THE LUMLEIAN LECTURES ON AËRO-THERAPEUTICS IN LUNG DISEASE.

Delivered before the Royal College of Physicians of London.

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LECTURE III.—BAROMETRIC PRESSURE IN ITS RELATION TO HEALTH AND DISEASE.

It is well known that at sea level barometric pressure is about 30 in., varying from a minimum of 27 in. to a maximum of 31 in.; that it increases on descending into mines, and that, if we could have a shaft sunk vertically forty-five miles into the earth, the air at the bottom would be as dense as quicksilver, while at the summit of the highest mountain of the Himalayas it would be rarefied to the extent of two-thirds. But what we have to deal with is the influence of lower degrees of density or of rarefaction on the human body.

INCREASE OF PRESSURE.

Taking the subject of increase of pressure first, we find our knowledge has been chiefly derived from the experiments of diving bells, pneumatic tubes, or caissons, and the effects on divers.

The symptoms on descending in diving bells depend on the

Diagram 5.—Air Lock of Forth Bridge; vertical section.

depth of water to be traversed, as, of course, the compression of air increases with the depth; but at about 30 feet deep pain and noises in the ears are felt, with a sensation of the head being bound with iron. According to Colladon, these cease on the bottom being reached, and the ascent is not disagreeable, except for a feeling as if the bones of the skull were separating. No change in pulse or respiration is noted, and the above-mentioned symptoms seem due to the rapid descent rather than to the compression of air. Owing to there being no ventilation of these bells, they were soon replaced by diving dresses, to which air was freely supplied, and by pneumatic tubes where atmospheric pressure was used to keep back the flow of water. In these tubes air is compressed to the extent of three to four, and even more, atmospheres,

and a large number of labourers remain at work for several hours at a time.

Caissons.—It may be as well to explain the means employed in pneumatic tubes to accustom the workmen to the great contrast of pressures between the tube and the external air. The caisson is connected with the upper world by shafts which the workmen descend, but at the top or bottom of the shaft—the former to be preferred—is an air lock or iron ante-chamber—well shown in the annexed drawing of the Forth Bridge air lock, furnished by Mr. Moir, one of the engineers, which the men enter, and, closing an air-tight door behind them, admit the compressed air from the caisson by means of a turncock till the pressure has reached the same degree as in the caisson itself, when a communicating door is opened and the men enter. Similarly on leaving the caisson or shaft they shut off the lock and reduce pressure to the normal by blowing off air through a tap into the external atmosphere. It is manifest on the management of this lock or chamber depends the safety and even life of the workmen, and the increase or diminution of pressure should always be made gradually and at a fixed rate. Mr. Moir found that they could endure a rate of pressure diminution of 5 lbs. a minute without danger or suffering, and that most of the accidents occurred when this was exceeded.

"CAISSON DISEASE."

Long exposure to this atmosphere, and more especially the change to air at ordinary pressure, gives rise to various symptoms which have been well described by Pol and other observers, and lately collected together under the title of "caisson disease," by Dr. Andrew Smith,¹ of New York.

Diagram 6.—Air Lock of Forth Bridge; transverse section.

The symptoms are:—severe and often excruciating pains coming on suddenly, commencing in or near both knees, and extending upwards into the trunk, associated with gastric pain and vomiting. The pain principally affects the muscles. In some cases it is followed by paralysis, generally paraplegia of lower extremities, and paralysis of the bladder and rectum. Cerebral symptoms, such as vertigo and headache, are frequently present. The symptoms appear to be the result of congestion of the brain and spinal cord, resulting in sanguineous effusion and congestion of most of the abdominal viscera. The pulse is rapid at first—that is, on leaving the tube—but quiets down afterwards, and resumes the normal in half an hour. The skin is cool, perspiring, and pallid, often

¹ The Physiological, Pathological, and Therapeutical Effects of Compressed Air.

of a leaden tint. The temperature is normal, paralysis is present in various degrees. In Dr. Jaminet's St. Louis cases it occurred in 47 out of 77 workers, or 61 per cent.; at New York, Dr. Andrew Smith found it only in 15 per cent., the difference being explained by the higher pressure used in the St. Louis caisson.

Paralysis most frequently affects the lower half of the body, but it may include the trunk or one or both arms, and affects sensation as well as motion, but the pains in the limbs may continue when they have become insensible to pinching or to pricking. The duration of caisson disease varies from three or four hours to six or eight days. The neuralgic pains do not generally last more than twelve hours, but have sometimes extended to five or six days. The paralysis often disappears in twelve hours, but sometimes lasts weeks. Death usually takes place from coma. The necropsies of patients dying from this disease show, according to Dr. van Rensselaer, congestion and softening of the spinal cord and congestion of the brain. In a few cases meningitis, both cerebral and spinal, was present, and in one case effusion of blood between the arachnoid and the pia mater, but, as most patients recover, the necropsies are few.

The symptoms of caisson disease never appear in the tube itself, but after leaving it, and depend partly on the time spent in the tube, but chiefly on the rapidity with which pressure is diminished, which never ought to exceed 5 lbs. a minute. Some workmen appear more easily affected than others, and the predisposing causes to attack seem to be:

1. Inexperience of the work, newcomers being more easily affected than old hands.

2. Fulness of habit, the full-blooded heavy-built man being more frequently attacked than the slim and wiry.

3. Severe exertion after leaving the caisson, such as ascending a long staircase, which Dr. Smith says may be avoided by using elevators, or by placing the air lock at the top of the shaft as in the North Bridge, instead of at the bottom, as all muscular exertion is more easily borne in the condensed air than in air at normal pressures.

4. Fasting before entering the tube. The remedy in the event of the caisson malady appearing in the air lock is to increase the pressure, when the symptoms gradually disappear.

"DIVERS' DISEASE."

Divers use compressed air in their operations at a depth of 54 metres in the sea, but they have to deal, in addition, with the pressure of the water on their bodies, which at that depth equals 6.4 atmospheres. They suffer from the same symptoms as the workers in pneumatic tubes, only more severely, and it is calculated that the Greek sponge divers have a mortality of 10 per cent. from this cause alone. They have prickings ("les puces," as the French call them), muscular pains which chiefly affect the muscles most used by the divers; pains in the joints, paralysis of different parts, and often paraplegia, including paralysis of the bladder and sphincter ani; all these symptoms generally supervening shortly after the diver has left the water. A *post-mortem* examination made in one case showed extravasation of blood between the spinal dura mater and the arachnoid, and the greater part of the cord in a state of softening.

THERAPEUTIC USES OF COMPRESSED AIR.

We now turn to the therapeutic uses of compressed air, for the application of which two sets of apparatus have been devised.

Methods by which Air is Inspired through a Mask tightly fitting to the Mouth.—A hollow metal cylinder closed at one end is plunged into a second or inverted cylinder containing water, in which it floats owing to the contained air. By means of pulleys and weights, an equilibrium is established, and a pipe is passed from the air cylinder through a drying box to the mask fitted to the patient's nose and mouth, enabling him to respire the air, which can be either rarefied by drawing off the water, or condensed by placing weights on the top of the air cylinder. Hauke's was one of the earliest forms of this; Waldenburg's, which is better known, is a modification of it. Some apparatus, like Cube's and Schnitzler's, consist of two cylinders, one for condensing and the other for rarefying, which can be alternately connected with the patient's mouth; others are constructed on the principle

of the centrifugal pump, by which air is stored up by the action of water. The forms of such apparatus are very numerous, and are to be found elsewhere,² but all are open to two objections: (1) that the use of the mask is exceedingly irksome, and often induces headache and faintness; and (2) that it is impossible to keep up a proper supply of air at the requisite pressure, and that consequently there is a danger of re-breathed air.

Compressed Air Baths.—The second form of applying compressed air is by surrounding the patient with an atmosphere of condensed air, as in a bath, a form largely used on the Continent, where no fewer than fifty establishments for this purpose are in operation. For a compressed air bath are necessary:—

1. A strong circular or ovoid wrought iron chamber with arched roof, with walls not thinner than three-sixteenths of an inch, and strengthened with girders and ribs of iron, provided with thick glass windows and a stout closely-fitting door. The size of the chamber to be regulated by the number of persons to be accommodated. The circular one at the Brompton Hospital is arranged for four, and measures 10 feet in diameter by 8 in height. The chamber must be furnished with inlet and outlet pipes, and an air-tight cupboard to pass in food and messages.

2. A compressing apparatus, steam or water power being usually the motor.

3. A reservoir for the reception of air, and to purify or cool it previous to use.

4. Valves to regulate the current to the chamber. The air is supplied from a pure source, and then filtered through cotton wool and, as it were, pumped through the bath, as accumulation is attained by the outlet being smaller than the inlet, and thus many changes of atmosphere are obtained during the sitting, which lasts, as a rule, two hours, half an hour being spent in increasing pressure, one hour in maintaining it at the highest point required, and half an hour for reducing it.

The pressure, for therapeutic purposes, seldom exceeds 10 lbs., two-thirds of an atmosphere, and the increase and decrease is therefore made at the rate of 1 lb. in three minutes. Air invariably rises in temperature during compression and cools during rarefaction, and in summer it is sometimes a great difficulty to keep the chamber cool, even with ice packing in the reservoir.

The effect of compressed air at this moderate pressure on healthy individuals differs considerably from the effect at the high pressures of 30 lbs. and 40 lbs. used in pneumatic tubes. The first sensation, as pressure is increased, is an unpleasant one in the throat, referred to the pharynx immediately behind the tonsil, which is relieved by swallowing saliva or drinking water. Pain is also felt in the membrana tympani. These sensations are due to the different calibres of the external auditory meatus and the Eustachian tube. The Eustachian tube being very much smaller than the external auditory meatus, the column of air penetrates with difficulty to the internal surface of the membrana tympani, and changes of pressure are slowly communicated, whereas through the meatus air passes freely, and causes, under these circumstances, a convexity inwards of the auditory membrane. This is owing to increase of pressure; the opposite takes place during reduction of pressure, for the middle ear is full of air of greater density as the change in it is slow, whereas the external meatus contains air of which the pressure is reduced rapidly; this gives rise to convexity outwards of the membrana tympani, hence the unpleasant sensations of the ear and throat at the beginning and end of the bath. It is said that all the special senses are impaired, but I cannot say I have found this. The voice becomes shrill, and singers often gain a note or two in the bath.

Some years ago I placed two remarkably healthy well-made house-physicians of the Brompton Hospital in the compressed air bath, where they remained three hours and a quarter, and most of my conclusions as to the effect of compressed air on normal subjects are the results of observations carefully taken by these gentlemen on each other, and afterwards checked by myself. The effect on respiration of the compressed air bath is that the individual finds he breathes slower, deeper, and more easily. The respiration rate, according to my observations, falls from 16 or 20 to 14 or 15 at least. Von Vivenot found it fall to 4 or even 3 a minute. Inspiration becomes very easy, but expiration being less easy, the ratio between them undergoes considerable modification, expiration being sometimes twice or three times as long as inspiration. The increased depth of the respiration is shown by Lowndes's spirometer, which invariably gives an increase in the amount of air expired.

² Oertel, *Respiratorische Therapie*.

It would appear that breathing compressed air increases lung capacity, probably by opening up more alveoli, which had previously not been brought into use, and we must suppose that the diminished number of respirations means that their amplitude makes up for their smaller number. The effect on the circulation is that the pulse is slower, smaller in volume, but of increased arterial tension, the capillaries smaller, and the veins less full of blood. The pulse rate diminishes 4 to 20 beats a minute, but on returning to the outer air it returns at once to the normal. Sphygmographic tracings show a lowering in the height of the tidal and diastolic waves.

The effect of the pressure on the circulation was admirably shown by Von Vivenot's observations on a white rabbit in the bath. Under normal pressure, with the rabbit quiet and at liberty, the ears were full of blood, the conjunctival vessels injected, and the iris tinted deep red, but in a compressed air bath the vessels of the conjunctivæ became finer and more pale, and in one experiment they alternately filled and emptied. When pressure was maintained at the maximum the iris and pupil became decolorised, and the ears, seen by transmitted light, showed empty vessels, and the larger vessels were scarcely visible.

From these latter observations the conclusion is that compressed air exercises an intropulsive influence on the circulation, affecting those surfaces most exposed to it, such as the skin and lungs. The blood is thus drawn into the organs protected from air pressure, namely, the brain, heart, liver, kidneys, and spleen. The pressure is exerted more on the capillaries and superficial veins than on the deeper veins and arteries, and its tendency would be to reduce pressure on the right side of the heart, and to increase it on the left. Dr. Burdon Sanderson thus accounts for the slower pulse rate, "the effect of the diminished fulness of the venous system is to retard the filling of the ventricles during the period of relaxation, and consequently to lengthen the diastolic period, and thus diminish the frequency of the pulse."

The introduction of a larger amount of oxygen causes greater absorption by the lungs, and leads to further oxidation and tissue change; this being proved by the bright colour of the blood, seen during bleedings in the bath, by the increase of the carbonic acid exhaled from the lungs, and of urea excreted by the kidneys. Muscular power is augmented, appetite generally improves, and weight is almost invariably gained. The temperature is not materially affected.

EFFECTS OF COMPRESSED AIR IN LUNG DISEASES.

We will now consider the effects of compressed air on various lung diseases, and I may state that my conclusions in the present instance are based on cases from my private notebooks and on 66 patients suffering from various forms of lung disease under my care at the Brompton Hospital treated in these baths,³ most carefully tabulated by my late house-physician, Dr. Horrocks.

Asthma.—Of bronchial asthma there were 15 patients—10 males and 5 females. In 7 asthma was largely complicated with emphysema. The average number of baths taken was 12 to 15. Of these patients, 12 improved and 3 did not improve. Out of 11 whose weights were taken, 9 gained weight—on an average 4½ lbs.—and 2 lost. The measurement of the circumference of the thorax at various levels was made in 7 patients, before and after the baths, and the circumference had increased in 4 and diminished in 3. The spirometer showed an increase of 25 to 33 per cent. in the 3 cases in which this test was applied. The principal effect of the baths on asthma appears to be sedative to the pulmonary plexuses of nerves and the pneumogastric. The attacks are rendered less severe, and, after a course of twenty or thirty baths, the intervals between the attacks become much longer. I do not remember one case where a complete cure was effected, but I recollect several where the patient remained free for months, and, in one instance, for years, from asthma. The effect on the paroxysm is immediate and wonderfully efficacious, and many asthmatics have expressed to me the wish that they could live in the bath and thus be freed from their sufferings. The effect on the emphysema accompanying it, is to reduce it, as percussion and auscultation show.

³ Further details of this treatment are given in my lectures on the *Compressed Air Bath and its Uses in the Treatment of Diseases*. London: Smith, Elder, and Co. 1885.

Chronic Bronchitis and Emphysema.—In chronic bronchitis and emphysema the effect is satisfactory; the cough diminishes and the expectoration is lessened; weight is gained; breathing is easier; but the great feature is the reduction of the emphysema. Examination of the chest shows diminution of the hyper-resonance and a return of the various displaced organs to their normal positions, and cyrtometric measurements give a reduction of the chest circumference at different levels, a reduction varying from ½ to 1½ inch. This indicates that a great deal of emphysema, even in adults, is of a temporary nature, produced often by severe paroxysms of coughing or dyspnoea, and capable of reduction, if respiration be rendered more easy, as in a compressed air atmosphere. In my 33 cases of chronic bronchitis and emphysema, who had on an average eighteen baths, 15 were measured cyrtometrically, and of these 11 were found to have decreased in circumference and 4 to have increased; 26 of the patients improved generally, 5 did not improve, and 2 died, one of heart failure from cardiac dilatation after five baths, and the other from an attack of capillary bronchitis, after having greatly improved from nine baths, when he contracted fresh bronchitis and died later.

Phthisis.—My experience of compressed air in phthisis is not altogether favourable. In 9 of the cases I submitted to the bath there was gain of weight and some diminution of cough and expectoration, and apparently the respiration became freer in the unaffected portions of the lungs, but in 2 cases the bath appeared to bring on hæmoptysis, and in 4 patients hæmoptysis came on during the treatment, though it could not be distinctly connected with it. Beyond the opening up or aëration of portions of the lung which had not been brought into play for some time, I could see none of the improvement resulting from compressed air which is so loudly proclaimed by Oertel and Simonoff, nor could I discover that it facilitated the absorption of lung consolidations or infiltration, though cases of this class were submitted to the bath; or, lastly, that it promoted, as Oertel states, the absorption of serous exudation in acute pleurisy, and tended to expand the compressed lung. My experience is that it exercises no effect in expanding a lung which has been compressed with fluid when the fluid has been removed, and, even after a course of air baths steadily persevered in, the fluid will reaccumulate, and will make itself known by indubitable physical signs, and by the diminishing amount of expiratory power as evidenced by the spirometer.

DECREASE OF PRESSURE.

The influence of diminished atmospheric pressure, or a rarefied atmosphere, on the human body has been tested in more than one way. Aëronauts have ascended in balloons to great heights, and Messrs. Glaisher and Coxwell attained an elevation, where the barometer showed only 9½ in. pressure, equivalent to 29,000 feet. The balloon rose still higher, but Glaisher had lost consciousness and could no longer register, and so the higher elevation was never recorded, though Coxwell fancied he saw the barometer stand at 7 inches, equivalent to a height of 37,000 feet. Mountain climbers, like Mr. Whymper, have reached elevations of 22,000 feet, and have borne the rarefaction, sometimes suffering from the joroche or mountain sickness, sometimes entirely escaping, the symptoms not always coming on at the greatest height, but in Mr. Whymper's case at 16,000 feet. In South America, after acclimatisation, large populations live at great elevations, and both there and in North America mining communities are to be found at altitudes up to 10,000 or 11,000 feet, and in the Rockies the formation of the country rather lends itself to residence at high levels, as there is a gradual rise from the valley of the Mississippi to the west, and step by step till the Rockies themselves are reached, and thus we have a vast tract of country lying at the same altitude as the high Swiss valleys of the Engadine and of Davos, in a more southerly latitude, and, with a warmer and drier climate, containing towns of considerable size.

CLIMATE OF HIGH ALTITUDE SANITARIA.

The climate of high altitude sanatoria necessarily varies with height, and latitude, and position in reference to shelter, winds, and rainfall; but they all possess, in addition to rarefaction of atmosphere, the quality of diathermancy, or the

increased facility by which the sun's rays are transmitted through the attenuated air. The last characteristic arises from rarefaction; and, according to Dr. Denison, causes an increase between sun and shade temperatures of 1° F. for every rise of 235 feet. High altitudes are stated to be aseptic, and this is true as long as there is no special cause to pollute the air. Both in the Alps and Rocky Mountains infusions of meat will keep for a long time exposed to the air in winter, but in villages, where there are large aggregations of human beings or of cattle and horses, the air is no longer purely aseptic, and septic organisms find their way into the infusions, causing putrefaction. Perhaps the diathermancy is the most striking feature of mountain climates, as it affords an explanation of the great solar temperatures which prevail during the day at high altitudes, and of the great nocturnal radiation.

The physiological effects of mountain climates on the organs and functions of patients and of healthy persons is very striking, and has been described by me elsewhere. They are briefly as follows. The skin is tanned by the solar rays, and more especially, according to Dr. Bowles, by the ultra-violet rays; the circulation is at first quickened, and the heart impulse becomes more powerful, but at the end of six or eight weeks the pulse rate becomes less rapid, and it eventually is slower than the normal. The respiration is at first quickened, but after six or eight weeks it also is found to have slowed, and to have gradually fallen to a rate below the normal. The breathing becomes deeper, the inspiration longer, and the expiration more complete.

Coincidentally with these changes there is an extension of the thorax in various directions, causing increase in circumference of 1 to 3 inches at different chest levels. There is also an increase of mobility of the thoracic walls. The cause of this is to be found in the greater physiological activity of the pulmonary organs, due to rarefaction of the atmosphere and consequently their more complete development, and this conclusion is confirmed by two facts: first, that this enlargement is most marked in those who take much exercise at high altitudes; secondly, that it is not always permanent, the thorax and its contents sometimes, though not invariably, reverting to the normal size after return to residence at sea level.

The above effects of mountain climates on the lowlander are confirmed by the features of mountain races themselves. The Indians of the Andes, the guides of the Alps, the chamois hunters of the Tyrol, the hill tribes of the Himalayas, all present the characteristics of a large thorax, deep inspiration, and great power of endurance for walking. Mountain races are, on the whole, wonderfully immune from disease, especially from scrofulous and phthisical disease, but this immunity depends on their avoidance of overcrowding, indoor life, and insufficient dietary, for in the presence of these no altitude could give immunity.

EFFECTS OF HIGH ALTITUDES ON PHTHISIS.

The use of high altitudes in the treatment of phthisis was, according to Dr. Archibald Smith, an established practice in South America for many years before it was introduced into Europe to the notice of medicine by Drs. Archibald Smith himself, Guilbert, Lombard, Jourdanet, Brehmer, and others, but this country owes its first clear scientific knowledge of the treatment to Dr. Hermann Weber, who contributed a valuable paper to vol. lii of the *Medico-Chirurgical Transactions*, entitled "On the Treatment of Phthisis by Prolonged Residence in Elevated Regions," which first directed my attention, and I believe that of others, to the subject, and caused me to pay a special visit in 1872 to Davos and St. Moritz with the object of investigating the climate and its effects. What I found by examining German consumptives at Davos—for there were then no English there—convinced me of the value of the treatment, and as soon as proper arrangements were made for the reception of English invalids, in the shape of an English-speaking doctor and hotels that would cater for English and not only for German requirements, I began sending patients, and I believe I have sent over 300 altogether to winter in these and other high altitude sanitariums. Of these, 247 cases of phthisis have been tabulated and form the basis of statistics which will now be given.

Sex.—183 were males, 64 were females, or, roughly speaking, three-fourths of the former and one-fourth of the latter.

Ages.—The average age for the males was 28 years, and for the females 25.5. As will be seen in the adjoining table, the great mass of both sexes were between 20 and 30; 11 per cent. of the males and 22 per cent. of the females were under 20, and only 7 per cent. of both sexes over 40.

Ages of High Altitude Patients.

	Males.		Females.		Total.	
	No.	Per Centage.	No.	Per Centage.	No.	Per Centage.
10 to 20 years... ..	21	11.00	14	21.87	35	14.16
20 to 30 "	95	51.91	36	56.25	131	53.03
30 to 40 "	48	26.30	11	26.56	59	23.88
40 to 50 "	19	10.38	3	4.70	22	8.90
Total	183		64		247	

The length of illness before climatic treatment was for the whole number 23.89 months; for the males, 19.06 months; for the females, 35.04 months; and this average was thus composed—102 had been ill for less than a year, some for only 2 or 3 months, others for 2, 3, 4, 5, 6, 7, or 8 years, 1 had a history of 9 years, 1 of 10, 2 of 16, and 1 of 20 years.

Family predisposition was present in 97 cases, or 40 per cent.; hæmoptysis in 112, or 45 per cent.

History and Nature of Cases.—The following complications existed: 3 of these patients had malformations of the thorax, of the pigeon-breast type, 1 had spinal curvature, 4 strumous abscesses of various parts of the body, 1 fistula in ano, 2 suffered from tuberculous testicle, 5 had syphilis, 4 had cardiac lesions (1 aortic regurgitant and 3 mitral regurgitant

TABLE III.—Showing the Influence of High Altitude Climates on the Condition of the Lungs in 247 Cases of Consumption.

				Result.											
Stage.	Number.	Percentage.	State of Lungs before Residence at High Altitudes.	Arrest of Disease.	Partial Arrest.	Decrease of Disease.	Stationary.	Advance of Disease.	Advance and Extension.	Unknown.	Arrest.	Improved.	Stationary.	Worse.	
Tubercu- lisation, 1st	161	65	67 had the right lung alone affected	44	15	3	1	1	1	2					
			42 had the left lung alone affected	27	5	1		1	2	1	2				
			52 had both lungs affected	20	18	2	3	2	5	2					
				91	41	6	4	4	8	5	25	87	211		
Softening and Excava- tion + Tubercu- lisation.	86	35	25 had right lung in 2nd or 3rd stage... ..	6	8	3	1	3	2	2					
			12 had right lung in 2nd or 3rd stage, and left in 1st stage	1	3	2	2		2	2					
			22 had left lung in 2nd or 3rd stage	4	7	1	3	4	2	1					
			26 had left lung in 2nd or 3rd stage, and right in 1st stage	3	7	2	3	2	6	3					
			1 had both lungs in 2nd stage					1							
				14	25	8	9	10	12	8		16	55	10	35
				105	66	14	13	14	20	13	24	87	5	19	
Totals				105	66	14	13	14	20	13	24	87	5	19	

Per Cent.
Both lungs affected in 91 = 37
One lung affected in 156 = 63

Per Cent.
Right alone affected in 92 = 37
Left alone affected in 64 = 26

disease), 1 had laryngeal catarrh (not tuberculous), 3 had dry basic pleurisy, 11 were cases of hæmorrhagic phthisis, and 2 of the catarrhal form; the rest of the patients were examples of chronic phthisis, as a rule without pyrexia, the existence of which would at once have precluded the recommendation of high altitudes, my experience being that the climate generally augments pyrexia.

State of Lungs.—Table III shows the state of lungs of these 247 patients before starting for high altitudes, and from this it will be seen that 161, or 65 per cent., were in the first or tuberculous stage, 67 having the right lung, 42 the left lung, and 52 both lungs affected. The extent of tuberculosis varied considerably, from disease of an apex to that of a lobe, but in all cases the lesion was undoubted, and in many the consolidation extensive. Softening and excavation were present in 86, or 35 per cent.; in 37 patients in the right lung, in 48 in the left lung, and in 1 in both lungs. Of the right lung cavity cases the disease was limited to the right lung in 25, in 12 the left lung was also tuberculised. Of the left lung cavity cases the disease was limited to the left lung in 22, and in 26 the right lung also was affected. Summing up, 65 per cent. of the patients were in the tuberculation stage, and 35 per cent. in the softening and excavation stage. The disease was unilateral in 63 per cent., and bilateral in 37 per cent.; the right lung alone was affected in 37 per cent, and the left alone in 26 per cent.

Length of Residence at High Altitudes.—The average residence of these 247 patients at high altitudes was 12.22 months, a little above a year, but this large average is deceptive, as it includes a certain number of persons in whom the disease has been arrested, but who have become residents in the sanatoria. The great mass of these patients have been, on an average, ten months, or about two winters each, at high altitudes; 123 patients passed collectively 123 years and 8 months at Davos, 1 spent 6 months at Arosa, 108 spent 72 years 11 months at St. Moritz, 10 passed 4 years 4 months at Maloja (this when the hotel was open in winter), 2 passed 13 months at Wiesen, 9 passed 22 years 10 months on the South African Highlands, and 6 spent 119 months in Colorado and New Mexico.

General Results.—Among the 246 patients a cure was effected in 101, or 40.89 per cent.; great improvement in 73, or 29.55 per cent.; improvement in 32, or 12.95 per cent.; making a total of improved 206, or 83.40 per cent.; 5 patients remained in a stationary condition, and 36, or 14.57 per cent., became worse. Roughly speaking, nearly seven-eighths improved and one-eighth deteriorated, of whom 48, or 19.43 per cent., died.

Local Results.—I have somewhat varied the classification of results from that of the other groups, making two classes where formerly only one existed, namely, arrest and partial arrest. By arrest is meant in the case of first stage patients, disappearance of all physical signs of disease. This is sometimes so complete that the medical examiner has to refer to his notes to ascertain which lung was affected. In the case of softening and excavation cases, arrest signifies disappearance of cavernous sounds, and even of signs of consolidation, and nothing to be detected beyond deficiency of expansion, some hard breathing over the whole side, and tubular breathing or prolonged expiration above the scapula. In some cases not even these signs are present. In contracted cavity cases there was a certain degree of immobility of the side and flattening of the thoracic wall, combined with hyper-resonance and prolonged expiratory sound.

Partial arrest means that though there is evidence of arrest of the disease, some physical signs remain, indicating limited consolidation or a contracting cavity.

Arrest took place in 105, or 42.85 per cent.

Partial arrest in 66, or 26.83 per cent.

Decrease took place in 14, or 5.71 per cent.

This makes a total of improved of 185, or 75.51 per cent.

In 14 there was advance of disease; in 20 advance and extension; in 13 extension alone, making a total of 47 worse, or 19.18 per cent.; and in 13 patients, or in 5½ per cent., the disease remained stationary.

Among the 159 first staggers, there were 91, or 57.23 per cent. of arrests; 41, or 25.78 per cent. of partial arrest, and 6 decreases; making the large total of 138 improved, or 87 per cent.; and only 10.69 per cent. worse. The improved among unilateral

cases mounted up to 91.5 per cent., the right lung being a shade more favourable than the left lung, but where both apices were involved the percentage of improved was 76.5.

The most surprising feature is the large figure of absolute arrests, which not only were far more numerous than in other climatic results, but were more complete. The "decrease of disease" only forms a very small item in the list.

Now we come to the second and third stages, and we see that in 17, or in 16 per cent., there was "arrest of disease" in 25, or 29 per cent. "partial arrest," and in 8 "decrease of disease," or making a total improved of 47, or 54.5 per cent. Nine patients remained in a stationary condition, and 30 showed either advance, advance and extension, or extension of disease, making a total of 30, or 35 per cent. of worse. The rise in the proportion of the worse among these, as compared with those in the first stage, is very striking, the number being doubled; and this is a good deal due to the double affection patients; as the percentage of improved among the unilateral cavity cases is for the right, 68 per cent., and for the left, 54½ per cent.; whereas for the bilateral it is 49 per cent.

It may be interesting to compare the results of other physicians.

Dr. Herman Weber told us, in discussing a paper of mine read at the Royal Medical and Chirurgical Society, 1888, that out of 106 phthisical patients he sent to high altitudes, 38 were cured, either permanently or temporarily, 42 greatly improved, 16 were stationary or but slightly improved, and 10 deteriorated. Of these 106 cases, 70 were in the first stage, of whom 36 were cured, 28 greatly improved, 11 were stationary, and 6 deteriorated. Of the 36 second and third stages, 2 were cured, 14 improved, 12 were stationary, and 8 deteriorated. These results, though as the general and local improvement is massed into one category it is difficult to make an accurate comparison, on the whole closely resemble my own results, but the cases, as they include a smaller number of second and third stage patients, are more favourable; like mine, they present a very large percentage of improved for first stage cases.

Dr. Fisk,⁴ of Denver, has furnished statistics of 100 phthisicals residing at Denver, only 4 of whom were females, and his results are: 67 per cent. more or less improved, 7 per cent. worse, 26 per cent. of deaths, and he calculates on 2 out of every 3 patients improving in Colorado.

Dr. Solly,⁵ of Colorado Springs, extracted from his notebooks 141 cases of phthisis, and did me the honour to frame his statistics exactly on the same lines as mine. His cases were, altogether, less favourable than mine. The patients had a longer history of illness, had more pyrexial complications, and contained more cavity cases and fewer first staggers. His results were general, and local improvement in 67=37 per cent.; deterioration in 32=63 per cent.

Dr. Denison,⁶ of Denver, published some years ago statistics of 202 consumptives residing in Denver, for an average of 1 year 9 months (a longer stay than that of my patients). They consisted of 148 males and 54 females, with an average history of two years' illness before climatic treatment; 37 per cent. were in the first stage and 63 per cent. in the second and third stages; 56 per cent. had both lungs affected. These patients were far less favourable than mine, but Dr. Denison's results were 69 per cent. improved, 12 per cent. stationary, and 28 per cent. worse—a very successful result, and confirming the above.

To return to my high altitude cases, they appear to warrant the following conclusions:

1. Enlargement of the thorax takes place unless opposed by the growth of fibrosis or by extensive pleuritic adhesions.
2. Males and females seem to do equally well, and profit most between the ages of 20 and 30—males over 30 and females under 20 benefiting least.
3. The climate is specially beneficial in hæmorrhagic cases and in hereditary cases, and appears in the latter class to exercise a distinctly counteracting influence on the development of phthisis.
4. It is most effective in cases of recent date, though of utility in those of long standing, and, to insure its full benefit

⁴ President's Address to Colorado State Society, 1888.

⁵ Sanitarian, February, 1891.

⁶ Rocky Mountain Health Resorts.

at least six months', and in many cases two years' stay is desirable.

5. With regard to the actual results of the climate, it undoubtedly produces great improvement in 75 per cent. of cases of phthisis generally, and in 43 per cent. it causes more or less complete arrest of the tuberculous process.

Its beneficial influence is best shown in tuberculous consolidation, where improvement may be looked for in 87 per cent. and arrest in 57 per cent. Arrest takes place in 16 per cent. of the patients with excavation, and great improvement in 55 per cent.

Residence at high altitudes causes hypertrophy of the healthy lung tissue and local pulmonary emphysema around the tuberculous lesions, giving rise, in due time, to thoracic enlargement. It is possible that arrest of tuberculous disease is partly owing to the pressure exercised on the tuberculous masses by the increasing bulk of surrounding lung tissue, which, by emptying the blood vessels, promotes caseation and cretification of the tubercle.

These changes are accompanied by general improvement in digestion and assimilation, the cessation of all symptoms of disease, the return of natural functions, as the menstrual in females when suspended, gain of weight, colour, muscular, respiratory, and circulatory power.

RELAPSE AFTER LEAVING HIGH ALTITUDES.

There is one important question often asked with regard to cases of arrest by mountain climates, and which is much discussed in the United States. When can they return to low levels, or must they always reside at high altitudes? The opinion of most of the American doctors is that for most patients it is necessary to spend years before quitting the high altitudes, and that often permanent residence is the only safeguard against relapse. Dr. Knight⁷ of Boston insists on a year's residence in Colorado after all symptoms have passed away, but he advises the hereditary cases never to leave. Dr. Solly⁸ thinks 50 per cent. of the arrested phthisis cases may return. Certain it is that very disastrous results have followed an early return to the damp Eastern States, and that a large number of old consumptives have settled down altogether in Colorado, and made it their home. As a rule they are an active energetic community, and are reported to form a considerable proportion of the population of Denver, which numbers 150,000. The medical faculty of that city includes some fine specimens of cured tuberculosis, and at a dinner given in my honour by Dr. Denison, of 10 present the average weight was 200 lbs., 8 of the guests being cases of arrested phthisis. At Colorado Springs the beautiful Cascade Avenue is lined with villas built by consumptives who have found their health and home there. There is a curious fact about these people. Colorado Springs has been in existence twenty-one years as a health resort for consumptives, who have not infrequently intermarried, but in all the families of phthisical intermarriages—and there have been many—as yet no tuberculous cases have appeared among the offspring.

But to return to the question of relapse after quitting high altitudes, judging by my cases, which were chiefly treated at Davos and St. Moritz, relapse is rare, and I have only been hitherto able to trace 20 cases of relapse after leaving the mountains among the 91 arrests. I have kept nearly all the patients tabulated in view, and, if I do not see them, can generally obtain information either from themselves, their relatives, or their medical men.

The only explanation I have to offer of my favourable results is the large preponderance among my patients of first stage cases, demonstrating the advantage of using the high altitude climate before the disease has attacked and destroyed large portions of the lungs, and the strength and vigour of the individual has been sapped by disease. I notice two causes which seriously interfered with the steady progress usual at high altitudes, one being the use of the Koch treatment, which was vigorously pursued during the winter of 1890-91 at Davos, and proved disastrous to several patients, and the other was the influenza, which prevailed very severely at St. Moritz and Davos for two winters, and unquestionably killed a great many of the more weakly patients.

HIGH ALTITUDE STATIONS.

I.—ALPINE RESORTS.

The stations of the Grisons, St. Moritz (6,000 feet), Davos (5,200 feet), Wiesen (4,771 feet), are all well known sanatoria and in every way suitable for winter and summer residence. The climate in winter is cold, with sufficient sunshine to allow of sitting out of doors in the sun's rays, but in the shade it generally freezes. At night the temperature falls far below the freezing point. The mean temperature for the winter varies from 26° to 30° F. The number of rainy or frosty days in winter is 50. Relative humidity is about 40 per cent. Arosa (6,100 feet), in a well sheltered position on the slopes of the Tschuggen stands above its beautiful valley, and is only 5½ hours by diligence from Coire, and fully deserves the commendation bestowed on it by Dr. William Ewart; it is now available for invalids.

Maloja (6,000ft.) with its admirable Kursaal, is only kept open in summer now, and therefore not so available as formerly. Andermatt (4,738 feet) on the St. Gothard route, and Leysin (4,757 feet), in the Canton de Vaud, are also utilised now as winter resorts.

The characteristics of the Alpine winter climate are great cold, combined with freedom from winds and fogs, consequently well borne by even delicate patients, who constantly in mid-winter sleep with their windows open, and walk and sit in the sunshine daily. Snow lies on the ground for three to five months, and the climate promotes abundant exercise, chiefly of the Canadian varieties, such as sleighing, skating, and tobogganing. In April, or before, the snow melts, and the atmosphere becomes exceedingly damp and the roads slushy, and invalids descend to a lower level for at least a month, returning in June for the summer, during which season there is more wind and rain, but not much dust. The good results of these Alpine climates may be judged of by the above statistics of patients, the greater number of whom resided in the Grisons.

2.—SOUTH AFRICA.

The South African mountain stations, where nine of my patients lived with benefit, are situate in the Cape Colony, the Orange Free State, and the Transvaal, at an altitude of from 4,000 to 5,000 feet, the conformation of the country being that of rolling veldt or prairie at a high level. Taking Bloemfontein, the capital of the Orange Free State, as a type, the climate is warm, with seldom any cold even in winter, and delicate persons sleep in the open all the year round, except during the rainy season and a few days of winter. The average minimum is 55° F., the average maximum for the six hot months 82° F., the relative humidity 55 per cent., and the rainfall 17 inches. The number of rainy days 70. It is a splendid climate, and has yielded excellent results in my hands and in that of others, and Cape railways and steamers have rendered the whole district fairly accessible, though the accommodation for invalids is not up to the European standard. In Cape Colony, Aliwal North, Beaufort West, and Matjesfontein in the Great Karoo district, Turkestan, Dordrecht, and Burghersdorp, and Lemoenfontein on the Nieuwveldt mountains, have been established as health resorts, and there will be an extension in this direction when required.

3.—COLORADO AND THE ROCKY MOUNTAINS.

The Rocky Mountain climates⁹, where 6 of the patients resided for periods of 3 to 11 years, with such great benefit, present many advantages, especially to Americans. Owing to the conformation of the country, the whole of the States of Colorado and New Mexico are of altitudes varying from 5,000 feet to 11,000 feet, and even rise to 14,000 feet in the Rocky Mountains themselves. There are three series of elevations suitable for invalid habitation.

1. The prairie plain, east of the Rockies, varying from 5,000 to 6,000 feet in altitude, containing among other places Denver, Boulder, Manitou, and Colorado Springs.

2. The lower range or foothills of the Rockies from 6,000 to 7,000 feet high, with their valleys.

3. The great natural parks at an elevation of from 7,000 to 10,000 feet. These lie in the heart of the Rockies, surrounded

⁷ *Sanitarian*, March, 1891.
⁸ *Op. cit.*

⁹ These are more fully described in my presidential address on the High Altitudes of Colorado, *Quarterly Journal of the Royal Meteorological Society*, 1893.

by mountains, well sheltered from winds, and appear to be the beds of ancient lakes, which have been drained by the formation of rifts or cañons. At present they consist partly of pasture and partly of forests of firs, the forests abounding in game of all sorts, and the pasture land support great herds of cattle. There are North, Middle, South, and San Luis Parks, all of vast extent, besides various smaller ones, such as Estes, Manitou, and Antelope Parks.

Considering the elevation their climate is remarkably mild, snow seldom lying long in winter, while in summer the altitude keeps the air comparatively cool. The parks are well supplied with water, and some, like the Middle Park, have sulphur springs; while railways encircle, and in some cases penetrate into them. Hotels have been established, and accommodation will shortly be improved and extended.

The climate of Colorado is remarkable for its dryness, owing to winds coming from the Pacific being filtered from all moisture by passing over the Sierras and the Rockies before reaching the greater part of Colorado. The result is an average rainfall of 14 inches, which is chiefly precipitated in the form of thunderstorms in the summer and autumn. It is a climate of considerable extremes, with a maximum of 100° F., and a minimum of 7° F., and a mean of 50° F., but the amount of sunshine is remarkable. The sun shines on an average for 330 days out of 365.

The winters are bright and clear, with frosty nights, but scarcely any snow, and on the prairie there is a good deal of wind. The climate on the whole may be described as very dry, and clear and sunny, very windy and abounding in electricity. This estimate is of course modified, according to the elevation, and to the position in regard to the mountain chain.

Compared with Alpine sanatoria Colorado offers the advantage of no snow-melting season, and of allowing continuous residence all the year round in a somewhat warmer and drier climate, but it has the drawbacks of wind and dust, most troublesome in summer. With regard to results, it has not yet produced as favourable statistics as the Swiss. It presents also a great variety of altitude, so that invalids pass their summers camping out in the parks, and leading an open-air life, hunting, shooting, and fishing, while they spend their winters in Denver and Colorado Springs, or in the foothill towns. But perhaps a greater attraction still to many is that, for a large proportion of patients, Colorado offers a prospect of profitable occupation, whether professional or commercial, and the Western people kindly welcome strangers into their rising State, well knowing that there is room for all within its large confines.

EFFECTS OF HIGH ALTITUDES IN OTHER DISEASES.

Before quitting high altitude climates I would mention in what other diseases besides phthisis they prove beneficial:

1. Imperfect thoracic and pulmonary development.
 2. Chronic pneumonia without bronchiectasis.
 3. Chronic pleurisy where the lung has not expanded after removal of the effusion.
 4. Bronchial asthma without emphysema.
- These climates are contraindicated in:
1. Phthisis with double cavities.
 2. Fibroid phthisis, and all cases where the pulmonary area at sea level hardly suffices for respiratory purposes.
 3. Catarrhal and laryngeal phthisis.
 4. Acute phthisis of all kinds, and especially when there is great irritability of the nervous system.
 5. Phthisis with pyrexia, and in pyrexial cases generally.
 6. Emphysema.
 7. Chronic bronchitis and bronchiectasis.
 8. Diseases of the heart and great vessels, except functional ones; diseases of the liver and the kidneys, including all forms of albuminuria (Andrew Clark).
 9. Diseases of the brain and spinal cord, and conditions of hypersensibility of the nervous system.
 10. Anæmia.
 11. In patients of advanced age or too feeble to take exercise.

The subjoined is a good example of the arresting power of the climate.

A young American lady, aged 23, sprung from a healthy stock, was seen by Sir Andrew Clark and myself in consultation with Dr. Brisbane on May 20th, 1878. She had suffered from cough and expectoration, night

sweats and evening pyrexia, and loss of flesh for about two years, and we detected consolidation of the right upper lobe, and cavernous sounds were heard in the first interspace. This lady married an Englishman, and passed two summers in the United (Eastern) States and two winters in England, one in Brighton and one in London, but lost ground, and when Sir Andrew Clark and I saw her again in February, 1881, though we found signs of contraction of the cavity at the right apex; crepitation was heard as low as the fourth rib in front and over the whole surface of the lung posteriorly. In spite of treatment the disease extended, and in May of the same year we discovered that the left apex was attacked. After a careful consideration of the case and a survey of the attendant circumstances, we recommended a year's sojourn at Colorado Springs, for which place she started in June, 1881. Finding it too hot she ascended to Waggon Wheel Gap (9,000 feet), 30 miles further in the Rockies, and resided there for three months with decided improvement. She then returned to Colorado Springs and lived an outdoor life, renouncing drugs, eating heartily, and drinking three quarts of milk a day. She increased in weight 36 lbs., and at one time lost her cough, but later it returned, and when I saw her in 1882 she complained of laryngeal irritation. She had become well bronzed, and complained of my not recognising her, which was perfectly true. The physical signs showed enlargement of the whole thorax, hyper-resonance everywhere; dry cavernous sounds were audible from the clavicle to the third rib on the right side. With the exception of a few fine crepitations in the right axilla, the crepitation had disappeared, but harsh breathing was audible over both lungs. Her walking power was very good. I saw no more of this patient, but when at Colorado Springs last October I heard from Dr. Reed the sequel of the case. The disease remained arrested for seven or eight years, the patient passing her winters at Colorado Springs and her summers in the Eastern States, but early in 1891 she went to New York to try a bacillicide treatment, of which starving was a leading feature, and returned to Colorado Springs in a miserable condition with progressive disease. She did not improve under Dr. Reed's treatment, and so was transferred to the care of a Christian Science lady, and gradually sank in a few weeks, dying in the spring of 1892.

The case is a sad one, but it demonstrates the wonderful arresting power of the climate over the onward march of phthisis, for the progress of the disease in 1881 was such that Sir Andrew Clark and I hesitated before recommending Colorado.

HOME STATIONS.

We have discussed the element of barometric pressure at some length, and time will, I fear, not suffice to enter upon the remaining elements enumerated—namely, *wind-force* and *atmospheric electricity*. Also, unwillingly, the consideration of several important climates, of which I possess statistics, must be omitted, such as Australia, West Indies, and, nearer home, the Mediterranean islands; and, on the Mediterranean and Atlantic coasts, Algiers, Malaga, Tangier, and Biarritz, and others. All these might have been discussed under one or other of the meteorological headings, which formed the basis of my classification; but time fails, and what would, I imagine, be most acceptable to my hearers may be some brief comparisons between the climate results already presented and those of our own home stations. I had not intended introducing these last at all, because they were treated at some length in my Lettsomian Lectures published in 1876; but I have, for the purpose of comparison, extracted the principal results of these patients, adding 49 fresh cases, making in all 292, and have classified them with the same headings as the others in Table IV:

This shows that the largest number of patients tabulated tried the home climates, and the smallest sea voyages; and that the average period of residences was for the Riviera nine months, for the home climates nine months and a-half, and for the high altitudes twelve months, though, as I showed when dealing with the statistics, ten months is nearer the real average of these last, the difference being made up of cured patients who have become residents. The sea voyages are almost impossible to reduce to an average of months, so I have had to make a rough one of voyages, the average being 1.6. The next three columns deal with the lung condition, and give the relative percentages of patients in each category, which do not differ widely, and between the highest and lowest percentages in the first and second and third stage categories there is only a difference of 7 per cent., in bilateral affections only 6 per cent. The high altitude cases seem to be rather the most favourable, and the home climates rather the least, but not markedly so.

The results are very striking. In general results the home climates yield the smallest percentage of improvement, and the largest of worse; next comes the Riviera, not much better; then, with a rise of 12 per cent. improved, are sea voyages, the percentage of worse being still large. High altitudes win easily in all categories, with its 83 per cent. improved, and only 14½ per cent. of worse.

In local results the arrest cases have been made a separate

TABLE IV.—Results of Different Climates Compared.

	No. of Patients	Average Length of Residence.	First Stage.	Second and Third Stages.	Bilateral Affection.	Results.						
						General.			Local.			
						Improved.	Stationary.	Worse.	Arrest.	Improved (including Arrest).	Stationary.	Worse.
		Months.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
High altitudes	247	12.2	65.0	35.0	37.0	83.4	2.02	14.57	42.5	75.5	5.3	19.1
Sea voyages ...	65	1.6 (average of voyage)	63.0	37.0	37.0	77.0	—	21.56	7.7	53.3	10.7	33.8
Riviera... ..	210	9.0	59.0	41.0	36.0	65.2	10.06	24.80	5.9	36.6	17.8	45.6
Home climates	292	9.7	58.0	42.0	42.0	63.7	8.21	28.00	2.0	38.9	20.0	41.1

division, but they are also included under the improvement percentage. We see here that the Riviera comes out worst, except for a large number of arrests. Next we find home climates, then separated by an interval of 14 per cent. more of improved, and 12 per cent. less of worse, are sea voyages. The high altitudes again come out *facile princeps* in all categories with favourable percentages, nearly double these of the Riviera and home climates. Looking calmly at these results, it must be admitted that there is strong evidence in favour of high altitude treatment.

The table does not profess to be perfect, but, considering the number of cases included and the average length of residence, it affords some fair grounds of comparison.

A METHOD OF PERFORMING INTESTINAL ANASTOMOSIS BY MEANS OF DECALCIFIED BONE BOBBINS.¹

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THE principle of lateral anastomosis by means of decalcified bone plates, invented by Dr. Senn, is now recognised as a most valuable surgical procedure, both in intestinal and in stomach surgery. The following method of employing a decalcified bone tube, shaped like a cotton bobbin, is brought forward as another means of accomplishing the anastomosis. The advantages claimed for the method are:

1. Rapidity of execution.
2. Simplicity and ease of performance, only two continuous sutures being required.
3. The avoidance of leaving large plates in the intestine.
4. Security against leakage by the double continuous suture.
5. The certainty of having an adequate and immediately patent opening.
6. The avoidance of the danger of after-closure of the opening by securing continuity of mucous surfaces through the new channel.
7. The avoidance of making incisions in the visceral walls larger than just necessary to admit the tube.
8. The adaptability of the principle to (a) lateral intestinal anastomosis; (b) lateral implantation, as in ileocolostomy; (c) gastro-enterostomy; (d) pylorotomy; (e) end-to-end enterorrhaphy after enterectomy; and (f) cholecystenterostomy.

The operation is performed as follows. For the sake of example let it be supposed that it is required to connect the ileum to the sigmoid flexure of the colon, as was actually done in the first case related.

An incision of 3 inches was made through the parietes of the abdomen in the usual position for inguinal colotomy, a loop of the sigmoid was brought up and drawn between the fingers of the left hand, so as to empty it of blood and of in-

testinal contents, the base of the loop was then encircled with a piece of drainage tube, which was tied in one knot and clamped by pressure forceps. In the same way a loop of ileum was emptied and clamped, both loops being brought outside the abdomen. A large piece of aseptic gauze, wrung out of hot antiseptic solution, was then applied around the loops and over the abdominal wound, so as for the time being to shut up the abdominal cavity.

Fig. 1.—Showing serous suture applied around the posterior half circle.

Nibbed forceps were applied as guides to the ileum and colon where they were to be opened. Two 18-inch long continuous sutures, threaded on curved sewing needles, were ready; the outer, of silk, was applied half an inch from the place where the viscera were to be opened, first to ileum and then to colon alternately, the suture taking up peritoneum and outer muscular coat only, and each suture taking up about one-third of an inch of surface. The suture was commenced on the right, proceeding to the left, the tail end of the suture remaining long, and when the extreme left end was reached the needle was not unthreaded, in order to complete the suturing after the bone tube had been inserted, and the marginal suture completed.

Fig. 2.—Showing the marginal suture applied around the posterior half circle.

The viscera were then incised, the openings being just sufficient to admit the bone tube, but, before its insertion, the marginal suture, which may either be of chromicised catgut or of silk stained with aniline, was applied from right to left, uniting the posterior margins of the two visceral openings, the suture including mucous membrane, the tail of the suture

¹ Read in the Section of Surgery at the Annual Meeting of the British Medical Association, held at Nottingham, July, 1892.