DECOMPRESSION TREATMENT OF WHOOPIING-COUGH

A CLINICAL SURVEY OF 903 CASES

BY

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Weekly or twice-weekly clinic sessions for the treatment of whooping-cough by low air-pressure in a decompression chamber have been held in this hospital since May, 1949, except for short periods when the prevalence of the disease was very low. The chamber was purchased from the Royal Air Force by the Ministry of Health in 1948, was conveyed to its present site by the London County Council, and was reconditioned and refitted by the Lewisham Group Hospital Management Committee. At that time considerable public interest had been aroused in high flying and decompression treatment, and, by request, I published a brief preliminary account of it with illustrations of the chamber in action (Banks, 1949).

Selection and Examination of Patients

During the five and a half years 903 patients were treated, but the results could be assessed in only 782, of whom 686 were out-patients and 96 in-patients. The out-patients were sent by their doctors by arrangement with the Emergency Bed Service, and in accordance with a simple plan. Patients were generally accepted only if they had been coughing for about three weeks or more, and the doctor was asked to instruct the parent to take to the clinic a record of the number of coughs, whoops, and vomits observed during the 48 hours before attendance. Every case was personally interviewed and examined by me or by my colleague Dr. L. J. M. Laurent. The history was checked and the estimated day of disease recorded. The record of coughs and vomits of food day and night for two days was verified; particulars of appetite, activity, lethargy, fretfulness, or loss of weight were noted; and the parent was asked whether she thought the condition was stationary, improving, or getting worse. The faeces, tympanic membranes, and chest were examined, the temperature was taken, any cyanosis or tachypnoea was noted, and in a very large proportion of cases the chest was radiographed.

I soon learned to reject the more acutely ill cases, especially those with pyrexia, or cyanosis, or with more than a minimal degree of pulmonary collapse as shown radiographically, usually by shadows filling the cardiophrenic angles. The cases deemed too ill for decompression were either admitted to hospital or sent home with a letter to the doctor advising rest in bed and, if necessary, treatment later for pulmonary collapse. Minimal atelectasis in a bright, active, apyrexial child was not regarded as a contraindication, nor were rhonchi and other signs of bronchitis without fever.

Decompression Treatment

The selected cases, up to six or eight at a time, went into the chamber accompanied by a nurse or ward orderly, or by the parent in the case of some infants or a young frightened child. In cold weather the children were kept warm by hot bottles and blankets, the chamber itself having been pre-heated by an electric radiator. Picture books and toys were provided and stories were read to the younger children, usually until they fell asleep lulled by the hum of the motor. Oxygen was laid on inside the chamber, but was used only once in five and a half years. A telephone connected the occupants of the chamber with the porter-operator, who watched them through a porthole window during the whole

course of the treatment. The pressure of air in the chamber was reduced progressively for about 20 minutes until the equivalent of a height of 12,000 feet (3,660 metres) was reached. This low pressure was maintained for 45 minutes and then gradually increased during the 20 to 25 minutes "descent." The treatment thus lasted about 90 minutes. Some pain in the ears and deafness were commonly experienced during the "descent" and for a short time thereafter. In this routine a hitch occurred only on two occasions, once when a woman in the chamber became hysterical, and once when the motor failed. In both cases "ground level" was regained without incident.

Assessment of Results

A form was provided upon which the parent or ward staff was asked to record the time and character of each cough and food vomit during a period of 48 hours *commencing one week after the treatment*; in addition they were asked to report in a few words their impressions of the progress or otherwise of the child from the date of treatment until the date of the report. The completed forms were sent to me generally about the tenth day after decompression. They were delayed for two weeks or so in a small proportion and occasionally a reminder had to be sent out after about two weeks. The factual report on coughs and vomits, and the mother's or ward sister's statement of her impressions of the result of the treatment, taken in conjunction with the recorded data before treatment and the stage of the disease, formed the basis upon which the assessment of the results was made. The factual report on coughs and vomits was usually far better done by the parent than by the ward staff, although the "summing up" by the ward staff after a week was quite good. A feature of this work, however, was the obvious care taken by most of the parents to produce an accurate factual record of coughs and vomits for the 48-hour period. Sometimes the statement of their impressions seemed unduly optimistic in view of the factual report, and in such cases it was treated with reserve.

The assessment of the results on this basis was usually not difficult. It was made by me personally in the great majority of cases, and by Dr. Laurent in my absence. Our marking was conservative and showed almost complete agreement. A sample series of 462 cases was assessed by Dr. Laurent independently, without knowledge of the marking which had already been given by me. His marking turned out to be the same as mine except in 14 cases—a difference of assessment of only 3% between two observers working independently.

The following classification of results was adopted:

XX=Improvement marked and rapid in four to seven days or less, with virtual cessation of the paroxysmal cough.

X=Improvement more gradual over seven to ten days, but probably significant.

X-=Improvement likely to be attributable to the natural progress of the disease at that stage.

O=No improvement in 10 days.

OO=Worse. (Cases excepted in which increased cough and expectoration was limited to 24-48 hours; this was not uncommon.)

TABLE I.—Cases Treated but Not Assessed

	1949	1950	1951	1952	1953	1954	Total
Disease too mild ..	1	7	7	6	5	—	26
" " acute ..	2	5	1	1	—	—	9
" " early* ..	—	8	1	1	2	1	13
No report ..	—	12	9	12	25	15	73
Total ..	3	32	18	20	32	16	121

* Less than 2½ weeks of disease.

Cases Excluded from Assessment (Table I)

Mild Cases.—Twenty-six cases, though treated, were so mild that no accurate assessment of the result was possible.

Acutely Ill Cases.—Nine cases with mild pyrexia or cyanosis and atelectasis were treated by decompression

experimentally in the first year or two. Such cases were thereafter excluded, as this was found to be wrong practice.

Early Cases.—Decompression is a physical treatment which cannot be expected to stem the advance of the disease in the first two and a half to three weeks. Although there was an occasional apparent exception to this rule the assessment of results probably gained in precision by the exclusion of the 13 cases treated at a stage of the disease earlier than two and a half weeks.

No Report.—Seventy-three treated cases had to be excluded because no report on the results was received.

Results

Effect on Cough, Vomiting, and General Conditions.—Table II indicates that marked rapid improvement with virtual cessation of paroxysmal cough (XX) occurred in

TABLE II.—Cases Treated by Decompression and Assessed Results

Classified Result*	1949	1950	1951	1952	1953	1954	Total	%
XX	20	68	55	30	26	21	220	28.2
X	21	93	60	33	36	23	266	34.1
X-	15	48	34	17	16	11	141	18.0
O	18	36	37	18	29	13	151	19.2
OO	—	3	—	1	—	—	4	0.5
Total assessed ..	74	248	186	99	107	68	782	100.0

* See text.

28.2% of the assessed cases, and slower but probably significant improvement (X) in a further 34.1%; while in 37.7% the treatment appeared to have no effect.

Effect on Vomiting.—A particularly valuable sequel to the treatment in many cases was the relief of vomiting (Table III). Among the 427 children who were vomiting

TABLE III.—Cases Vomiting Food (more than once daily)

	1949	1950	1951	1952	1953	1954	Total	%
Vomiting stopped ..	18	84	60	33	30	21	246	57.7
„ reduced ..	10	30	22	7	10	6	85	20.0
„ unre- lieved ..	9	34	22	12	15	4	96	22.3
Total ..	37	148	104	52	55	31	427	100.0

food more than once daily just before treatment, the vomiting stopped fairly abruptly in 57.7%, was reduced in a further 20%, and was unrelieved in 22.3%. This was something for which the parents were especially grateful.

Influence of Sex.—Table IV shows the sex incidence of the assessed cases. There is a considerable preponderance of females, as in all statistics of whooping-cough. This

TABLE IV.—Sex Incidence of Assessed Cases

	1949	1950	1951	1952	1953	1954	Total
Males	36	112	80	41	44	28	341
Females	38	136	106	58	63	40	441

is an unexplained feature of the disease. The assessed results showed no relation to sex. To category XX, 26% males and 28.5% females were assigned; and to category X, 37.5% males and 30.8% females.

Influence of Age.—Table V shows that 63 of the assessed cases were infants under 12 months, 454 were children aged

TABLE V.—Age Groups of Assessed Cases

Age:	Under 1 Year	1-4	5-9	10-15	15+	Total
No. of cases	63	454	244	7	14	782

1-4 years, 244 were 5-9 years, 7 were 10-15 years, and 14 were over 15 years. Table VI suggests that results may be best in the age group 5-9 years, with 34.4% assessed as XX and 36% assessed as X. Results in the 1-4 years group were about average, while those in infants under 12 months

were possibly slightly inferior (19% assessed as XX and 35% as X); the number in this group, however, was rather small for comparison. Most observers have concluded that the results of decompression treatment are independent of

TABLE VI.—Results in Relation to Age

Assessment	Under 1 Year		1-4		5-9		10-15	15+
	Cases	%	Cases	%	Cases	%	Cases	Cases
XX	12	19	117	25.8	84	34.4	—	2
X	22	35	156	34.1	87	36	2	6
X-	15	—	85	—	37	—	—	2
O and OO ..	14	—	96	—	36	—	5	4
	63		454		244		7	14

age, but there is a suggestion in Table VI that results in babies and adults may not be quite so good as in children aged 1-9 years and especially in those aged 5-9 years.

Second Decompression.—Although the figures are small, Table VII suggests that a second treatment did not often yield good results when the first treatment failed, except,

TABLE VII.—Results After a Second Decompression Treatment

Assessment:	XX	X	X-	O and OO	Total
All cases	5	6	8	5	24
First decompression too early	2	2	1	1	6
Net No. of second decom- pression cases ..	3	4	7	4	18

perhaps, when the first treatment was given too early (before two and a half weeks of the disease). When the latter subgroup was excluded, a second decompression yielded results only about half as good as the average for all cases.

Results of Other Observers

Treatment of whooping-cough by high flying began in Strasbourg in 1927, when air pilots took children in the paroxysmal stage up to a height of 10,000 feet (3,050 metres). From 1937 to 1939 small-scale trials were carried out in Strasbourg, Switzerland, Germany, Holland, Poland, Spain, Uruguay, Chile, and a very few in England. Not all were favourable. In 1943 open aeroplanes were used in Strasbourg and Switzerland, a dangerous practice which was soon abandoned. Matter (1946) reported on high-flying treatment in 100 patients between the ages of 2 months and 40 years. He concluded that cases over three weeks from onset of the disease profited most, that vomiting stopped in one to two days, appetite returned, sleep improved, and convalescence was shortened.

Baldy and Richou (1946), employing the decompression chamber in Paris, treated 275 children and 21 adults, of whom, however, only 128 were followed up for 21 days. Of the latter group, 22% were reported as practically cured in less than five days, 51% frankly improved, and 4% had paroxysms and vomiting temporarily aggravated. They concluded that the third to fourth week of the disease was the best time for treatment and that repetition of the treatment did not materially increase successes. Contraindications to the treatment were fever, respiratory and cardiac complications, epistaxis and other haemorrhage, acute nasopharyngeal or ear infections, hernia, surgical emphysema, and malnutrition (conditions which I have grouped together generally as the "acutely ill patient").

Lauener and Maeder (1942), in Berne, treated 256 cases by flights to a height of 12,000 ft. (3,660 metres), each lasting one and a half hours. They reported "abrupt cure" after one flight in 57 (22.8%) and slower cure over about eight days in 80 (32%). They also took 24 cases up the Jungfrau to an altitude of 10,000 ft. (3,050 metres) and kept them there three hours with results that were disappointing. There may have been a counteracting effect here of cold and other factors. A trial of low-pressure chamber treatment, however, in 65 cases taken to the equivalent of 14,000 ft. (4,270 metres) yielded "rapid cure" in 31%, "undoubted

improvement" in 50%, no improvement in 16%, and 3% were made worse. Clantour (1946), in Paris, treated 127 cases by high flying with somewhat similar results. Bergquist (1948) treated 45 children in Stockholm—20 by high flying for 45 minutes and 25 in the low-pressure chamber for 45 minutes. On the basis of this very small experience and the very short period of low-pressure treatment he condemned both methods.

Harporth (1949), in Denmark, compared 101 cases treated by high flying with 59 cases treated by decompression to the equivalent of 3,500 metres (11,500 ft.) for 90 minutes. Other smaller groups were put in the decompression chamber without adequate decompression. The difference in results obtained in the various subgroups of decompression cases was said to be negligible and on this basis he concluded that decompression *per se* had no effect. High flying, however, was thought to be effective. Lalli (1949), of the Italian Air Force, treated 476 cases with three to six flights of 20 to 30 minutes' duration every three or four days for about 15 days. "This is quite a different technique from that of most other observers and the very favourable results reported are difficult to assess considering the length of time that must have elapsed from the start of treatment to the date of assessment of the results."

Discussion

The results which I report here conform reasonably well with those of Matter (1946), Baldy and Richou (1946), and Lauener and Maeder (1942), but the number of cases and the duration of the experiment have considerably exceeded those of any other observer. The method of selection of the cases, the chest radiography, the careful recording of paroxysms and vomits just before and a week after treatment, and the conservative assessment of results by two independent observers may be considered favourable points in this investigation. Nevertheless the results reported are largely derived from subjective assessment. The subjective element in the assessment of results of whooping-cough cannot be wholly avoided but it should be limited, if possible, by the use of controls. I have failed, however, to find a way of conducting a controlled investigation and I see no present prospect of achieving this aim.

It would be quite possible to make controls of each alternate batch of patients by running the motor without producing decompression of any significant amount. The patients might thus be deceived into thinking that they had had the treatment. But such deception would be unlikely to remain long undiscovered. The entire absence of ear symptoms in whole batches of patients would almost certainly arouse suspicion. The net effect would probably be to spoil the existing good relationship with patients and doctors and to stop the flow of patients to the clinic. It might also be possible to conduct a controlled experiment in the same way but with the knowledge and consent of doctors and patients. However, the local practitioners when consulted did not favour this suggestion. All hope of a controlled experiment with the present set-up had therefore to be reluctantly abandoned; and this applied also to in-patients, relatively few of whom are suitable for decompression.

The mechanism of action of the treatment has been the subject of much speculation, but is still unexplained. The low pressure of the air breathed seems to be the essential factor, since results seem to be practically similar whether high flying or the decompression chamber is used. The deeper breathing induced may help to clear mucus from the bronchi and perhaps to aerate small collapsed areas in some yet undetermined way. It is conceivable that molecular release of blood gases may be favoured, both because of the lowered pressure of the alveolar air and because of the trend to alkalosis produced by the increased pulmonary ventilation. Blood CO_2 might thus diffuse more freely through alveolar walls and help to expand collapsed-alveoli and to loosen exudate in the bronchioles; this in turn could

render cough more productive. A study of the composition of the alveolar air combined with estimations of the blood gases, alkali reserve, blood pH, blood pressure, and urinary chlorides of patients while in the chamber might throw some light on the mechanism involved. But these matters are still undetermined largely because of the practical difficulties of obtaining the data in out-patients who are nearly all young children.

Leucocyte counts shed no light on the problem. A transfer of oxidase from neutrophils to red cells was observed by Seabra (1947) in men accustomed to flying at high altitudes. Rats which were decompressed for six days exhibited this transfer and resisted infection better than non-decompressed controls. These facts, however, seem to have little bearing on the effect of a single decompression.

Credit for the apparent good results has been attributed to psychological factors. Many parents certainly come with high expectations and there is a certain amount of emotion aroused in the patients by the novelty of the treatment. But after the start any excitement present soon evaporates. The children tend to become bored and the younger ones usually drop off to sleep. The mothers were warned against extravagant expectations and told categorically that the treatment had a good effect in some cases but in others had no effect at all. This warning was indeed reflected in the statement of their impressions of the result, some asserting roundly that they could see no difference after the treatment. Psychological factors in this series can, I think, be discounted.

Which cases are likely to be successful and which to be failures? It is clear that the treatment is nearly always useless at a stage of the disease earlier than two and a half weeks, that after the sixth week the percentage of apparent successes is apt to drop, and that the "acutely ill" patient is almost certain to be made worse by decompression. But when the cases are properly selected, I can answer this question no better now than I could five and a half years ago. I look upon decompression as a physical treatment which may exert a favourable influence in some unknown way on the course of the disease in a proportion of carefully selected cases. Such a favourable influence may be partially or completely counteracted by other unfavourable influences, such as "catching a cold" or poor environmental domestic circumstances. Whooping-cough not infrequently pursues an erratic course, exacerbation occurring after periods of improvement. In these circumstances the relative uniformity of the results of decompression treatment reported in the more important papers published on the subject is rather remarkable and may be thought to constitute a *prima facie* case in its favour.

A decompression clinic for whooping-cough has outstanding advantages beyond the mere question of decompression treatment. When conducted by an experienced physician it acts as a valuable centre of advice for practitioners in their difficult cases, especially those in which pulmonary collapse is found. The running costs are not high when the staff of the hospital is used, but ambulance transport may be a costly item. This has usually to be provided as a routine on grounds of the infectivity of the patient, at least in the first five weeks of the disease.

Summary

A decompression clinic for the treatment of whooping-cough by means of low air-pressures is described and incidental advantages of such a clinic are suggested.

Of 782 carefully selected and assessed cases, 28.2% were reported to show marked rapid improvement in some four to seven days following decompression, and 34.1% to show more gradual but probably significant improvement. The remainder showed no more than the expected change at that stage of the disease, or no improvement at all.

Of the children who were vomiting food more than once daily 57.7% stopped vomiting within a few days after the treatment, and in another 20% vomiting was relieved.

Decompression treatment is usually unsuccessful at a stage of the disease earlier than two and a half weeks and is harmful to the acutely ill case with pyrexia, cyanosis, or appreciable atelectasis.

The results reported are based on careful selection of cases and combined assessment by parents and doctors. An adequate controlled experiment has not yet been done but should be attempted when opportunity offers.

The mechanism of the action of decompression in whooping-cough has not been elucidated. Further trials should preferably include biochemical studies.

I thank my colleague Dr. L. J. M. Laurent for his valuable co-operation throughout, for reporting on a visit to Dr. Richou and others in Paris in 1948, for his part in the conduct of the clinic, and particularly in the assessment of the results.

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CEREBRAL CYSTICERCOSIS

COMMON BUT UNFAMILIAR MANIFESTATIONS

BY

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Though cerebral infestation with the larval stage of the *Taenia solium* has been recognized since the middle of the last century, it was after the extensive work of MacArthur (1934), Dixon and Smithers (1934), Brailsford (1941), and Dixon and Hargreaves (1944) that cysticercosis was given an important place among the conditions causing epilepsy. So well known is this that the diagnosis is unlikely to escape consideration in a patient suffering convulsions who has lived or served in India or the Far East.

It is the purpose of this paper to emphasize the clinical manifestations of this disease, other than epileptic convulsions, which, though both important and common, have received scant attention in this country. At the same time it will be seen that India and the Far East are not the only, nor even the main, areas where the condition may easily be acquired. Brief illustrative case histories are given, grouped under appropriate sub-headings, but, as will be evident, the same patient may show several different features.

Periods of Disordered Behaviour

This group includes a wide variety of abnormal manifestations, unassociated with any true convulsion, but occurring during periods of disturbed consciousness, accompanied sometimes by involuntary micturition, and often consisting of bizarre or violent behaviour.

Case 1.—A Polish male aged 41 was examined on May 28, 1954. Since 1945 he had been subject to frequent attacks of

violent behaviour, lasting three to five minutes, accompanied occasionally by involuntary micturition, stopping suddenly, and followed by several hours' deep sleep. The day before examination he had, without warning or provocation, attacked a friend with a chair, resisted the restraint of five men, and then suddenly passed into a deep sleep, having no memory of the incident on waking. Physical examination was negative, but a white blood count showed an eosinophilia of 800 to 950 per c.mm. Skull x-ray films were normal, but x-ray films of the thigh muscles showed typical calcified cysticerci. The attacks were greatly improved by the use of primidone.

Case 2.—This patient, a Polish boy aged 11, was born in Austria and had lived five years in the Ukraine. Since early 1954 he had been subject to attacks, usually during breakfast, in which he would make grimacing movements of the face for one minute, then sit quite still staring into space for two or three minutes, then repeat several numbers, and suddenly return to normal, though sometimes a little drowsy afterwards and with slight headache. Physical examination on September 17, 1954, was negative, but a white blood count showed a constant eosinophilia of about 1,000 per c.mm. Stools were normal. X-ray films of the thighs showed calcified cysticerci.

These probably represent attacks of psychomotor epilepsy, and it is remarkable how infrequently the standard leads of the electroencephalogram are of help in cysticercosis. It is possible that the lesions are situated in areas of the temporal lobes which would require more elaborate techniques to demonstrate.

Transient Loss of Function

The sudden loss of use of, or of sensation in, a limb, or the sudden loss of speech, with subsequent rapid recovery, is not uncommon in the early stages of a cerebral neoplasm and in cerebrovascular disease. Episodes of this type are often seen in cerebral cysticercosis, and have on occasion, in apparently healthy young soldiers, been regarded as hysterical.

Case 3.—A British man aged 20 was admitted to the Queen Elizabeth Hospital, Birmingham, on November 10, 1953, complaining of three episodes, in the previous five years, of sudden loss of use of the left hand, with numbness of the hand, rapidly recovering. One attack lasted several hours. He had in addition, and at separate times, had several episodes of unexplained loss of consciousness. He lived the first ten years of his life in India. Physical examination was negative and a full blood count normal. The cerebrospinal fluid contained two mononuclear and one polymorphonuclear cells per c.mm., with 132 mg. of protein per 100 ml., and a paretic Lange curve. The electroencephalogram showed only very occasional 5-6 c/sec. waves occurring synchronously in all leads. X-ray examination of the skull showed a number of small foci of intracerebral calcification, and x-ray films of the thigh muscles showed numerous calcified cysticerci.

Case 4.—A British ex-Regular-Army soldier aged 32 who had spent two periods of service in India and China was admitted to the Queen Elizabeth Hospital, Birmingham, on October 23, 1941, complaining of periods of sudden onset of loss of speech during the previous six years, usually lasting several hours, but on one occasion lasting three days. The most recent attack was accompanied by paralysis of the right arm and leg for several hours, recovery being very rapid. In addition, and at separate times, he had had periods of unexplained loss of consciousness, during one of which he had passed urine, and during another had fought off those who had come to his assistance. Physical examination was negative apart from two small subcutaneous nodules in the left arm and the left thigh. A full blood count and x-ray examination of the skull were normal, but x-ray films of the thigh muscles showed numerous calcified cysticerci. Biopsy showed the subcutaneous nodule from the arm to be a lipoma, but that from the thigh proved to be a cysticercus.

Acute Intermittent Obstructive Hydrocephalus

This, though one of the longest-known non-epileptic manifestations of intracranial cysticercosis, is one of the least well recognized in England. Bruns's symptom-complex (Bruns, 1906) consisted of the sudden onset of violent headache, vomiting, tinnitus, and vertigo, passing on in the more severe attacks to deep coma and even death, and often precipitated by sudden movements of the head. It was considered to be diagnostic of a solitary cysticercus in the fourth ventricle.