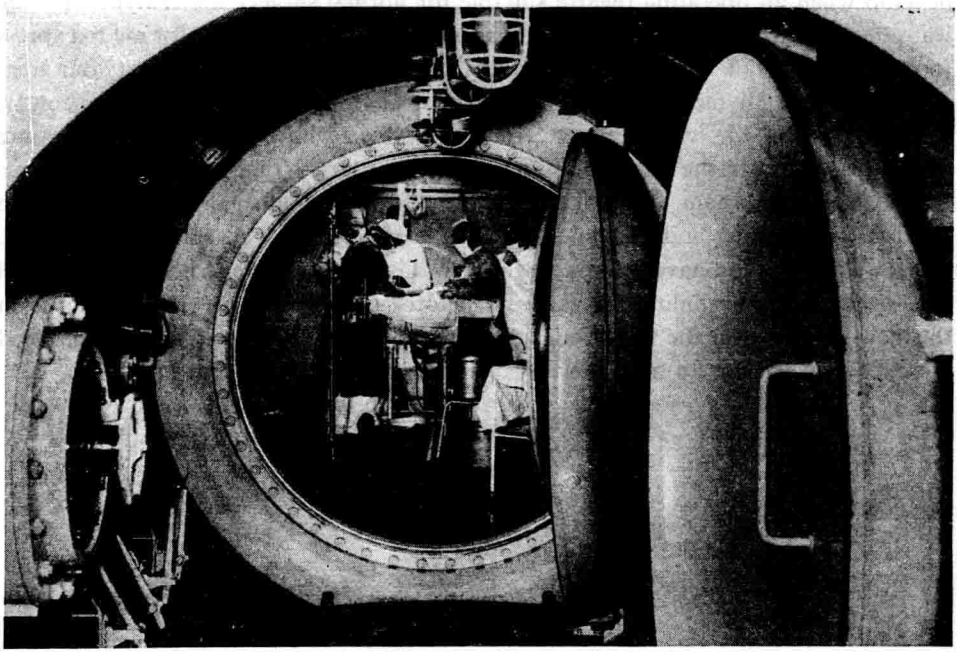

Fig. 4. Caisson of the Wilhelmina Gasthuis. View inside.

reason why we thought it wise to have an international congress of people of whom we know that they are really interested in this field.

As a start we thought it better to have a very small congress which would allow of a better, direct discussion and for that reason the participants in this meeting are here only on invitation. Practically all of those whom we invited, accepted; I am most grateful for this and feel very honoured. I and my coworkers, who shared with me the personal risks of the work at the beginning will do all our best to make your stay in Amsterdam both interesting and enjoyable.

So I think the points to be discussed at the present congress are the following: in the first place the great enthusiasm of medical men and laymen all over the world has shown that many people think of the hyperpressure chamber as a sort of wonder machine, capable of curing all bodily and even mental diseases. The limits of the field will now have to be marked exactly.

Secondly, the slow follow-up after my first communication shows that many people are hesitating, not only because of the novelty of the idea, but also on account of the dangers which this work is supposed to involve, namely the dangers of the bends, and the dangers of oxygen intoxications. These dangers really do exist. The discussions which will now take place will have to teach how to avoid them.

So a tremendous clinical work has started in this new field all over the world. It started in a small caisson of the Royal Dutch Navy (Figs. 1 and 2), but it could only really

develop when an operating theatre suitable for normal surgery under hyperpressure was constructed (Figs. 3 and 4). For this reason it is a great pleasure for me to express to you Mr. van Hall, Mayor of Amsterdam, and President of this University our great estimation; we all feel indebted to you because it was you who, spontaneously, with the help of Mr. van Leer rendered it possible to have the first hyperpressure operating theatre in the world built here in Amsterdam. You continued the famous tradition of Amsterdam, where for several centuries the high magistrates have given freedom of thought and freedom of scientific research to all citizens of this city.

I am glad that you have come here to open this first congress; I hope you will feel it as a heavy responsibility, for as I said before, a tremendous work has started in this new field all over the world; and the cause of all this work will always be traced back to your decision to have the first hyperbaric operation theatre built.

THE HISTORICAL PERSPECTIVE OF HYPERBARIC THERAPY *

JULIUS H. JACOBSON II, JOANNES H. C. MORSCH AND LESLIE RENDELL-BAKER
Departments of Surgery and Anesthesia, The Mount Sinai Hospital, New York, N.Y. (U.S.A.)

The therapeutic administration of oxygen under pressures higher than that of the atmosphere promises to be an advance comparable in importance to the introduction of blood transfusion and antibiotics. The purpose of this report is to review the many and checkered attempts at using this method that have been recorded in the annals of medical history. Interest in this form of treatment goes back to antiquity; the current renaissance of interest makes it important that the reasons for past failures be understood so that current enthusiasm may be tempered and the method placed on a sound scientific and clinical basis.

Aristotle mentions the diving bell in his *Problemata*: "For they can give respiration to divers equally by letting down a bucket, for this does not fill with water, but retains its air. The lowering had to be done by force." According to Davis[10], Aristotle writes of a diving bell used by Alexander the Great at his siege of Tyre (332 B.C.). Demarchi[10] (1490–1574) refers to an apparatus constructed in 1531 for the purpose of raising the galleys of Caligula which were sunk in the Lake of Nemi. He was able to remain under water for one hour. Fontaine[12] quotes Traisnier (1562) describing two Greeks diving to the bottom of the Tagus in 1538. The experiment was observed by Charles V of Spain. Apparently the diving bell was a large kettle suspended by ropes. A lighted candle placed within the bell was not extinguished during the dive.

The first recorded attempt to use a hyperbaric chamber in medicine was made by the British physician Henshaw in 1662 (Ref. 26). His chamber or "domicilium" was fitted with a large pair of organ bellows valved so that the air could be either compressed or rarified. The therapeutic rationale was to use elevated pressures for acute and low pressures for chronic disease.

> "In time of good health this domicilium is proposed as a good expedient to help digestion, to promote insensible respiration, to facilitate breathing and expectoration, and consequently, of excellent use for the prevention of most affections of the lungs".

An historical account of hyperbaric oxygenation would not be complete without mention of Priestley's discovery[24] of oxygen in 1775 and his classic description:

* This study has been supported by Grant # HE-07706 of the U.S. Public Health Service.

> "From the greater strength and vivacity of the flame of a candle in this pure air, it may be conjectured, that it might be peculiarly salutary to the lungs in certain morbid cases . . . . But, perhaps, we may also infer from these experiments, that though pure dephlogisticated air might be very useful as a medicine, it might not be so proper for us in the usual healthy state of the body: for as a candle burns out much faster in dephlogisticated than in common air, so we might, as may be said, live out too fast, and the animal powers be too soon exhausted in this pure kind of air. A moralist, at least, may say that the air which nature has provided for us is as good as we deserve . . . . The feeling of it to my lungs was not sensibly different from that of common air; but I fancied that my breast felt peculiarly light and easy for some time afterwards. Who can tell but that, in time, this pure air may become a fashionable article of luxury. Hitherto only two mice and myself have had the privilege of breathing it."

No further reports are found in the literature until 1782. The Dutch Academy of Sciences in Haarlem, The Netherlands, attempted to foster interest in hyperbaric work by awarding a prize for the design of an apparatus to study the effect of high pressures in biology[2]. The prize was offered again in 1785, 1788, and 1791, but there were no contenders. Interest did not reawaken in the field for another half century. However, it is indeed prophetic that the current meeting and surge of enthusiasm which surrounds it are stimulated by Boerema and his group in Holland.

In the 1830's new interest was kindled in France by the work of Junod[17] (1834), Tabarie[29,30] (1838), and Pravaz[22,23] (1837). Junod's chamber, the first of that period, was a copper sphere measuring 5 ft. in diameter. Pressures of 2, 2.5, and 4 atmospheres absolute were employed. He stated that the circulation to the internal organs was increased and attributed the sense of well-being, felt within the chamber, to improvement in cerebral blood flow. Tabarie claimed improvement in 49 cases of respiratory disease and focused his attention on the importance of raising and lowering the pressures within the chamber very gradually. The largest chamber of the decade was built by Pravaz in Lyon; it accommodated 12 patients at one time and the therapeutic regimen was named "Le Bain d'air comprimé". He felt that the "compressed air baths" would dilate the bronchi which was considered beneficial in cases of pulmonary tuberculosis, capillary hemorrhages, deafness, cholera, chest deformities, rickets, metrorrhagia, acute conjunctivitis, chronic laryngitis, tracheitis, and pertussis. A typical case history follows:

> "A young lady, who had the bad habit of wearing a too tight girdle, suffered from frequent hemoptysis. This resulted in severe weakness, which was aggravated by copious blood loss during her menstrual periods lasting sometimes for 8 to 10 days.
>
> I prescribed the air bath after she consulted me, and she used it every day for about a month. With the help of this apparatus the bleeding subsided and her menstrual periods returned to normal. Her muscular strength and digestion improved markedly."

This type of description is quite typical of the clinical case histories of patients up to modern times. It becomes evident that the hyperbaric pressure chamber was simply another variant of the mineral water Spa and the claimed cures were similar.

It seems likely that the work of the early French investigators first suggested the employment of compressed air for the caisson as we know it today. Triger[32], in 1841,

Fig. 1. Statuette of a court jester dwarf doing the "Grecian *Bend*"