THE TREATMENT OF GASEOUS DISTENTION OF THE INTESTINE BY THE INHALATION OF NINETY-FIVE PER CENT OXYGEN*

DESCRIPTION OF AN APPARATUS FOR THE CLINICAL ADMINISTRATION OF HIGH OXYGEN MIXTURES

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THE purpose of this communication is to describe a method for the treatment of intractable distention of the small intestine by the inhalation of 95 per cent oxygen. The principle underlying the use of this agent is based on recent studies in animals[1, 2, 3] which demonstrated, (1) that nitrogen and hydrogen are the major constituents of the gases causing distention, and (2) that the inhalation of pure oxygen effects a substantial reduction in the gas volume of the obstructed small intestine inflated with these gases.

The inhalation of pure oxygen accomplishes this result by preventing the entrance of atmospheric nitrogen into the lungs. The nitrogen in the blood and tissues is consequently rapidly exhaled (60 per cent within one hour).[4] The resulting fall in the partial pressure of this gas in the blood not only prevents its diffusion from the blood into the intestine but at the same time accelerates its diffusion from the intestine into the blood. Our experiments showed that after the inhalation of pure oxygen for 24 hours the volume of nitrogen originally injected into the small intestine obstructed at the pylorus and ileocecal valve was reduced approximately 62 per cent in comparison with an absorption of some 10 per cent when air is breathed.

When the small intestine was inflated with hydrogen, the residual gas volume was likewise found to be considerably smaller in an animal breathing oxygen than in one breathing air, although the difference between the two was not nearly so great as in the case of nitrogen. The beneficial effects of oxygen on the intestine distended with hydrogen were found to be due not to any increase in the rate of diffusion of hydrogen from the intestine into the blood, but to the fact that the nitrogen which ordinarily diffuses into the intestine in considerable quantity from the blood has been eliminated and is not available during the period of oxygen inhalation.

The decompressing action of oxygen was however shown to be ineffective for the distended stomach, apparently because the surface area available for absorption is very much less than that of the small intestine.[3] Since the

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stomach, like the unobstructed colon, can be readily deflated by a rubber tube, oxygen should find its usefulness restricted primarily to distention of the small intestine.

It is clear from the foregoing that the closer to 100 per cent the concentration of inspired oxygen the more effective it should be in decreasing the volume of distending gases. In animals 70 per cent oxygen does not reduce the gas volume sufficiently to be of practical value. The oxygen tents in current use do not provide a concentration higher than 70 per cent even with an extravagant supply of oxygen. We have therefore constructed a modified Barach tent (Figs. 1 and 2) which will yield an oxygen concentration of at least 95 per cent for the treatment of obstinate distention.*

The essential change consists in replacing the ordinary tent by a small rubberized canvas helmet, the bottom of which is closed by a very soft pliable rubber diaphragm with a circular defect (diameter three inches) to accommodate the patient's neck snugly and without discomfort. A closed circuit is thereby created which is sufficiently tight and small in volume so that a concentration of oxygen of about 95 per cent or over is rapidly attained.

To reach this percentage it is, of course, necessary to eliminate the room air present in the system as well as the nitrogen exhaled by the patient. All of the lung nitrogen is removed within the first three to five minutes of pure oxygen administration.[4] At the outset, oxygen is delivered at the rate of 12 liters per minute. By means of a two-way valve on the delivery side of the circuit the system is washed out for about 20 seconds several times during the first 15 minutes. During this washing-out period the hood, except for its rigid roof, collapses gently about the patient's head; but upon closure of the valve the hood reinflates rapidly. Following these preliminary maneuvers the rate of flow of oxygen is reduced to from four to five liters per minute. Gas samples obtained from a sampling jet on the return side of the circuit show oxygen percentages varying from 92 to 98 per cent within 15 to 20 minutes after starting. Now and then during the course of the administration of oxygen the apparatus is washed out and replaced by pure oxygen in order to get rid of the small amounts of nitrogen which continue to be eliminated from the blood, tissues and intestine.

The hood is suspended over the patient's head and can be accommodated to any position, although the sitting position is most convenient. Such a hood provides ample elasticity and volume to permit full respiratory excursions without the restricted feeling one experiences in the rigid helmet devised by Benedict[5] for short periods of administration of pure oxygen. In contrast to the ordinary tent, the subject's body is accessible for nursing purposes and for physical examination of the chest, without losing the benefits of oxygen therapy during these manipulations. Subjectively there is an absence of the imprisoned feeling of the ordinary tent which is objectionable to many

* The details of the apparatus were worked out in collaboration with the Warren E. Collins Company of Boston, who constructed the machine as illustrated.

patients. Three celluloid windows provide for ample vision and patients can hear and be heard readily without having to open the tent. A sleeve is provided below the front window for feeding purposes, but it is much simpler

FIG. 1.—Photograph of apparatus for the clinical administration of 95 per cent oxygen.

to deliver food and drink through the opening in the diaphragm around the neck. The resulting inflow of room air is not a serious disadvantage because the entire system can be washed out and pure oxygen replaced within a few minutes.

The rest of the unit is mounted on the same stand as the hood and consists of a motor blower which sucks the air out of the hood and then drives it through two insulated cans filled with ice. One of the cans also contains a tray of soda lime for absorption of CO_2. The air together with additional oxygen from the tank is then delivered through a flattened slit-mouthed nozzle into the hood and is directed downward in front of the subject's face. It is then sucked back through a perforated tube in the top of

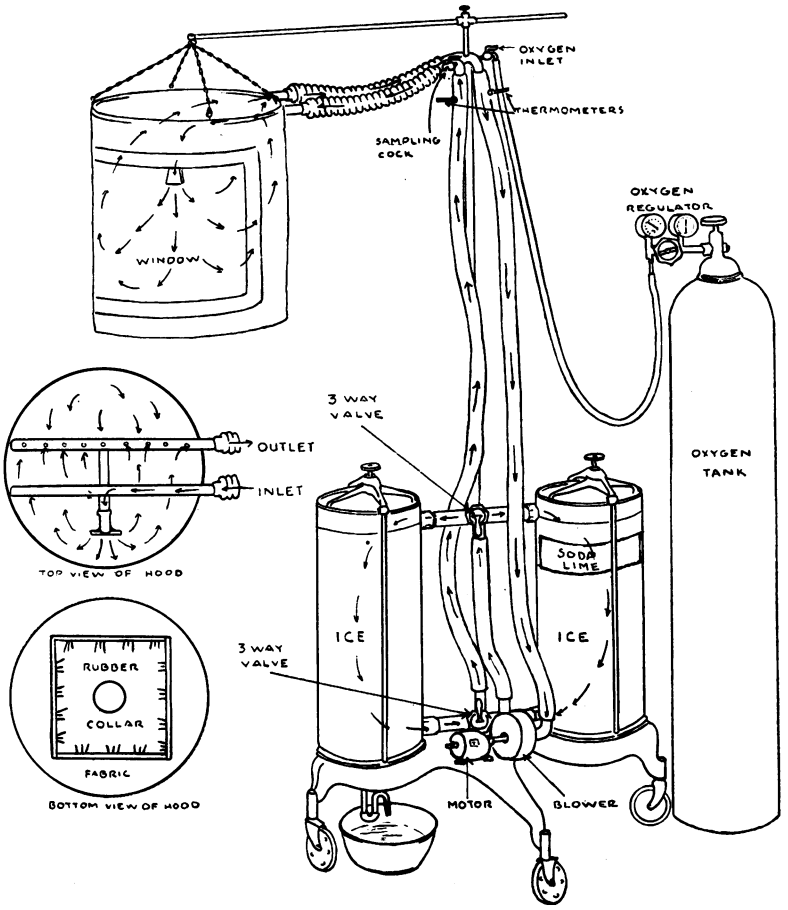

FIG. 2.—Diagrammatic sketch of apparatus for the clinical administration of 95 per cent oxygen.

the hood. Thermometers on the intake and return tubes afford a measure of the cooling efficiency of the system. With a normal human subject in the helmet and a room temperature of 24°C the oxygen enters the hood at a temperature of 15°C to 16°C. When the cooling is inadequate the temperature difference lessens, thus indicating the need for ice replacement. Either ice-can may be refilled, without interrupting the oxygen flow, by shunting the can to be filled out of the circuit by means of valves which

direct the gas flow through both cans or either one, as desired. Water drains out of the bottom of either can through a siphon outlet common to both. A resistance box on the stand controls the intensity of the blast from the blower to meet the subject's preference as to ventilating speed. If for any reason the helmet becomes uncomfortable it can be readily removed, even by the patient. The operating cost of this apparatus is less than that of the ordinary tent because of the smaller volume of oxygen necessary to maintain the desired concentration.

The reduction of the gas volume in the small intestine of animals obtained by this apparatus* compares favorably with the results in previous experiments[3] in which commercially pure oxygen was supplied by a tracheal cannula. Thus the decrease in gas volume in the small intestine by the tracheal cannula method averaged 40 per cent after 12 hours and 57.5 per cent after 24 hours. With this apparatus the results in two 12-hour experiments were 60 and 66 per cent and in two 24-hour experiments 63 and 70 per cent.

Due cognizance must be taken of the toxic properties of high concentrations of oxygen before submitting patients to this agent. We shall deal with this aspect of the subject more fully in a subsequent clinical report. In passing it may be worth summarizing briefly what data is at hand in this connection. Animals can breathe 70 per cent oxygen indefinitely, but higher concentrations eventually produce pulmonary edema. No apparent harm however results from pure oxygen if given to animals for 16 out of every 24 hours for many days.[6] Healthy men can breathe pure oxygen for at least four hours without toxic symptoms.[4] Sayres[7] has exposed men to 100 per cent oxygen for eight hours continuously with impunity. Evans and Dushordwe[8] state that they have given pure oxygen to patients with cardiac or pulmonary disease for 24 hours or longer with nothing but benefit. Since they employ a mask and allow feeding at the same time it may be doubted that the patients receive pure oxygen continuously.

Our clinical experience to date with the use of the apparatus described above is limited to five cases.

CASE REPORTS

CASE I.—A male, aged 65, entered the hospital complaining of generalized abdominal pain of three days' duration. The history was altogether unreliable owing to the confused mental status of the patient. For two years he had been troubled with nocturia and straining during micturition. In spite of repeated enemata he had passed no flatus during the last 24 hours. For the past 12 hours he had vomited a dark brown fluid repeatedly.

Physical examination revealed a dehydrated male with peripheral vascular collapse. The abdomen was severely distended, tense, generally tender, tympanitic everywhere except for dulness to percussion in the flanks and lower abdomen. A fluid wave was present. Red blood cell count 3,600,000, hemoglobin, 70 per cent (T), white blood cell count 20,300, blood nonprotein nitrogen 109, blood chlorides 446. A roentgenologic interpretation of a flat film of the abdomen was as follows: "The small bowel, especially in the left upper quadrant appears distended and shows numerous fluid levels. There is also some disten-

* In the animal experiments we used instead of the helmet a water sealed box supplied with a water valve to allow the escape of excess gas.

tion of the large bowel." Immediate laparotomy through a lower right rectus incision revealed a generalized peritonitis with large quantities of free fluid. In the field of operation the intestine was not distended. Immediately after operation the patient was placed in the helmet and he breathed 95 per cent oxygen until his death 14 hours after operation.

Autopsy revealed an obstructing median lobe of the prostate with a ruptured diverticulum in the dome of the bladder, and generalized peritonitis with over a liter of purulent fluid. Fibrous adhesions were found everywhere among the organs in the peritoneal cavity but there was no evidence of mechanical obstruction. *The entire small intestine was collapsed and contained no gas.* There was no edema, atelectasis or consolidation of the lungs, but there was slight congestion of both bases. The bronchial tree contained a small amount of secretion but no blood. The pulmonary vessels were normal. Microscopic examination of the lungs showed no hemorrhagic extravasation. The alveolar walls were not thickened. A few arterioles contained red cells in clumps resembling small thrombi. The rest of the autopsy was irrelevant.

COMMENT.—These findings indicate that there was no damage to the lungs as a result of 14 hours of continous oxygen inhalation. The evidence in this instance as to the influence of pure oxygen inhalations on the degree of distention is somewhat equivocal, but it is certainly unusual to find the entire small intestine collapsed in cases of generalized peritonitis.

CASE II.—A male, aged 72, was admitted to the hospital with a diagnosis of coronary thrombosis, three weeks after the onset of severe chest pain associated with paroxysmal nocturnal dyspnea, weakness and fever. For four days preceding entry there had been no bowel evacuation. On admission the patient was slightly cyanotic, had a blood pressure of 110/90 and was moderately distended. There were moist râles at the bases of both lungs and he was thought to be developing a bronchopneumonia. The distention increased in spite of enemata, dry heat and turpentine stupes to the abdomen. There was occasional peristalsis but without appreciable expulsion of flatus. Two days after admission the patient was placed in the helmet and 95 per cent oxygen administered for a period of nine and one-half hours with a one-half hour interval outside the helmet.

During the period of oxygen administration the cyanosis disappeared, the pulse was slowed from 92 to 82, the blood pressure remained essentially the same, and the white blood cell count fluctuated from 11,000 to 13,000. *The abdominal girth measurements decreased some six cm.* Flatus was expelled in small amounts from time to time. Three hours after the oxygen was stopped the patient deflated spontaneously and the girth of the abdomen decreased to nearly normal. The patient remained comfortable and the lungs cleared up entirely in the next few days. Five days later the distention recurred but was relieved by ordinary procedures. The patient left the hospital much improved 17 days after entry.

COMMENT.—In brief, this case is one in which a patient with acute coronary disease breathed 95 per cent oxygen for nine hours with no demonstrable deleterious effect. It is by no means conclusive of the value of 95 per cent oxygen for intestinal distention inasmuch as the greater degree of deflation occurred several hours after stopping the inhalation of oxygen. But it is not ureasonable to assume that a severely distended intestine, incapable of peristaltic activity by virtue of the overstretching of its muscle, may be restored to effective peristaltic activity by decreasing its gas volume sufficiently to enable the muscle to recover its tone. Thus it is possible that the oxygen inhalation, having facilitated a significant absorption of nitrogen

via the blood (as evidenced by the six cm. decrease in abdominal girth), made it possible for the intestine to recover its tone and so to complete its deflation. Additional evidence in favor of this assumption is given in the following case history.

CASE III.—A girl, aged six, 72 hours before admission had a severe chill followed by intermittent fever, anorexia, constipation, and oliguria. She had recently recovered from a cold. Shortly before entry she vomited and began to have diarrhea with rectal tenesmus. On admission the child was extremely toxic and pale and was complaining of generalized abdominal pain.

Physical examination was not remarkable except for the abdomen which showed a board-like rigidity and diffuse tenderness, especially in both lower quadrants. The temperature fluctuated between 101°F and 105°F, the pulse from 120 to 140, and the respirations 20. The urine was negative, the red blood cell count was 3,250,000, hemoglobin 65 per cent (T) and the white blood cell count was 22,500 with a differential of 88 per cent polymorphonuclear leukocytes, of which 16 per cent were band forms. Blood and stool cultures were negative. For six days the patient continued to have diarrhea. The abdomen would alternately soften and become rigid. In spite of the fact that she passed flatus freely the abdomen gradually became more distended. On the sixth day after entry the child was slightly cyanotic, respirations became labored and the abdominal distention and rigidity increased. She was put into the helmet and 95 per cent oxygen administered. The following table gives the measurements of the abdominal girth at three levels before, during and after the period of oxygen therapy (Table I).

TABLE I

Abdominal Girth in Centimeters

Date	Hour	At costal margin	At umbilicus	Halfway between umbilicus and symphysis pubis	Remarks
March 22, '35	5:30 P.M.	66	63.5	64.5	
	5:30 P.M.	Oxygen helmet applied *			No flatus passed during this period.
	8:30 P.M.	64	64	62	
	11:30 P.M.	63	61.5	61	
March 23, '35	2:30 A.M.	63	61	59.5	2:25 Expelled large amount of flatus.
					3:15 Expelled large amount of flatus and had large stool.
					3:25 Expelled large amount of flatus.
					4:30 Expelling flatus freely.
	5:30 A.M.	61	59	58	
	8:30 A.M.	61	59	58	
	11:30 A.M.	61	60	59	11:30 Abdomen much less distended though not soft.
	2:30 P.M.	60	59	58	
	6:00 P.M.	Oxygen discontinued			
March 24, '35	7:30 A.M.	61	59.5	58	
	5:30 P.M.	63	61	59	
March 25, '35	7:30 A.M.	60.5	59	57	

* From 5:30 P.M. March 22 to 6 P.M. March 23 the helmet was removed every four to six hours for about one-half hour. Total time of exposure to 95 per cent oxygen was 20 hours.

During the period in the helmet the pulse dropped from 130 to about 110, an effect commonly observed when high oxygen mixtures are breathed. The cyanosis disappeared. Shaw and Behnke[4] have noticed an occasional instance of an increase in the white blood cell count, but none occurred in this instance.

The child proceeded to improve rapidly within the next 24 hours and distention did not recur. The diarrhea stopped. Three days later she was well on the road to recovery. At present she shows some induration in the pouch of Douglas and seems to be localizing a small pelvic abscess. The abdomen is flat, and not tender; the appetite and bowel function are practically normal.

COMMENT.—In this patient moderate distention had been present from the time of entry until 36 hours preceding oxygen administration when it became severe. Throughout this period the child had been expelling flatus now and then in small amounts but not sufficient to prevent increasing distention. It will be noted in Table I that for the first eight hours of oxygen inhalation no flatus was expelled per rectum or regurgitated by mouth, but the abdominal girth was substantially reduced. After this, there were frequent discharges of large amounts of flatus so that an effective decompression of the intestine occurred within 15 hours after beginning the oxygen inhalation. Presumably the oxygen had accomplished sufficient shrinking of the bowel by the absorption of nitrogen via the blood so that the intestine (which was undoubtedly in an irritable state as evidenced by the severe diarrhea) was able to complete the deflation by peristalsis.

The prompt and complete recovery which followed almost immediately after 20 hours of breathing 95 per cent oxygen without subjective or objective signs of damage to the brain or lungs constitutes evidence that either the toxic properties of high concentrations of oxygen do not assert themselves until after such an interval or that they can be minimized or avoided by intermittent administration.

In the animal experiments already referred to it was noted that a substantial decrease amounting to over 40 per cent of the initial distending volume was observed after 12 hours of intermittent oxygen administration. In the preceding case a significant decrease was noted within eight hours. In the following case an appreciable decrease was observed within six hours. During this time there was no belching or discharge of flatus by rectum so that the shrinkage in distending volume can be attributed to increased absorption via the blood as a result of the use of oxygen.

CASE IV.—A male, aged 46, house painter by occupation, entered the hospital complaining of generalized abdominal pain and constipation of three days' duration. The pain was characteristic of intestinal colic and had been associated with much retching and occasional vomiting. For three days, in spite of repeated enemata and magnesium sulphate by mouth, he had passed nothing by rectum and gradually became markedly distended. Examination on admission revealed nothing remarkable except pulmonary emphysema and a distended abdomen which was tympanitic throughout to percussion. There was no audible peristalsis. He was suspected of having lead colic. The urine was found to contain lead. Pending a roentgenologic study of the colon the following morning to rule out a large bowel obstruction, he was given 95 per cent oxygen by the helmet (Table II).

TABLE II

Time	Conc. of O_2 in the helmet	Pulse rate	Blood pressure	White blood cell count	Circumference of abdomen in cm. at: Costal margin	Umbilicus	Midway between umb. and symph. pubis
10:40 P.M.	Oxygen started						
10:40 P.M.	90%	76	170/120	10,000	95.5	97.25	95.5
11:30 P.M.	94	76	140/86	..	93.0	98.0	96.5
1:30 A.M.	92	88	160/90	..	95.0	96.0	94.5
2:30 A.M.	99	88	140/90	18,950	93.0	96.0	95.0
4:30 A.M.	98	76	130/86	..	92.0	95.5	92.
7:30 A.M.	94	80	140/90	15,800	92.0	95.	91.0
8:30 A.M.	Oxygen discontinued						
9:30 A.M.	Barium enema; roentgenologic findings negative.						

The patient was by no means completely relieved of distention after ten hours of oxygen therapy, but there was no doubt that the abdomen had been considerably reduced in size within six hours and that distention had been considerably relieved in spite of the fact that no gas was passed by rectum during this period. Oxygen was discontinued during the following day until evening when after another six hours in the helmet an enema resulted in practically complete deflation.

CASE V.—A girl of seven was admitted with bilateral bronchopneumonia and empyema due to a streptococcus infection. She was extremely dyspneic and cyanotic on admission and seemed almost moribund. The abdomen was markedly distended. She was placed in a Barach-Collins oxygen tent for 24 hours but the cyanosis did not appear. Because of this and because there was a well marked abdominal distention which did not yield to hot stupes and enemata she was given 95 per cent oxygen by the helmet. The cyanosis was replaced by a pink color in the lips and fingers. Without removing the helmet she was placed on her side and a left trocar thoracotomy was done. During the following six hours the pulse dropped from 170 to 156, but the respiratory rate remained unchanged at 68. Oxygen was continued for 15 hours, with three interruptions outside of the helmet for periods of 30, ten and five minutes. At the end of this time she expelled a large amount of flatus and the abdomen became soft.

Oxygen was continued, with occasional interruptions totalling two hours, for the next eight hours because intense cyanosis returned as soon as she was removed from the helmet. The following day mild distention recurred, but for the preceding 12 hours she had refused to stay in the helmet except for periods too short to be effective for deflation purposes. The pulse had meanwhile dropped to an average of 140, and the white blood cell count fell from 38,000 to 18,400. These changes were in all probability due to surgical drainage of the left pleural cavity. A right trocar thoracotomy was then done. The child in the course of the subsequent six weeks improved very considerably and is now in the convalescent stage.

COMMENT.—In this patient the dangerously low vital capacity due to the pulmonary infection was threatened still more by abdominal distention. The ordinary oxygen tent had failed to relieve the cyanosis and the usual measures for the relief of the distention had likewise proved ineffective. By the use

of 95 per cent oxygen the cyanosis was dispelled and, as in Cases II and III, an adequate deflation of the intestine was accomplished.

It is impossible to affirm or deny the occurrence of toxic effects of 95 per cent oxygen in this child. However, the pulmonary edema or hemorrhage and the cerebral effects attributable to oxygen poisoning were not observed.

DISCUSSION.—There are a few recorded observations on the effect of 95 per cent oxygen on abdominal distention. Thus Evans and Dushordwe[8] incidentally observed that their pneumonia patients who were given pure oxygen by nasal catheter were relieved of their distention within 36 to 48 hours. They assume that anoxemia causes distention and that the relief of the anoxemia restores intestinal muscle tonus with resulting deflation. By this hypothesis oxygen must be considered only indirectly responsible for the relief of the distention and of value only in virtue of the existence of anoxemia.

W. T. McConnell and R. L. McCormack[9] report 16 cases of distention following cesarean section which were relieved by 95 per cent oxygen and five per cent carbon dioxide. They state that "the distention is due to shock, paralysis of the splanchnic nervous system, loss of smooth muscle tone and decrease in local circulation. An increase in carbon dioxide tension has long been known to stimulate smooth muscle activity. Therefore, one would expect the administration of carbon dioxide and oxygen to stimulate peristalsis and restore normal cellular function." Apparently the authors considered carbon dioxide the chief agent responsible for the relief of the distention, but it is not clear what rôle 95 per cent oxygen played. When one notes further that they used this gas mixture three or four times for five-minute periods every three to four hours, it is difficult to see how the use of 95 per cent oxygen for a total of some 20 minutes in all could have had any important bearing on the results observed.

We have already referred to the experimental evidence showing that the inhalation of 95 per cent oxygen causes a much more rapid deflation of distended intestine than occurs when air is breathed. Since this observation was made on the mechanically obstructed intestine the favorable effect of oxygen in these experiments cannot be attributed to the possible effect of oxygen on muscle tonus except insofar as increased muscle tonus results in increased intra-intestinal pressure with resulting increase in the speed of absorption of intestinal gases. That this can be of nothing more than minor significance however is clear from the evidence we have presented in a previous report.[3] In the unobstructed intestine it is not safe to assume that oxygen aids in the deflation by an effect on muscle tonus until well controlled observations showing such an effect are available.

The oxygen saturation of the blood has little or nothing to do with the effect of breathing pure oxygen on gaseous distention of the intestine. Our experimental observations demonstrate that the effect of oxygen depends primarily on the laws governing gaseous exchange across a semipermeable

membrane and lies in the fact that *by excluding nitrogen from the inspired air*, the nitrogen in the blood and tissues is exhaled and in consequence the nitrogen in the intestine diffuses out of the intestine into the blood much more rapidly than occurs when air is breathed. At the same time nitrogen which ordinarily diffuses from the blood into a distended intestine in large quantities is no longer available for this purpose.

That this mechanism operates in man is apparent from Cases III and IV in which a sizable decrease in abdominal girth was observed after a number of hours of inhalation of 95 per cent oxygen and *before any gas was passed by rectum.* None of the patients included in this report were victims of mechanical obstruction and all of them eventually completed the deflation spontaneously. Their failure to do so for several days preceding the administration of oxygen with all the usual measures for the treatment of distention suggests that the oxygen permitted the unobstructed but overstretched intestine to recover effective peristaltic activity simply by accomplishing a partial shrinking of the bowel lumen.

One may infer that the deflation attributed to oxygen in the five patients reported might well have occurred without its use. This cannot be denied. On the other hand the fact that the distention had persisted in each case for at least several days in spite of intensive treatment and that it was effectively disposed of within a reasonable period after the initiation of oxygen therapy makes the correlation seem more than coincidental. The significance of the oxygen is not minimized by the observation that a large fraction of the distending gases was evacuated by peristalsis. That eventuality should indeed be anticipated in any case of distention of functional origin once the intestine has been relieved of the mechanical disadvantage of overdistention. It is precisely this function which we attribute to oxygen, for in each of the five cases reported the distention remained intractable to the ordinary therapeutic measures and yielded only after oxygen had been observed to decrease the degree of abdominal distention without a concomitant discharge of flatus (Cases I, III, and IV) or with only a negligible discharge (Cases II and V).

There should therefore be no need in the average case of ileus to rely on the administration of oxygen to complete the deflation except perhaps in instances of mechanical obstruction in which operation may be contraindicated, although this will admittedly be a rare circumstance.

Oxygen may prove quite useful in distended patients during a period when the surgeon is not certain whether he is dealing with a mechanical or functional ileus. In a recent experience of this type oxygen was given with the usual result of a decrease in abdominal girth, following which enterostomy was done for mechanical obstruction. At operation it was noted that most of the patient's residual distention was due to large amounts of intra-intestinal and intraperitoneal transudate.

In resorting to the use of 95 per cent oxygen for the treatment of distention we have not ignored the possible dangers involved. The available

evidence indicates that when it is given intermittently its toxic properties can be avoided. Our experimental data has demonstrated that intervals of respite in room air for one-half to one hour following three or four-hour periods in the helmet can be allowed without vitiating the effect of the oxygen already inhaled. Since the needs of the average patient will in any case require occasional interruptions and periods of rest outside the helmet the intermittent administration of oxygen proves to be more practical and at the same time safer than continuous administration. We have observed no untoward respiratory or cerebral effects in either man or animals from oxygen employed in this way for periods lasting as long as 24 hours, which is well within the limits necessary to accomplish the desired result.

The length of time necessary to effect a substantial improvement by oxygen cannot be predicted in any given instance. In the five cases cited the shortest period required was six hours. Since oxygen does not absorb gases from the stomach in any appreciable volume the use of the stomach tube to obviate the entrance of these gases into the intestine is a valuable procedure preliminary to the administration of oxygen and should shorten the time of sojourn in the helmet. Once in the helmet the patient can swallow only oxygen, a gas of no consequence in intestinal distention.[2, 3] The selection of foods which are minimal gas producers[2] will, by preventing the accumulation of hydrogen in the gut, also decrease the period of time necessary for a successful issue.

Although our objective in devising this method is the treatment of obstinate distention such as may be encountered postoperatively, or in peritonitis, or perhaps in cases of suspected mechanical obstruction in which surgical relief is being withheld for one reason or another, its usefulness is by no means restricted to this purpose. Other possible indications are the following: (1) after operations on the gastro-intestinal tract when tension on suture lines must be avoided 95 per cent oxygen may serve as a prophylactic against the occurrence of distention because nitrogen, which is the chief constituent of the distending gases, is thereby excluded from the patient's environment. (2) The apparatus is conveniently applicable for the relief of anoxemia in cardiac and respiratory disorders. Indeed in instances in which anoxemia and distention coexist, a double purpose would be served. (3) Ninety-five per cent oxygen may find a possible usefulness in mediastinal emphysema. We have not as yet encountered a case for trial of the method but on theoretical grounds it may be worth a trial because the absorption of nitrogen from the soft tissues is accelerated by breathing pure oxygen. A recent investigation has established this observation beyond peradventure.[10] (4) Finally, the method may be of value in patients suffering with severe or persistent headache following encephalography. This will be the subject of a forthcoming report.

CONCLUSIONS

(1) Experimental evidence has been obtained which indicates that the

inhalation of 95 per cent oxygen may be effective for the relief of gaseous distention of the intestine.

(2) The inhalation of 95 per cent oxygen is therefore suggested as an agent for the treatment of intestinal distention when the usual methods available for this purpose are either contra-indicated or have proved unavailing.

(3) A safe, practical and economical method for the clinical administration of 95 per cent oxygen for this purpose is described. When properly used the dangers of oxygen poisoning can be avoided.

(4) Five patients with varying disorders, all victims of severe distention, were exposed to 95 per cent oxygen by means of this apparatus for periods varying from eight to 24 hours. The results do not conclusively demonstrate the clinical value of the method, but they are sufficiently gratifying to justify this preliminary report and to encourage further trial.

(5) Indications, aside from intestinal distention, for the use of the method are suggested.

REFERENCES

[1] McIver, M. A., Redfield, A. C., and Benedict, E. B.: Gaseous Exchange between Blood and Lumen of Stomach and Intestine. Jour. Phys., vol. 76, p. 92, 1926.

[2] Fine, J., and Levenson, W. S.: Effect of Foods on Postoperative Distention. Amer. Jour. Surg., vol. 21, p. 184, 1933.

[3] Fine, J., Sears, J. B., and Banks, B. M.: The Effect of Oxygen Inhalation on Gaseous Distention of the Stomach and Small Intestine. Am. J. Digest. Dir. & Nutrition, August, 1935.

[4] Shaw, L. A., and Behnke, A. R.: Personal communication.

[5] Benedict, F. G.: A Helmet for Use in Clinical Studies of Gaseous Metabolism. New England Jour. Med., vol. 203, p. 180, 1930.

[6] Sayres, R. R.: Quoted by Evans. See reference.[7]

[7] Sayres, R. R: Quoted by Barach, A. L.: Personal communication.

[8] Evans, J. B., and Durshordwe, C. J.: Further Observations on Oxygen Therapy in the Treatment of Penumonia. Anes. and Anal., vol. 11, p. 193, 1932.

[9] McConnell, W. T., and McCormack, R. L.: Carbon Dioxide and Oxygen in Obstetrics. Jour. Amer. Med. Asso., vol. 101, p. 1783, Dec. 2, 1933.

[10] Fine, J., Frehling, S., and Starr, A.: Experimental Observations on the Effect of 95 Per Cent Oxygen on the Absorption of Air from the Body Tissues. J. Thor. Surg., vol. 4, p. 635, 1935.