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ON THE CONTINUOUS  
ADMINISTRATION OF NITROUS  
OXIDE AND OXYGEN  
FOR SURGICAL OPERATIONS

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*A Thesis*

By

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Typical Case.

|          |        |         |   |
|----------|--------|---------|---|
| Case I.  | Mrs E. | 2½ min. |   |
| " II.    | A.B.   | 5       | " |
| " III.   | Mrs M. | 12½     | " |
| " IV.    | B.E.   | 20      | " |
| " V.     | E.G.   | 8       | " |
| " VI.    | Mrs M. | 10      | " |
| " VII.   | E.W.   | 10      | " |
| " VIII.  | J.B.   | 20      | " |
| " IX.    | R.F.   | 8       | " |
| " X.     | M.W.   | 10      | " |
| " XI.    | J.B.   | 5       | " |
| " XII.   | G.P.   | 20      | " |
| " XIII.  | I.F.   | 5       | " |
| " XIV.   | K.R.   | 7½      | " |
| " XV.    | F.W.   | 7       | " |
| " XVI.   | G.P.   | 10      | " |
| " XVII.  | T.R.   | 10      | " |
| " XVIII. | L.C.   | 15      | " |
| " XIX.   | A.W.   | 13½     | " |
| " XX.    | F.R.   | 12½     | " |
| " XXI.   | A.W.   | 38      | " |
| " XXII.  | A.R.   | 7½      | " |
| " XXIII. | J.T.   | 6½      | " |

|            |        |                    |      |
|------------|--------|--------------------|------|
| Case XXIV. | Mrs T. | 14                 | min. |
| " XXV      | E.G.   | 15                 | "    |
| " XXVI     | E.W.   | 15                 | "    |
| " XXVII    | J.E.   | 5                  | "    |
| " XXVIII   | E.G.   | ( not continuous ) |      |
| " XXIX     | E.P.   | 8½                 | "    |
| " XXX      | E.W.   | 11                 | "    |
| " XXXI     | A.J.   | 9                  | "    |

Method of description employed - Phenomena of first two stages of Anaesthesia similar in all cases - Character of Anaesthesia during third stage - Highest limit of indicator with satisfactory Anaesthesia - Vomiting during administration - Respiratory trouble - After effects - concluding remarks -



Note The numbers in brackets in the following pages refer to the Bibliography inserted at the end.



Ever since the year 1847, when Dr J.Y.Simpson introduced Chloroform as a " new anaesthetic Agent " in Surgery and Midwifery the question of anaesthetics has been brought prominently before the Medical World. It must be admitted that every agent hitherto used for this purpose has been proved by experience to have its own disadvantages, nor can we say that a perfect anaesthetic has yet been found . By a perfect anaesthetic I mean one which may be administered without risk and which is not disagreeable to the patient, which can abolish during operation all sensation, muscular rigidity and reflex action without interfering with or endangering the vital functions, and which is not followed by any disagreeable after effects.

Unfortunately it must be admitted that now more than fifty years after the introduction of Chloroform as a general anaesthetic but little advance has been made towards either improving the method of its administration or in diminishing the risk attending its use. Ether has been largely employed in Surgical work and is undoubtedly a safer anaesthetic than Chloroform, but it is so disagreeable to the patient and the after effects produced by it are so lasting, that one does not willingly employ it except

in major operations or when a more or less prolonged stay in bed is advisable after operation.

It is not therefore likely to supersede Chloroform in general Surgery and certainly not in Minor operations. Nitrous Oxide at the present day

occupies an important position as an anaesthetic and there is a tendency to extend its application more and more to ordinary Surgical operations.

This Gas has been in use as an anaesthetic since the year 1867, but it was for some time after its introduction regarded as a agent capable only of being applied to Dental work.

Prior to the year 1880, the possibility of a continuous administration of Nitrous Oxide did not occur to those who daily used it for the extraction of teeth.

Anaesthetists seemed content to avail themselves merely of the brief period of unconsciousness produced by the anaesthetic after removal of the face piece, and made no effort to invent a method of administration which would allow of its application to ordinary Surgical operations.

This was due to a widely prevailing misconception as to the true Physiological action of the Gas.

The researches of Paul Bert, Mons Martin, Hillischer and others demonstrated the possibility of producing

*Nitrous Oxide and Oxygen*

a prolonged state of unconsciousness with ~~Oxygen~~ in

*in* definite proportions. Unfortunately their experiments involved the use of a cumbersome and expensive apparatus of tubes, valves, weights and Gasometers, and the results they obtained, though interesting from a Physiological point of view, had little or no bearing on practical anaesthetics.

In more recent years Dr Hewitt has devised a simple and portable apparatus for the administration of Gas and Oxygen, so that it is now possible for those who employ Nitrous Oxide in Dentistry to extend its application if they wish, to the wider field of general operative Surgery.

Previous to the year 1867 and even for some time after that date, Gas was regarded with considerable distrust by Anaesthetists.

It was difficult to obtain pure Nitrous Oxide, the method of its administration was not well understood and the results obtained with it were not reliable. Symptoms of excitement and intoxication were often met with and the anaesthesia produced by it was not always satisfactory.

The first satisfactory apparatus for the administration of Nitrous Oxide was invented by Evans of Paris who gave a demonstration of his method at the National

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Dental Hospital in 1868. Mr Clover produced a further improvement on this inhaler and with his apparatus the results obtained by the anaesthetic became more constant and reliable, and Nitrous Oxide began to be regarded as a valuable agent for producing anaesthesia in Dentistry.

The main factor in producing these better results was the careful exclusion of air and the administration of a pure Nitrous Oxide Gas.

When this improved method of administration came into general use it was noticed that the laughter, excitement and intoxication from which the Gas had obtained its popular name, were seldom met with, but that owing to the rigid exclusion of air, a new train of symptoms closely resembling those of ordinary Asphyxia appeared in their place. (1)

These symptoms were always present when full Anaesthesia was attained, and this fact led to the belief that not only were they necessary phenomena in the production of Anaesthesia by Nitrous Oxide, but that the sole physiological action of the Gas was to produce Asphyxia and hence unconsciousness.

The researches of Paul Bert, who first began to publish his results in 1878 (2) led to a truer knowledge of the physiological action of Nitrous Oxide.

He established the fact that if Gas and Oxygen were breathed in certain proportions and at a certain atmospheric pressure, Anaesthesia could be produced without any lividity, stertor or other asphyxial symptoms, and that a continued administration was therefore possible.

In Feb 15th, 1879.(3) his first experiment on a human subject was successfully carried out.

He used an airtight metal chamber in which the pressure was capable of being raised by the pumps.

This chamber contained a mixture of 85 per cent of Nitrous Oxide and 15 per cent of oxygen, and the combined Gases were administered to the patient by means of a face piece with two valves.

The operation was for avulsion of a toe nail and the patient was thoroughly anaesthetised throughout without any signs or excitement or change in colour.

Dr Hewitt (4,5,6) gives an account of the various endeavours to produce more definite results with mixtures of Gas and Oxygen in fixed proportions and at known pressures.

Experiments were conducted by Mons Martin, Dr Hillischer, Witzel and Dr Wood of Philadelphia with somewhat conflicting results. The most interesting of those experiments was one performed by Mons Martin, (7)

who kept an animal breathing a mixture of 85 per cent Of Nitrous Oxide with 15 per cent of Oxygen, under a pressure of 110 cm., for three consecutive days. The animal was completely narcotised during the administration but suffered no bad effects from the long continued inhalation of Nitrous Oxide.

Dr Hewitts own experiments were on the lines of Paul Bert, but at first he was not so successful.

He published his results in 1889. (6)

At that time he used a Gasometer communicating with cylinders which contained respectively Nitrous Oxide and Oxygen, the separate Gases being allowed to mix in the Gasometer in definite proportions.

The mixture of Gases was kept at a fixed pressure by means of weights and was administered to the patient through an ordinary face piece with valves.

By this apparatus he was able to produce satisfactory Anaesthesia without excitement, stertor or cyanosis.

In 1892 at the Annual Meeting of the British Dental Association (8) he exhibited a new apparatus for the administration of Nitrous Oxide and Oxygen.

In this apparatus there was no necessity for a Gasometer or closed chamber, the Gases being brought together into a mixing cylinder connected with the face piece, while a revolving dial, by opening a series

of apertures admitting Oxygen, allowed the proportion of the Gases to be altered at the will of the administrator. Each of these holes admits to the mixing cylinder from  $3\frac{1}{2}$  to  $1\frac{1}{2}$  per cent of Oxygen, and when all the holes are brought into play the patient is breathing about 14 per cent of Oxygen.

The tension of the Gases which Paul Bert regarded as so important a factor in producing successful Anaesthesia was in this apparatus regulated by the extent to which the rubber Gas bags were distended. He had found that no fixed percentage of Oxygen gave satisfactory results with all subjects, and he considered it best to have a portable apparatus which would allow the administrator to vary the amount of Oxygen given to suit the requirements of his patient.

A further improvement in this apparatus was brought out in 1894. (9) and this arrangement with its air way, expiratory valve, and mixing cylinder with vertical indicator has so far been found sufficient for the application of the mixed Gases both to Dentistry and the continuous administration required in ordinary Surgical operations.

It cannot, however, be regarded as an absolutely perfect apparatus and further modifications are desirable before it can be widely applied to the major operations of Surgery.

Simultaneously with the introduction of Gas and Oxygen for improving and prolonging the Anaesthesia in Dentistry a second modification of the pure Nitrous Oxide method was brought before the Medical World.

Mr G. Rowell at the Annual meeting of the British Dental Association for 1892 described some very good results obtained by him when using Gas combined with air. (11) He says that though gas when diluted very largely with air produces no Anaesthesia at all, and though air if present in any considerable quantity produces an unsatisfactory Anaesthesia, yet it is possible to give a sufficient quantity of air to reduce the Asphyxial symptoms to a minimum and yet render the patient quite unconscious.

By giving air in this way he found that the inhalation period was prolonged and the resulting period of Anaesthesia was also proportionately lengthened.

He used Mr Hewitts face-piece with stop-cock and free airway so that air could be admitted or turned off at the will of the administrator.

He allowed the patient first to breathe pure Nitrous Oxide, then after twelve to eighteen breaths he gave one breath of air through the airway.

Five or six breaths of Gas were then given followed by another breath of air provided the patient showed



no signs of excitement. It was found that two breaths of air given in this way during the inhalation period usually prolonged the period of Anaesthesia from 5 to 10 seconds, and occasionally he was able to give 4 or 5 breaths of air before removal of the face piece without causing signs of excitement.

Mr Caush of Brighton who has shown me this apparatus used by Mr Rowell, tells me that he is able in most cases to obtain Anaesthesia sufficient for extraction lasting for from fifty to sixty seconds after removal of the face piece.

This method of administration is largely employed in Dentistry and has even been used for continuous administration; but it is admitted by its warmest advocates, that it is difficult to obtain satisfactory Anaesthesia with it in the case of alcoholics, muscular subjects and patients with any tendency to spasm of the respiratory muscles.

Beyond a trifling saving of expense it does not appear to have any advantage over the Oxygen method, though an expert no doubt can obtain very satisfactory results with it.

The recent results obtained by Dr Hewitt with definite mixtures of Gas and Oxygen and of Gas and air and published by him in a paper read before the

Royal Medico Cheirurgical Society on the 14th February of this year (12) go far to show the superiority of Oxygen combined with Gas over mixtures of Nitrous Oxide and air. These experiments in the hands of an observer like Dr Hewitt must be regarded as summing up the experience of the Scientific World on the subject and therefore as final.

He took careful notes of 107 cases where measured quantities of Gas and air were administered to patients; 102 cases where corresponding mixtures of Gas and Oxygen were employed to produce Anaesthesia and 22 cases where pure Nitrous Oxide was given.

For purposes of comparison he devised a system by which he allowed a certain number of bad marks for each unsatisfactory symptom observed during Anaesthesia. In each case 200 was the highest possible number of marks allowed for disagreeable symptoms such as convulsions, lividity, stertor, retching, phonation, excitement, reflex movements, after effects and unduly short Anaesthesia.

Taking a case where the mixed Gases were inhaled without discomfort, movement or sound, where there was no alteration in colour or noisy breathing and the Anaesthesia was of a satisfactory duration and not followed by any unpleasant after effects,

the number of marks allowed would be 0.

It was found that in the series of cases where pure Gas was given an average of 93.7 marks had to be allowed for symptoms of unsatisfactory Anaesthesia. When air was used in combination with Gas, better results were obtained, only 58.1 bad marks having to be recorded as an average in the series where 25 per cent of air was administered along with the Nitrous Oxide.

Where Oxygen was employed a still more satisfactory Anaesthesia was obtained and the lowest number reached in the administrations was in the series where 10 per cent of Oxygen was given.

In this series the average number of marks fell as low as 23.

Dr Hewitt (13) considers air not so suitable for eliminating Asphyxial symptoms as Oxygen because the useless Nitrogen replaces the Nitrous Oxide and tends to imperfect Anaesthesia while its action is more uncertain.

These experiments have confirmed his opinion that it is impossible to work with any one proportion of Oxygen, so that in practice the only way to produce a satisfactory Anaesthesia is to employ a movable indicator which allows the administrator to alter the

proportion of Oxygen according to the requirements of each individual case.

Soon after the introduction of Dr Hewitts improved Gas and Oxygen apparatus in 1894 the possibility of using the combination in ordinary Surgical operations suggested itself to Anaesthetists.

Dr Hewitt (14) says he found it a useful Anaesthetic for removing small tumours and other small operations requiring an Anaesthesia not exceeding 60 seconds.

The possibility of its being used in more prolonged operations was not brought before the Medical World till a later date.

Mr Bellamy Gardner in 1896 used Gas and Oxygen for Anaesthesia during the removal of adenoids and was then induced to try it in cases where a continuous administration was required.

His first trial of Nitrous Oxide and Oxygen in an operation not necessitating removal of the face piece was for the scraping out of a tubercular gland.

The duration of the operation was 4½ minutes and the result was in every way satisfactory.

This was in May 24th 1896.

His first article on the subject appeared in the Lancet of June 12th 1897, being followed by another in the Gynaecological Journal for August of the same year.

Having read this article and being in the habit of using Dr Hewitts apparatus for Dental work I decided to employ it wherever practicable in the casualty department and the ordinary operations of the Hospital. I have taken notes of 31 cases in which I have administered Gas and Oxygen continuously with a view to ascertaining how far this Anaesthetic may be regarded as a substitute for Chloroform and Ether in the work of a general Hospital.

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 The Physiology of Nitrous Oxide. ....

I. The action of Nitrous Oxide in the blood.  
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The researches of Dr Oliver and Mr F. C. Garret on the Gases of the blood during Anaesthesia (15) throw important light on this subject.,

In experimenting with rabbits they found that, if Nitrous Oxide was given to the extreme stage of Asphyxia, death ensued from failure of respiration and ultimately cessation of the hearts action.

On examining the blood, it was found that the carbonic acid Gas was diminished, that Nitrous Oxide was present in large quantity and that ~~Oxy~~gen was almost entirely absent.

It is now generally held, (16) that Nitrous Oxide when absorbed into the blood is carried in loose combination with the Haemoglobin of the red blood corpuscles; it displaces the Oxygen of the Haemoglobin

but gives no Oxygen to the tissues, and is expired again unchanged as Nitrous Oxide.

When Oxygen is administered along with Nitrous Oxide, this combination still exists and it is a noticeable feature of the continuous administration that even arterial blood assumes and maintains the dark purple colour caused by this new product.

It is impossible to suppose that sufficient Oxygen could be carried in the blood plasma (at least under ordinary pressures) as a free Gas to maintain the Vital centres at their proper working level.

The conclusion is therefore forced on one, that some of the red blood corpuscles take up the Oxygen, while in others the Haemoglobin remains in combination with the Nitrous Oxide.

This would lead one to suppose that there is a diminished supply of Oxygen to the tissues when Nitrous Oxide is administered in combination with Oxygen, although this deficiency is not great enough to cause any danger to life even in greatly prolonged inhalations.

This partial Oxygen starvation would necessarily lead to a diminished tissue metabolism and thus account for the diminished production of Carbonic Acid Gas.

II. The action of Nitrous Oxide on the heart and Pulmonary circulation.

On this point there is considerable difference of opinion.

Mr G. Johnston holds that the action of Nitrous Oxide is purely that of an Asphyxiant, producing the familiar Asphyxial phenomena of distension of the right side of the heart, venous engorgement and ultimately over distension of the right Auricle and Ventricle.

In support of this theory Mr Johnston conducted a series of experiments (17) the results of which are, briefly, as follows -

In giving pure Nitrous Oxide continuously to Dogs first the left side of the heart became distended, and then the right, the pulmonary arterioles being contracted and the venous system engorged.

These experiments prove in his opinion, that when death occurs from overdose of Nitrous Oxide there is primarily a contraction of the pulmonary arterioles causing over distension of the right side of the heart, then paralysis of respiration and finally cessation of the hearts action.

This is probably correct and is supported by the experiments of Dr Oliver and ~~Mr~~ <sup>reference</sup> Mr Garret already to (15), who found that the heart continued beating for

some time after the respiration stopped and that fairly vigorous cardiac action was always restored by removing a little blood from the over distended right heart.

It must be remembered however that this continuous administration of pure Gas illustrates not the physiological action of Nitrous Oxide on the system, but the combined effects of Gas administration and the total deprivation of Oxygen.

Mr Johnstons experiments are interesting in demonstrating the fact that Asphyxia results from the prolonged administration of pure Nitrous Oxide and that in this condition a reflex contraction of the pulmonary arterioles is the determining factor in the final cessation of the hearts action.

In a series of Check experiments Mr Johnston found that when the muscular coats of the vessels were paralysed by the use of Curare and atropine the heart continued beating for fifteen minutes longer than it did when the pulmonary vessels were not prevented from contracting.

The theory of Mr Johnston that the phenomena of the administration of pure Gas differ in no respect from those of ordinary Asphyxia , is not supported by the observation of other authorities and is practically



untenable now that the physiological effect of Gas administered over several minutes has been observed with the Asphyxial element eliminated.

Dr Hewitt (18). and Mr D. Buxton (19). consider that Nitrous Oxide has per se no specific action on the heart, and that no undue dilatation nor engorgement of the right side is produced by its administration. Mr Buxton has shown that there is a slight fall in the blood pressure during inhalation but that the heart continues to beat steadily on after the respiration has almost ceased, and the hearts action in these circumstances differs completely from the laboured cardiac action and increased blood pressure seen in ordinary Asphyxia.

III. Action of Nitrous Oxide on the Brain and Medulla.

Mr Dudley Buxton (20). has performed a long series of experiments on animals with a view to determine the exact manner in which Nitrous Oxide affects the nerve centres.

He watched the changes taking place under its administration in the brain and Spinal cord of dogs, a portion of whose skulls had been removed by trephine so as to exposethe brain and membranes.

When Gas is given the brain begins to swell and protrudes through the trephine hole .

At first the colour of the membranes is normal, then it becomes purple, while the pulsations diminish in amplitude, .

On discontinuing the administration the pulsations increase, while the colour gradually changes back to normal.

The Spinal cord was also found to swell up when Gas was administered and underwent the same change in colour.

Mr Buxton was able by Cheek experiments to demonstrate the fact that the unconsciousness produced by Gas was not due to any compression caused by this swelling of the brain, and also he discovered that in ordinary Asphyxia there is no swelling of the brain and cord, but rather a diminution in size.

He also points out that the unconsciousness of Asphyxia is produced much more slowly than the Anaesthesia of Nitrous Oxide.

The effect on the brain and Medulla he believes to be a specific one, and it results in the loss of sensation and of the skin and deep reflexes, while on the respiratory and cardiac centres it has, in his opinion, a continuous sedative effect.

Dr Hewitt (6) holds the same view as Mr Buxton, having formed his conclusions independently by

experimenting with Gas and Oxygen.

He points out, that pure Gas is only respirable for a short time and, that its administration produces all the symptoms of Asphyxia, namely, lividity, stertor, jerky breathing, dilatation of the pupils and rapid pulse.

Some of these symptoms are always observed in administering pure Gas before Anaesthesia is attained. These symptoms, however, he does not consider a necessary part of the Anaesthesia (as was formerly supposed) but they are due to the deprivation of Oxygen.

When Oxygen is given along with Gas they do not appear, while the resulting Anaesthesia is as full and complete as when Gas is administered by itself.

There is no doubt that the phenomena of the continuous inhalation of Gas and Oxygen bear out the correctness of Dr Hewitts and Mr Buxtons opinions.

The difficulty is to determine whether the physiological effect of the Gas is due entirely to a specific action on the brain and Medulla or whether the imperfect Oxygenation of the tissues, which, though it does not amount to Asphyxia, is certainly considerable, is to be considered a factor in the resulting Anaesthesia.

I have noticed on the one hand that if over 12 per cent of Oxygen be given along with the Gas for any length of time the Anaesthesia is always unsatisfactory the patient tending to struggle and show signs of excitement.

This fact would appear to support the view that full unconsciousness cannot be maintained without a partial Oxygen starvation.

On the other hand I have noticed, that, if there be impairment of respiration, the Anaesthesia is also incomplete and unsatisfactory even though Asphyxial symptoms are present to the extent of cyanosis and stertor.

This fact is certainly opposed to Mr Johnston's Asphyxial theory and is almost direct proof of the specific action of Nitrous Oxide as an Anaesthetic agent.

If Gas owed its Anaesthetic properties entirely to its producing Asphyxia more or less complete, the patient should be fully unconscious when lividity and stertor supervine, while on the contrary he is less fully under than when breathing the mixture of Nitrous Oxide and Oxygen freely into his lungs.

The truth appears to be that Nitrous Oxide is a true Anaesthetic with a specific action on the brain and Medulla,

and the resulting unconsciousness has features widely different from those produced by the mere deprivation of Oxygen seen in ordinary Asphyxia, yet the physiological effect of the inhalation of this Gas is in part dependent on an impaired Oxygenation of the tissues produced by its combining with the Haemoglobin and thus to a greater or less extent displacing Oxygen from the corpuscles.

The Anaesthesia produced by the combination of Nitrous Oxide and oxygen.

I. As compared with that produced by pure Nitrous Oxide.

The phenomena of pure Nitrous Oxide Anaesthesia as employed in dental work are too familiar to require a detailed description.

It is necessary, however, to point out the more prominent features of the Anaesthesia for purposes of comparison.

With pure Nitrous Oxide Anaesthesia is produced very rapidly, there being full unconsciousness as a rule in from 57 to 60 seconds.

The period of inhalation is limited, the Anaesthetic having to be withdrawn when certain symptoms present themselves.

By the time unconsciousness is reached, signs of Asphyxiation are present, namely deep cyanosis venous engorgement, muscular spasm producing jerky stertorous breathing, and clonic convulsive movements of the limbs.

On discontinuing the administration the Asphyxial symptoms pass off rapidly and consciousness is fully regained in from 30 to 40 seconds.

The return to consciousness of surrounding objects is rather abrupt.

The pupils are widely dilated towards the close of the inhalation and the eyeballs present a markedly blue tinge.

The pulse is very rapid, sometimes as high as 160 per minute, and the tension is low.

When Oxygen is given along with Nitrous Oxide the phenomena of the Anaesthesia are entirely different.

Unconsciousness is produced much more slowly, there being rarely full Anaesthesia before the inhalation has lasted over 110 seconds, and sometimes when the Oxygen is rather pushed the conjunctival reflex does not disappear till the end of the third minute of inhalation.

During the period of inhalation the breathing shows practically no alteration beyond a deepening and

quickenning just before the disappearance of the lid reflex.

As a rule there is less excitement and tendency to struggle than when pure Gas is given, even in the case of neurotic subjects.

The period of inhalation is not limited, and the administration of Gas and Oxygen may be indefinitely prolonged without any unpleasant symptoms presenting themselves. \*

When unconsciousness is reached the lividity, stertor and jactitation seen in the administration of pure Gas are absent.

The colour is perfectly natural, the lips slightly pale but not livid, the breathing is soft and regular and muscular spasm is not present.

On discontinuing the administration there is no sudden change in the appearance of the patient beyond a slight flushing of the cheeks.

Consciousness of surrounding objects returns more gradually than when Gas alone is used and is fully regained in about 60 seconds after removal of the face piece.



The available Anaesthesia is usually regarded as lasting from 44 to 60 seconds, though I have seen cases where full unconsciousness lasted for 90 seconds after the inhalation was stopped.

The pupils are only moderately dilated or normal in size when the lid reflex has ceased and the eyeballs remain unchanged in colour.

The pulse is not so rapid as when under Nitrous Oxide alone, being usually between 100 and 120 beats per minute. The tension is well maintained.

II. The Anaesthesia produced by Nitrous Oxide and Oxygen compared with that by Chloroform and Ether.

(A). Before full unconsciousness is reached.

In Chloroform Anaesthesia the time for the patient to go under is usually from 2 to 3 minutes.

In the administration of Ether this period is rather longer being as a rule from 4 to 5 minutes.

In the case of both Anaesthetics there are very considerable variations from the average time according to the extent to which the Anaesthetic is pushed or otherwise.

With Nitrous Oxide and Oxygen the period before unconsciousness is reached is usually from 110 to 120 seconds, and variations from this limit are very uncommon unless the administrator purposely pushes the Oxygen so as to prolong the inhalation period.

During the first stage of this period the phenomena differ considerably from those presented by a patient under the other two Anaesthetics.

Chloroform, though pleasant to inhale is not relished by most persons in full Anaesthetic strength, while Ether is distinctly disagreeable.

It is almost universal to have patients cough, hold the breath and rapidly open and shut the eyes when inhaling Chloroform, and many struggle against the Anaesthetic and try to pull away the mask.

With Ether the sense of discomfort is much more forcibly manifested and in the majority of cases some persuasion is required to induce the patient to go on breathing the Anaesthetic.

In practically all cases there is irritation of the air passages and tendency to cough.

In marked contrast to all this is the manner in which the mixed Gases are received.

The face piece being applied, *and* one or two breaths given through the airway, the Nitrous Oxide and Oxygen are turned on. Without the least tremor or change in the rate or character of the respirations the mixed Gases are quietly inspired.

The eyes remain closed, the breathing is tranquil and the face perfectly passive.

The whole demeanour of the patient indicates that the administration of this Anaesthetic causes no unpleasant sensation whatever.

In the second stage of Anaesthesia further differences may be noticed.

In Chloroform administration there is always, except in children, some perceptible excitement just before the deeper unconsciousness is reached, and at the same time there is a marked quickening and deepening of the respirations.

In Ether administration this phenomenon is even more accentuated and is accompanied with flushing or even lividity of the face, the pulse becoming full and bounding, and the breathing loud and snoring.

With Nitrous Oxide and Oxygen this stage is passed through very quietly even in the case of alcoholic subjects. There is none of the muttering incoherent talk, the hissing respiration nor the flinging about of the arms so commonly met with when the other Anaesthetics are administered to this class of patient.

I have never found it necessary in the least to restrain the patient, who presents as a rule an appearance closely resembling that of natural sleep.

The only indication of the approaching termination of the second stage is a gradual unclosing of the eyelids, (which hitherto tended to close spasmodically if touched) while at the same time the lids show a tendency to twitch.

While the eyelids are thus gradually opening the respirations become fuller and louder and then suddenly change to the softer type of breathing that denotes full unconsciousness .

These phenomena have been observed by me in about 400 cases and they come on almost invariably at the end of the first minute and a half of inhalation.

When the respirations have become slower and quieter after the temporary quickening it will be found that

the eyeballs are fixed, looking either straight forwards or turned slightly upwards and outwards, and the lid reflex has become sluggish.

By the end of the second minute of inhalation this reflex is entirely gone, and the limbs are well relaxed though they usually do not attain their full degree of flaccidity for another 60 seconds.

When the lid reflex has disappeared the breathing is soft and regular in character, rather more accentuated than that of deep Chloroform Anaesthesia, though quite unlike the noisy snoring respirations of Ether.

As a rule it resembles the quiet full respiration of natural sleep.

(B). During the third stage of Anaesthesia.

(I). Lasting power of the Anaesthetic.

In Chloroform administration the Anaesthesia is very profound and is well maintained, so that once the patient is entirely unconscious the Anaesthetic may be entirely withdrawn at intervals.

In the case of Ether also the administration need not be continuous during the progress of the operation, usually four inhalations of Ether alternating with 4 breaths of air being sufficient to maintain a satisfactory degree of Anaesthesia, while occasionally the face piece may be entirely removed for a short period without the patient showing signs of coming out.

Nitrous Oxide and Oxygen being a Gaseous mixture, its effects are more evanescent and the administration must be absolutely continuous throughout the entire period of the operation.

This Anaesthetic not only has little lasting power, but also the entrance of the least quantity of air under the face piece causes symptoms of imperfect Anaesthesia.

The period of unconsciousness after removal of the face piece is generally calculated to last for from 40 to 60 seconds,.

In the continuous administration this cannot be depended on and three or four full inspirations of air under the face piece would cause the patient to show signs of excitement and would disturb the progress of the Anaesthesia

(2). The degree of Anaesthesia produced by Nitrous Oxide and Oxygen.

Mr Bellamy Gardner, thinks that Nitrous Oxide and Oxygen does not produce as absolute a state of unconsciousness as Chloroform and Ether.

Personally, I think the Anaesthesia produced by the mixed Gases is quite as deep as that obtained by the other two Anaesthetics, but it is difficult to maintain a condition of absolute unconsciousness with muscular flaccidity and absence of all reflexes for any length of time without allowing the patient to become unduly cyanosed.

As a rule I find the lid and other reflexes absent during the entire period of operation, but in some cases and especially where a high percentage of Oxygen is being given the patient seems to pass suddenly from deep unconsciousness to a state of imperfect Anaesthesia when the reflexes begin to give trouble.

(3). Effect of Nitrous Oxide and Oxygen on the Respiration.

In certain persons and more particularly in Alcoholics there is a tendency to reflex Muscular Spasm and fixation of the chest wall.

This tendency is met with when Chloroform or Ether is administered to the same class of patient, but is then more easily controlled by pushing the Anaesthetic. Spasm of this kind occurring during the inhalation of Nitrous Oxide and Oxygen is as a rule readily relieved by giving a breath of air through the airway and then continuously though not too rapidly increasing the percentage of Oxygen.

I have, however, seen one case where the spasm was so long continued and the lividity so marked that I decided to abandon the administration of Nitrous Oxide and the operation was completed under Ether.

This is the only case in which I have seen a tendency to struggle while the patient was going under, and I attribute the difficulty in this instance to the fact that the part to be operated on, a crushed finger, was being cleaned up during the early stage of inhalation and thus the patient, a very powerful and highly neurotic man, became excited before consciousness was lost.



Milder forms of spasm are not uncommon and if they are not at once relieved by giving air, are a source of considerable trouble to the administrator, who has to exercise great care to keep his patient under without allowing Asphyxial symptoms to appear.

In ordinary cases the respiration remains regular and tranquil as described at the termination of the second stage of Anaesthesia,.

When it becomes snoring in character the patient is always found to be deeply under, and I regard this change in the breathing as an indication for the percentage of Oxygen to be raised.

In very prolonged administrations when a high percentage of Oxygen is being given, the breathing becomes quieter in character and closely resembles the type of respiration observed in deep Chloroform Anaesthesia.

(4). Effect of Nitrous Oxide and Oxygen on the Pulse Rate.

In Chloroform Anaesthesia there is no fixed pulse rate, the pulse as a rule varying but little from that noted at the commencement of the administration.

Speaking generally there is a slight tendency to slowing of the rate and in some subjects the pulse also gets rather feebler as the Anaesthesia proceeds.

If the pulse is very rapid when the patient comes on the operating table it will continue to beat at a rate above normal during the entire administration.

I have noticed a pulse running at 140 before the administration slow down to 110 when the third stage of Anaesthesia was reached but it remained at that rate during an operation lasting 20 minutes.

A pulse of 98 per minute before the administration of Chloroform slowed down to 82 when the patient became entirely unconscious and a pulse of 80 per minute remained at that rate during the administration

If vomiting occurs there is always a marked acceleration of the pulse rate for a time.

When a patient is under Ether the pulse is full and bounding and for the first ten minutes of Anaesthesia

tends to be rather quicker than normal.

Later on it usually slows down to the normal rate and sometimes I have seen it fall to 60 per minute.

As a general rule Ether may be said to cause slight acceleration of the pulse rate.

If the pulse is rapid when the patient comes on the operating table it remains above normal during the administration,.

I have seen a pulse of 120 per minute before the inhalation of Ether fall to 98 when the patient became unconscious and maintain that rate during the operation.

A pulse of 88 before operation usually remains at that rate, though in a prolonged operation it may slow down to 70.

The pulse under Nitrous Oxide and Oxygen closely resembles that under Ether.

The tension is always good, while its rate is in contrast to the comparatively slow pulse observed under Chloroform and the rapid low tension pulse which is characteristic of the Anaesthesia produced by pure Nitrous Oxide.

The usual rate is from 120 to 100 beats per minute, the number of pulsations sometimes falling to 90.

When the pulse rate falls below 90 I consider it an indication that the patient is not taking the Anaesthetic well.

Nitrous Oxide and Oxygen, therefore, causes a distinct acceleration of the pulse rate which is maintained throughout the entire administration.

A very rapid pulse before inhalation will slow down to 110 or 100 but will not fall below that rate, and a pulse of 80 will be accelerated to 110 or 120, afterwards slowing down to 100 but not as a rule coming back to normal.

#### (5). The Effect of Nitrous Oxide and Oxygen on the pupils.

The state of the pupils forms an important guide to the Anaesthetist as to whether the administration is being properly carried out.

In Chloroform and Ether Anaesthesia the pupils are moderately contracted when the patient is well under, dilating again when the patient is coming out of the Anaesthetic.

This is also the case in the Anaesthesia of Nitrous Oxide and Oxygen.

When the lid reflex has disappeared the pupils are slightly contracted. If the patient becomes sick or gets unduly cyanosed they at once dilate and in extreme cyanosis they become very widely dilated.

It is very important to watch the eyes carefully during the entire administration as not only does the state of the pupils form a useful guide to the Anaesthetist in altering the percentage of Oxygen, but also they give an early indication of the approach of any Asphyxial symptoms.

(6). Effect of Nitrous Oxide and Oxygen on the colour of the skin and mucous surfaces and on the colour of the blood.

In the early part of the administration the colour of the skin is unchanged; the appearance of the patient at this stage differs little from that of a person under Chloroform, and is in marked contrast to the flushed face or livid appearance so commonly observed in the inhalation of Ether.

In many cases of Nitrous Oxide and Oxygen administration I have noticed a slight pink flush in the cheeks at

first, though in a large proportion of cases this is absent. At the end of 10 minutes of inhalation the cheeks are usually slightly cyanosed, though if a large proportion of Oxygen can be tolerated the colour remains perfectly natural.

The lips always show a tendency to moderate cyanosis though the red colour is as a rule not lost till after five or six minutes of inhalation.

Towards the end of a prolonged administration when a larger proportion of Oxygen can be tolerated the colour of the lips approaches more to the natural tint.

The eyeballs as a rule retain their normal white appearance but become slightly blueish in tint when the patient is tending to cyanosis.

When this alteration in colour appears it is an indication for the percentage of Oxygen to be raised.

The colour of the blood is a dark purple in the veins, arteries and capillaries after the first three or four minutes of inhalation, and retains this dark colour throughout the entire administration.

(7), The effect of Nitrous Oxide and Oxygen on the muscles.

Entire muscular relaxation is readily produced and maintained under Chloroform.

In the Anaesthesia of Ether there is a slight tendency to rigidity at first; this, however, gradually passes off and once entire flaccidity of the muscles is *produced it is easily maintained. Muscular relaxation is* readily produced in the administration of Nitrous Oxide and Oxygen but it is difficult to keep it up for any length of time.

If the muscles tend to get rigid at any stage of the administration the Anaesthetist naturally gives a smaller percentage of Oxygen, but if this be unskillfully done the patient may become slightly Asphyxiated and the slight rigidity he is attempting to correct may be changed to the tonic spasm of moderate Asphyxiation.

In many of the cases of continuous administration of the mixed Gases I have obtained complete muscular relaxation throughout the entire Anaesthesia and in all the cases I have had sufficient flaccidity of the muscles to allow of the patient being readily held if desired in the lithotomy position.

(8). Tendency of Nitrous Oxide and Oxygen to produce vomiting.

A small percentage of cases show a persistent tendency to vomit during the administration of any Anaesthetic

In the administration of Chloroform and Ether the awkward period can be usually tided over by pushing the Anaesthetic and getting the patient rapidly under.

This tendency is certainly not so often met with in the inhalation of the mixed Gases.

When vomiting does occur I think it is not due to any action of Nitrous Oxide on the vomiting centre but to a morbid condition of the stomach from undigested food or some other irritant.

I had trouble from this cause in four cases and in all of these there was either undigested food in the stomach or a natural tendency to vomit on the slightest provocation.



( c )

During Recovery.  
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When the face piece is removed after a moderately prolonged inhalation of Nitrous Oxide and Oxygen, the time before consciousness is restored is measured not by minutes as in Chloroform or Ether but by seconds.

After two or three respirations the face flushes up red and the lips regain their normal colour.

In 50 seconds as a rule the patient will respond if spoken to and in one minute from the withdrawal of the Anaesthetic consciousness is fully restored.

The patient generally remains quiet and shows no desire to rouse himself, but if requested to do so will readily sit up or assist in adjusting his clothing.

After five minutes he is quite recovered and able to walk back to the ward.

(D) The after effects of Nitrous Oxide and Oxygen.

The vomiting and prostration following a Chloroform administration are entirely absent as are also the excitement, intoxication and nausea so commonly met with after Ether.

In most cases the patient on recovering consciousness feels slightly dazed for a few minutes but beyond that experiences no discomfort whatever.

In one or two cases I have seen the patient retch while coming round but this action did not seem associated with any discomfort and it was not repeated after leaving the operating theatre.

Some patients complain of giddiness or headache after a prolonged administration but this does not persist for more than an hour or two after the termination of the operation.

The appetite and digestion do not appear to be at all impaired by the inhalation of Nitrous Oxide.

Dangers connected with the administration of Nitrous Oxide and Oxygen.



The physiological action of Nitrous Oxide and Oxygen differs considerably from that of Chloroform and Ether.

It may be well to consider briefly how the three Anaesthetics in general use compare with each other in the frequency and intensity of the dangerous symptoms produced by their administration and also in their record as to fatal results.

Chloroform though our best and most generally used Anaesthetic is admittedly dangerous and has a mortality of 1 in 3,258.

Dr Hewitt (21) considers it so for the following reasons:

It has a slight primary depressing effect on the heart, though in the great majority of cases this is to a degree far short of actual danger.

It renders the subject liable to a reflex syncope through the vagus from disturbance of sensory nerves during the operation.

There is thus a double tendency to depress the hearts action, the one actual, the other potential and a dangerous or fatal syncope is more likely to occur if vomiting supervenes, if there be any

embarrassment of respiration, if there be much disturbance of sensory nerves when the patient is not entirely unconscious or if the subject is in a state of panic.

Should the patient struggle or take very deep breaths and the Anaesthetic be rather pushed, an overdose may readily be given unless great care be exercised, and bad symptoms from this cause come on suddenly and without warning.

Ether is a safer Anaesthetic than Chloroform and has a mortality of only one in 14,897.

Dr Hewitt (22) considers that it has a primary stimulating effect on the heart and produces no special tendency to reflex failure of the circulation. When bad symptoms come on during its administration they are always connected with respiratory difficulty except in greatly debilitated subjects or where severe shock results from the operation.

An overdose is not likely to be given as the change in the respiration gives warning to the Anaesthetist in good time to prevent serious consequences.

Nitrous Oxide as employed in dentistry is undoubtedly a safer Anaesthetic than the other two.

The recorded deaths under this Anaesthetic since its introduction number only 18 - (23) .

Of these fatal cases three were recorded as due to apoplexy resulting from the cerebral congestion.

In looking over the deaths under Nitrous Oxide recorded in the Journal of the British Dental Association and the Lancet between 1889 and 1898 I find 5 fatal cases.

Two of these are reported as due to syncope but it is suggested (24 , 25) that the real cause of death was some obstruction to free respiration, possibly a faulty position of the tongue, preventing the characteristic rapid elimination of the Gas and thus leading to Asphyxia and sudden cardiac failure.

In two cases, Lady Milne's (27) and that of a young girl ~~(28)~~ death was attributed to tight lacing.

In the fifth case (28) the inhalation of Nitrous Oxide had been stopped and Ether was being administered when a sudden failure of respiration occurred followed immediately by cessation of the hearts action.

Possibly in this instance the Ether caused spasm of the respiratory muscles and the already partially dilated

heart was unable to cope with the extra strain thus put upon it.

Nitrous Oxide appears to have no primary depressing effect on the heart or respiration and death does not occur under its administration in healthy subjects.

The determining causes of these fatal accidents appear to have been tight lacing, faulty position of the tongue or some other mechanical obstruction to the respiration acting on a feeble or dilated heart, which could not cope with the strain thrown upon it by a partial Asphyxiation.

Apart from fatal accidents dangerous symptoms have appeared during the administration of pure Nitrous Oxide from the following causes.

(1) Overdose of the Anaesthetic.

No fatal case of overdose has been recorded except when the Gas was self administered.

Mr Bellamy Gardner, in some private notes of his cases records a very interesting instance where an overdose was administered through the foot key becoming jammed, and thus allowing the Gas bag to become

greatly overdistended. The patient was a man of 41, pale and thin but fairly robust.

After a few inspirations of the Nitrous Oxide at high pressure he suddenly stopped breathing.

Jactitation came on, the face being of an ash grey colour and the pulse beating very feebly and rapidly. Though artificial respiration was resorted to at once the pupils went on dilating and general convulsions of a mild type supervened about one minute after the respiration had stopped.

In three minutes natural breathing was restored and the operation was then continued under Ether.

This case bears out Dr Hewitts statement that when an overdose of Nitrous Oxide is administered the respiration fails before any grave symptoms of cardiac depression occur.

Probably a moderate overdose is dangerous only in weakly persons, as a healthy heart can hold out for some time against any extra strain thrown upon it.

(2) Failure of respiration may occur from obstruction caused by falling back of the tongue, by adenoids or other growths at the back of the throat, by muscular spasm or by any mechanical intreferece with the free passage of air after removal of the face piece.

(3) Syncope.

No fatal cases of primary syncope have been recorded. Where partial heart failure has occured it has usually been secondary to respiratory embarrassment.

Nitrous Oxide and Oxygen has so far not been associated with any fatal accident.

It is difficult to estimate the number of administrations of this Anaesthetic for dental work but they must now amount to over 20,000.

Mr Bellamy Gardner (23) states that out of many thousand cases he has only twice seen instances of marked cardiac depression during the inhalation of Nitrous Oxide and Oxygen.

In neither of those cases were the symptoms very alarming.

The addition of Oxygen to Nitrous Oxide eliminates the Asphyxial element and thus appears to render this



combination of Gases the safest Anaesthetic known.

The question may be raised whether in administering Nitrous Oxide and oxygen continuously for surgical operations generally any additional element of danger has to be allowed for.

In surgical operations where Chloroform or Ether has been administered serious symptoms appear to have been caused by cardiac depression either primary or secondary to the shock of the operation, depression accompanying vomiting, or respiratory embarrassment. Failure of respiration has also been the cause of grave symptoms whether due to an overdose of the Anaesthetic or to some obstruction to the free access of air.

Nitrous Oxide and Oxygen do not appear to have any primary depressing effect on the heart.

No fatal cases of reflex syncope have been recorded in Dental work and it is not likely that any additional risk can arise from operations affecting structures which as a rule are less sensitive than the branches of the 5th nerve involved in the extraction of teeth.

The position of the patient, which is usually the

supine one, should also render him less liable to faint than the upright position associated with the Dentist's chair.

Vomiting only rarely occurs and when it does arise during the inhalation of Nitrous Oxide and Oxygen is not accompanied by the symptoms of cardiac depression observed under Chloroform.

There appears therefore to be no additional element of danger from heart failure in the continuous administration of Nitrous Oxide and Oxygen and the risk from this cause need not be seriously considered in the case of adults and children above five years of age.

I make this reservation as to the age of the patients because of an important fact recorded by

Mr Bellamy Gardner in his paper read at the last meeting of the Society of Anaesthetists (23) .

He states that though he has never had trouble from cardiac failure in adults or children above five years of age, he had three cases of syncope when giving this Anaesthetic to infants.

In those cases there appeared to be spasm of the chest wall during the progress of the operation and this was followed by sudden cessation of the pulse and marked pallor.

In each instance the hearts action was restored by prompt treatment, but the symptoms were very alarming.

Mr Gardner considers that in young children the reflexes are much more unstable and that in those cases the shock of the operation induced a reflex syncope similar to that met with under Chloroform.

Failure of respiration may arise during the continuous administration of Nitrous Oxide and Oxygen from an overdose of the Anaesthetic, from muscular spasm, from mechanical obstruction in the respiratory passages or from disease in the lung preventing the entrance of Oxygen.

Danger from these causes is doubtless slightly increased when the administration is continued over a long period.

Fixation of the chest wall and spasm of the respiratory muscles may be due to an imperfect Anaesthesia induced by giving to high a percentage of Oxygen or may arise from the tonic spasm of approaching Asphyxia. An error of judgement on the part of the administrator may do little harm if the face piece be removed as soon as the patient becomes unconscious; but it would cause very serious danger if it led to the wrong treatment for the condition being applied and carried

out over several minutes of inhalation.

I think the main and probably the only serious danger attending the continuous administration of Nitrous Oxide and Oxygen is from this cause; a danger which need not arise if the Anesthetist has already made himself acquainted with the features of this form of Anaesthesia as seen in dental work and exercises ordinary care and watchfulness during the progress of the operation.

Mr Bellamy Gardner has had three or four cases where fixation of the chest wall and temporary cessation of respiration occurred from persistent spasm, and in two cases where I administered the same Anaesthetic I had equally alarming symptoms.

The breathing became imperceptible, the pulse was very rapid and there was marked cyanosis with widely dilated pupils, but on removing the face piece and pressing on the chest wall to stimulate respiration vigorous breathing was rapidly restored and the inhalation proceeded without any further trouble.

Mechanical obstruction to the respiration from falling back of the tongue may be more apt to occur with the patient in the supine position.

I have always kept the jaw well pulled forwards just as in the administration of Chloroform and have never met with any trouble from this cause.

Vomiting of solid food is very rare and only occurred in one of my cases.

If this trouble is met with there need be no special risk to the patient if the face piece be removed and the mouth cleared from the particles of food before resuming the inhalation

As a rule a slight tendency to vomit may be checked by pushing the Anaesthetic just as with Chloroform.

Nitrous Oxide and Oxygen continuously administered is in my opinion a safe Anaesthetic for the following reasons.

It produces no primary cardiac depression except, possibly, in the case of infants, and does not tend to induce any reflex failure of the heart.

It does not induce vomiting and if this symptom does appear it is not accompanied by any marked depression.

It does not produce any irritation of the respiratory tract and any reflex spasm of the muscles that arises may as a rule be readily relieved by giving the patient a breath of air.

The Anaesthetic Gas is so rapidly eliminated, that the transition period between deep Anaesthesia and complete restoration to consciousness with its attendant risks is quickly passed over, and, if an overdose by any inadvertence be given, the Anaesthetic cannot, for the same reason, remain long enough in the system to cause serious danger.

### The Method of Administration.

The apparatus used is Hewitts improved Gas and Oxygen inhaler with mixing cylinder, revolving dial, indicator and stopcock with free airway.

Attached to the double Gas bag are the usual cylinders containing the separate Gases and fixed in a stand by Messrs G. Barth & Coy's "triple union."

It is well to have 100 gallons of Nitrous Oxide, *in the stand* and the Oxygen cylinder for convenience of adjustment corresponds in size to the other cylinders.

The cylinders may be fitted with foot keys or may be placed on a table, and an assistant may be told off to regulate the Gas supply with wrenches, turning off and on as required by a sign from the administrator .

It is well to instruct the assistant previously how to regulate the supply and to point out the importance of keeping the Gas bags evenly distended.

Following the advice of Mr Bellamy Gardner I have enlarged the 9th and 10th holes for the admission of Oxygen so that when the indicator stands at 10 and the Oxygen bags <sup>are</sup> moderately distended the patient is receiving about 20 per cent of Oxygen.

It is always well to give a little Oxygen from the first.

Some administrators always begin with pure Gas for fear of producing excitement, but personally I have found it answer best to commence with the indicator at 1, and then work up the percentage gradually and steadily till the lid reflex disappears, when the indicator as a rule stands at 5 or 6.

When the patient is under, it is well not to push the Oxygen but rather feel ones way carefully, only occasionally working the indicator up to 8 in the first 5 minutes of inhalation.

After that period more Oxygen can be tolerated without symptoms of excitement and the indicator may be kept working between 8, 7 & 6, the administrator passing occasionally back to 5 or 4 if the Anaesthesia does not appear sufficiently deep.

Any marked lividity at this stage is probably due to muscular spasm and is best relieved by giving a breath of air through the airway.

When air is thus given the percentage of Oxygen should always be gradually worked up, beginning with the indicator at 4.

If there be any tendency to vomit, it may be relieved by pushing the Gas slightly, but, if any solid food is brought up, the face piece must be removed and the



mouth cleared before resuming the inhalation.

After 10 minutes' Anaesthesia the indicator may in most cases be kept working between 8 and 7 and after 15 minutes between 9, 8 & 7, though it is well occasionally to pass it back to 6 and 5.

As a rule the 10th hole is kept in reserve and on no account is the indicator to be kept there for more than 2 or 3 inspirations unless the patient be very deeply under and the breathing rather snoring in character.

#### Rules for Administration.

- (1) See that the Gas supply is sufficient, allowing 50 gallons of Nitrous Oxide for every 15 minutes of Anaesthesia.

Always inspect the entire apparatus before commencing, examining the foot keys, the stopcock and especially see that the expiratory valve is working properly.

- (2) Inflate the pneumatic fitting in the face piece.
- (3) Fill the bags for the Gases half full and apply the face piece, allowing the patient to breath air quietly through the airway, so as to see if the expiratory valve is working properly.

On no account allow the patient to be disturbed by any manipulation of the part to be operated on till he loses consciousness.

- (4) If the Oxygen bag is becoming empty during the administration, inflate it and see that the Nitrous Oxide bag is made to correspond with it in size.
- (5) Watch the expiratory valve and the patient's pupils during the entire inhalation and do not let the attention wander for a moment.
- (6) Do not hesitate to give a breath of air if there be muscular spasm with lividity.

Nitrous Oxide and Oxygen is a suitable Anaesthetic for the following class of operations.

The opening of abscesses, fistulas and sinuses.

The scraping of tubercular glands and tubercular infiltrations of the skin.

The breaking down of adhesions in joints.

Operations on fingers and toes .

Circumcisions and operations on the Genitals.

The removal of tumours and cysts.

Minor Gynaological operations and examinations previous to the major operations.

The dressing of cases involving much pain.

In addition to the above class of operations I recommend it as a substitute for Chloroform or Ether in cases where there is much sickness or distress following the administration of those Anaesthetics, in cases where syncope might be apprehended under Chloroform, in cases where the patient is frightened at the idea of having either of the Anaesthetics in general use, and in cases where rapid and complete recovery is desirable.

The special value of the Anaesthetic is in Hospital casualties and case room work, where it is desirable to have the patient able to return home as soon as possible after the operation.

The difficulties connected with the administration of Nitrous Oxide and Oxygen are as follows.

The apparatus is bulky, cumbersome and complicated as compared with our Chloroform and Ether inhalers and is very apt to get out of order.

If the face piece is not accurately fitted, and well pressed down, if the valves are out of gear and not working smoothly or if the pressure in one of the Gas bags is in excess of the other, the Anaesthesia will be unsatisfactory.

The apparatus having been designed for Dental work and the upright position, the administrator finds it awkward to use when the patient is lying on his back.

When the supine position is employed care must be taken to prevent Kinking of the tubes or Gas bags and also it is difficult for the Anaesthetist when stooping over the operating table to get sufficient purchase on the foot keys to allow of their being turned readily and rapidly.

Considerable experience is necessary to secure satisfactory Anaesthesia, as the administrator must study the condition of his patient from moment to moment and regulate the percentage of Oxygen according to

the indications afforded by the state of his pupils, the respirations and the degree of unconsciousness exhibited.

He must also learn to vary the percentage of Oxygen in advance of his patient's condition at the time, increasing the amount, if the degree of Anaesthesia present will allow, but always working the indicator back before the least excitement appears.

On the other hand, if the patient be tending to come out, the Anaesthetist must give less Oxygen, but while doing so must watch for any signs of approaching Asphyxia, and be ready to increase the percentage of Oxygen in time to prevent their actual occurrence.

The Gas bags require careful watching, and considerable experience is required before the Anaesthetist finds himself able to keep them evenly and not overdistended.

Some of these difficulties are inseparable from the use of a gaseous mixture in portable form, but many of them can be obviated by a few alterations in the apparatus.

If the apparatus be properly overhauled before use, the valves seen to be working properly and the fitting of the face piece seen to, the administrator will

not in ordinary cases be troubled with an unsatisfactory Anaesthesia.

The difficulty of the foot keys I have got over by training a nurse to turn the Gases off and on by means of a wrench and keep the gas bags evenly distended during the inhalation.

In this way I found no difficulty in keeping the face piece accurately fitted in any position the Surgeon might desire, and was able to devote my undivided attention to the patient.

Even the changes from the supine to the lithotomy position and again placing the patient on her side have been satisfactorily<sup>ily</sup> carried out without permitting the entrance of air under the face piece.

With experience the administrator gets to know the different types and constitutions to be met with in the operating theatre, and the regulation of the percentage of Oxygen begins to follow fairly fixed rules.

The eye and hand soon get trained to work in concert and the administration becomes less of a conscious effort and more mechanical.

Once the Anaesthesia is well established the patient keeps under with less varying of the percentage of Oxygen and the strain on the administrator is correspondingly diminished.

Nitrous Oxide and Oxygen is not to be recommended as a substitute for Chloroform and is not suitable for all cases.

Unless it is a question of this agent or no Anaesthetic at all, I do not recommend it for operations where absolute muscular relaxation during the entire period is a sine qua non.

Owing to the expense of the Nitrous Oxide and the strain on the Anaesthetist it is not suitable for very prolonged operations.

It does not answer well with children who are frightened by the face piece and are apt to struggle during the early part of the administration, so that the resulting Anaesthesia is often unsatisfactory. In very young children there appears to be risk of reflex cardiac depression.

This Anaesthetic does not give good results where there is any obstruction to the free entrance of air to the lungs, and it cannot be recommended for persons suffering from Bronchitis or lung disease.

Persons with adenoids or other growths in the nasopharynx

and respiratory tracts generally also take the Anaesthetic badly and are apt to become rather livid and give trouble to the administrator if he tries to produce a very profound state of unconsciousness.

For the same reason it is difficult to obtain a satisfactory Anaesthesia where the patient's breathing from fear or other cause is markedly shallow and feeble, and it is always well to see that sufficiently deep and regular respirations are being taken before commencing the inhalation.

The Anaesthesia does not give good results with alcoholics till some experience has been attained by <sup>the</sup> Anaesthetist, but after a little practice a fairly satisfactory Anaesthesia is produced and maintained even with those rather difficult subjects.



The advantages of Nitrous Oxide and Oxygen as an Anaesthetic.

Preparation of the patient for the operation is not so necessary.

The absence of all disagreeable sensations while going under and the almost complete immunity from after effects render it a popular Anaesthetic with one's patients.

The rapid recovery after the inhalation ensures *an important* saving of time to the Hospital staff and is also an advantage to the patient, more particularly in the case of minor Surgical operations.

Owing to the absence of after effects and any disturbance of Gastric digestion the Surgeon will find this agent useful in cases where a small operation or painful dressing has to be frequently repeated.

Patients do not look back on a continuous administration of Nitrous Oxide and Oxygen as a painful but rather as a pleasant experience and the prospect of repeated administrations does not cause any mental distress.

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Notes of Cases.

Typical case of the continuous administration of Nitrous Oxide and Oxygen.

L.C 20 years ~~old~~ - Domestic Servant - rather anaemic.

The operation was the amputation of a thumb for diseased bone.

When placed on the operating table patient was nervous and slightly hysterical. The pulse at this time was 140 per minute. She was placed on her back on the table, the head being raised by a pillow.

A nurse was told off to regulate the supply of the Gases from the cylinders, the foot keys being dispensed with and the cylinders with their attachments being placed on a small table.

The face piece was applied and the patient was allowed to take several breaths of air through the airway, partly to reassure her and partly to test the acting of the expiratory valve.

The indicator was then turned to 1 and two inspirations given, then to 2 for three inspirations, then to 3, and the percentage of Oxygen gradually and steadily raised in this manner till about 20 inspirations had been taken, when the indicator stood at 6.

It was then put back to 5 and kept working between this figure and 6 till the lid reflex had disappeared.

At this stage the pulse was 120 per minute, the breathing slow, quiet and regular, the colour of the face being natural, the pupils moderately dilated and the eyeballs fixed and turned upwards.

The indicator was then raised to 8 and was kept working between 7 and 8 for the rest of the inhalation, After she had been under for 10 minutes the eyeballs were noticed to be slightly blue in colour and the indicator was raised to 10.

The breathing after one or two inspirations became rather stridulous, so she was given one breath of air through the airway and the indicator immediately placed at 7.

It was kept between 7 and 8 for the remainder of the operation which lasted for 15 minutes from the commencement of the preliminary cleansing.

During the introduction of the last stitches there was slight phonation but otherwise the patient was absolutely quiet and the limbs flaccid throughout the entire administration.

Immediately before removal of the face piece the pupils were slightly contracted, the breathing slow and quiet and the colour of the face perfectly natural. The patient regained consciousness in one minute from the cessation of the administration, and in 5 minutes

was able to walk back to the ward.

She retched once on returning to the ward, but otherwise experienced no distress.

Case I.

Mrs E. aet 58 - feeble - broken down - operation  
opening abaccess in leg - Duration 2½ minutes -  
position - supine. Time to go under 2 minutes -  
Character of Anaesthesia very satisfactory.

Cyanosis )  
Stertor ) absent  
Rigidity )

Respiration - Soft snoring - Highest limit of indicator 8. Recovery rapid and complete - After effects none.

Case II.

A. B. aet 32 - operation. Breaking down adhesions in  
Elbow. Duration 5 min - position - sitting up in bed  
Time to go under 2 minutes. Character of Anaesthesia  
Satisfactory.

Cyanosis )  
Stertor ) absent  
Excitement )  
Rigidity - slight  
Respiration - tranquil

Pulse 90 before commencement 120 during Anaesthesia -  
Highest limit or indicator 6 - Recovery rapid - complete  
After effects none.

Case III.

Mrs M. 53. Suffering from slight Bronchitis.

Operation. Opening abscess in palm. Duration 12½ min

Position supine - Time to go under 2 min.

Character of Anaesthesia not entirely satisfactory.

|            |   |  |
|------------|---|--|
| Cyanosis   | } | Present in earlier stages.                 |
| Stertor    |   |  |
| Rigidity   |   |  |
| Excitement | } | Tranquil Anaesthesia produced after 6 min. |
|            |   |  |

Respiration - some reflex spasm at first, - later became fuller and more regular pulse not observed.

Recovery rapid and complete - After effects none.

Highest limit of indicator 4 at first later 7.

Case III. Remarks

This patient was a difficult subject from the fact that respiration was interfered with by a tendency to reflex spasm as well as by the presence of Bronchitis.

She became slightly stertorous once or twice and air had to be admitted 4 times during the administration.

When the spasm had passed off the Anaesthesia was quite satisfactory and free from all signs of excitement and rigidity.

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Case IV.

B. E. aet 23 Operation opening and scraping Sinuses

in shoulder - Duration 20 minutes Position supine

Time to go under 2 minutes.

Character of Anaesthesia very satisfactory, slight excitement in early stage.

Stertor ) absent throughout.

Rigidity } Present to slight extent during first  
Excitement } 5 minutes.

Lividity — present in early stage, but relieved by

giving breath of air.

Highest limit of indicator with satisfactory

Anaesthesia 5, later 7 & 8

Recovery rapid and complete - after effects slight headache.

Case V.

E. G. aet 25 - Feeble and poorly nourished subject.

Operation opening submaxillary abscess.

Duration 8 min - Position supine

Time to go under 2 minutes

Character of Anaesthesia very satisfactory

Cyanosis }  
Excitement } absent throughout.  
Rigidity }

Respiration quiet and regular. Recovery rapid and complete - after effects none.

Highest limit of indicator 7.

Case VI:

Mrs M. 53 - Alcoholic - Operation opening collection of pus near wrist joint - scraping and flushing out.

Duration 10 minutes Position - upright in chair.

Time to go under 2 minutes . Character of Anaesthesia not very satisfactory.

Cyanosis }  
Muscular } Slight present in early stage.  
Spasm }  
Excitement }  
Stertor occurred once after five minutes inhalation, but disappeared on giving two breaths of air.

Respiration rather irregular in character - occasionally snoring. Highest limit of indicator 5.

Air given 4 times during the administration.

Recovery - Rapid - After effects none.

Case VII.

E. W. aet 21 Anaemic - highly nervous.

Operation scraping neglected whitlow, incising and flushing out. Duration 10 minutes Position sitting upright in chair. Time to go under 2 $\frac{1}{4}$  min.

Character of Anaesthesia very satisfactory.

Cyanosis }  
Rigidity } absent throughout.  
Stertor }  
Excitement }

Respiration soft regular and tranquil.

Highest limit of indicator 7. Recovery rapid. After effects. Slight sickness on regaining consciousness, not repeated.

J. B. 20 Muscular man, rather nervous and excitable

Operation - Removal of venereal warts - circumcision

Duration 20 minutes - Position supine - Time to go under

2 minutes Character of Anaesthesia Highly satisfactory

|            |   |                    |
|------------|---|--------------------|
| Cyanosis   | } | absent throughout. |
| Stertor    |   |                    |
| Excitement |   |                    |

Rigidity Slight occurred once, the indicator having been kept for several inspirations at 10.

It passed off on moving indicator back to 4.

Respiration soft, deep and regular .

Highest limit of indicator 8.

Recovery rapid and complete.

After effects none - Walked back to Ward.

Remarks - The breathing was very jerky and irregular before I commenced the inhalation and I made the patient go on breathing air through the airway for 2 minutes before the Anaesthetic was turned on.





the respirations became almost imperceptible and the pupils widely dilated.

I removed the face piece and compressed the chest wall when the breathing gradually returned to normal, the colour improved and the pupils contracted.

The bad symptoms did not last more than 15 seconds, but the appearance of the patient during that period was very alarming. On continuing the inhalation there was no further trouble.

Recovery rapid and complete After effects - slight giddiness.

Highest limit of indicator, early part of inhalation 5 later 8.

Remarks In shifting the patient to the lithotomy position, I neglected to press the face piece well down - air was then admitted and caused excitement and reflex spasm.

With the idea of getting her under more rapidly I put back the indicator to 1 when she became rapidly stertorous and then got partially Asphyxiated.

Had I given a breath of air the spasm would probably have passed off and the disagreeable symptoms have been avoided.

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Case XI.

T. B. aet 18 - male - Strong and well nourished.

Operation Incision down to Tibia for Periostitis.

Duration 5 minutes - Position supine.

Time to go under 2 minutes.

Character of Anaesthesia highly  
satisfactory.

Cyanosis }  
Stertor } absent throughout.  
Rigidity }  
Excitement }

Respiration slow, deep and tranquil.

Highest limit of indicator 8. Recovery rapid.

After effects none.

Case XII.

G. P. 23 F. Mulatto. pale and anaemic -

Operation - Cicatricial contraction of anus dilated  
by bougie

Duration 20 minutes. Time to go under 2½ minutes

Position Lithotomy. Character of Anaesthesia

Highly satisfactory.

Cyanosis }  
Stertor } absent throughout.  
Rigidity }  
Excitement }

Respiration slow, quiet and deep.

Highest limit of indicator 7, Recovery rapid

After effects slight giddiness

Case XIII.

J. F. aet 25 Operation opening and scraping abscess

Duration 5 minutes Position sitting in chair.

Time to go under 2min. Character of Anaesthesia

very satisfactory.

|            |   |                    |
|------------|---|--------------------|
| Cyanosis   | } | absent throughout. |
| Stertor    |   |                    |
| Excitement |   |                    |
| Rigidity   |   |                    |

Respiration soft snoring - Highest limit of indicator

6 - Recovery rapid - After effects none.

Case XIV.

K. R. aet 15 - anaemic - Operation opening and

scraping abscess in neck - Duration 7½ minutes

Position sitting in chair - Time to go under 2 min.

Character of Anaesthesia very satisfactory.

|            |   |                    |
|------------|---|--------------------|
| Cyanosis   | } | absent throughout. |
| Stertor    |   |                    |
| Excitement |   |                    |
| Lividity   |   |                    |

Respiration soft and tranquil.

Highest limit of indicator 7.

Recovery rapid - After effects none.

F. W. 22 - pale and rather stout, suffering from adenoids. Operation opening deep abscess over coccyx - Duration 7 minutes - Position first supine then lithotomy, then on left side.  
Time to go under 2 minutes.

Anaesthesia not very satisfactory.

Cyanosis ) appeared (slight) when just under -  
Stertor ) ceased on giving a breath of air.

Rigidity ) present when patient had been under for  
**Excitement**) 3 minutes, then passed off and returned at the end of the administration.

Vomiting occurred just as the operation was completed and before the patient had regained consciousness.

Respiration quiet and regular except at early stage of administration when there was stertor.

Highest limit of indicator 5.

Recovery rapid.

After effects Giddiness and headache.

Remarks This was a difficult subject owing to the presence of adenoids and a tendency to shallow breathing. The repeated changes of position also embarrassed the Anaesthetist and rendered it difficult to keep the patient sufficiently under - Too low a percentage of Oxygen was given at the commencement; hence the stertorous breathing.

Case XVI.

G. P.(F) Mulato - pale and anaemic - Operation  
examination of Rectum

Duration 10 min. Position lithotomy Time to go under.  
2 minutes Character of Anaesthesia very satisfactory.

Cyanosis }  
Stertor } absent throughout.  
Rigidity }  
Excitement }

Respiration slow, deep and tranquil - Limit of indicator

8 Recovery rapid After effects none.

Case XVII.

T. R. 25 - (F) anaemic - Operation Incision for  
fissure of Rectum. Position lithotomy Duration 10 min.

Time to go under 2 min - air given through airway

for 1 minute before turning on Gas -

Character<sup>of</sup> Anaesthesia very satisfactory.

Cyanosis }  
Stertor } absent throughout.  
Rigidity }  
Excitement }

Phonation slight at 5th minute, checked by moving  
indicator from 6 to 4 -

Respiration slow, deep and regular -

Highest limit of indicator early stage 5, later 8 -

Recovery rapid - After effects none.

Case XVIII.

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L. C. aet 20 - pale anaemic subject and very nervous

Operation amputation of thumb.

Duration 15 minutes - Position supine.

Time to go under 2 minutes.

Character of Anaesthesia - Highly satisfactory.

Cyanosis }  
Stertor } absent.  
Rigidity }  
Excitement }

Respiration - Tranquil - slightly stridulous after  
10 minutes' Anaesthesia - this relieved by giving  
breath of air through airway.

Pulse when on table 140  
when fully under 120

Highest figure reached by indicator, early stage 7

later stage 9 - Recovery rapid and complete -

After effects none.

Case XIX.

A. W. 14 - Operation skin grafting and scraping  
stump of finger.

Duration 13½ minutes - position Supine.

Time to go under 2¼ minutes.

Character of Anaesthesia satisfactory.

Cyanosis }  
Stertor } absent.

Rigidity } Slight in early part  
Phonation } of administration.  
Excitement )

Vomiting occurred when patient had been under for 8 minutes but ceased when the Anaesthetic was pushed, and did not necessitate removal of face piece.

Respiration Tranquil.

Pulse when on operating table 88.  
when lid reflex gone 120.  
during vomiting 145.  
Towards close of administration 106.

After effects - Vomiting once on removal of face piece, but not repeated. After return to the ward complained of giddiness and slight headache.

Remarks This patient had Chloroform for an operation on her fingers about 7 days previous to the gas administration and had vomited incessantly for 3 days after it. The contrast between the after effects of the two Anaesthetics was very striking.

Case XX.

F. R. 12 - Operation scraping tubercular sinuses round elbow. Duration 12½ minutes Position supine.

Time to go under 2 minutes.

Anaesthesia satisfactory.

Cyanosis )  
Stertor ) absent throughout.  
Rigidity )  
Excitement )

Vomiting occurred once during inhalation.

Respiration - slow, quiet and regular except during the vomiting.



Pupils contracted, dilated when patient became sick.

Pulse before administration 88

during inhalation 120.

Recovery rapid After effects none

Highest limit of indicator 6 later 8.

Remarks - Too high a percentage of Oxygen was given at first, hence the onset of vomiting.

This sickness was merely a retching and no food material was brought up. I did not remove the face piece but gave one breath of air through the airway, at the same time tilting the apparatus on one side to allow of the escape of mucus and saliva. I then resumed the administration with indicator at 4 when the symptoms rapidly subsided.

The rest of the time the Anaesthesia was perfectly satisfactory.

Case XXI

A. W. 36 - Healthy florid looking woman.

Operation - Searching for needle in hand, 4 incisions.

Duration 38 minutes - position supine.

Time to go under 2 1/2 min. Character of Anaesthesia

very satisfactory.

Cyanosis present twice during first 10 minutes.

Stertor present just as the lid reflex disappeared -  
ceased on giving two breaths of air.

Rigidity )  
Phonation ) appeared twice in the first 10 min.  
Excitement )

Breathing slow quiet and regular after 10 minutes.

Pulse Before administration 96.  
During Anaesthesia 108.

Highest limit of indicator during 1st 18 minutes 5  
during last 20 minutes 8 - 4 breaths of air given in  
the first 13 minutes.

Recovery rather slow - patient did not rouse herself  
for 2 minutes after removal of face piece.

Remarks- The breathing was shallow and jerky at first  
hence the longer period before disappearance  
of the lid reflex, and the tendency to  
stertor. There was spasm and rigidity at  
first and it was difficult to determine  
the exact percentage of Oxygen suitable  
for this patient.  
After 10 minutes the tendency to spasm  
passed off and for the rest of the admin -  
istration the Anaesthesia was perfectly  
satisfactory.

A. R. (F) aet 22 Anaemic and very nervous.

removal of Fibro-Lipoma on deltoïd, and cyst of face.

Duration  $7\frac{1}{2}$  min - position supine

Time to go under  $1\frac{1}{2}$  minutes.

Character of Anaesthesia highly satisfactory.

|            |   |                                 |
|------------|---|---------------------------------|
| Cyanosis   | } | all entirely absent throughout. |
| Stertor    |   |                                 |
| Rigidity   |   |                                 |
| Excitement |   |                                 |

Respiration slow deep and tranquil

Pulse when on table 120.

remained at 120 throughout.

Highest limit of indicator in early stage 6, later 7

Recovery rather slow, fully 90 seconds.

After effects none.

In this case the colour never changed during administration.

The appearance exactly resembled that of natural sleep.

## Case XXIII.

J. T. 13 - Strumous Operation - Circumcision

Duration  $6\frac{1}{2}$  minutes - position supine .

Time to go under 3 minutes. Anaesthesia highly satisfactory.

Cyanosis (slight) appeared twice during administration.

Relieved by giving one breath of air.

|            |   |                    |
|------------|---|--------------------|
| Stertor    | } | absent throughout. |
| Excitement |   |                    |
| Rigidity   |   |                    |

Pupils contracted.

Breathing Shallow at first, later became deep, slow and tranquil.

Recovery rapid.

After effects none - walked home immediately after the operation.

Remarks This boy looked pale and ill and from his appearance I would have apprehended syncope if Chloroform had been used.

Case XXIV.

Mrs T. 32, feeble nervous and suffering from dyspepsia.

Operation removal of small tumour from hand.

Duration 14 minutes position supine.

Time to go under 3 minutes.

Character of Anaesthesia very satisfactory.

Cyanosis present after 6 minutes inhalation, *and* during vomiting.

Stertor  
Rigidity  
Excitement } absent.

Vomiting occurred after 6 minutes and necessitated removal of face piece, owing to the presence of large masses of food in the mouth.

Breathing shallow at first - later deep, slow and tranquil.

|       |   |                       |     |
|-------|---|-----------------------|-----|
| Pulse | { | ordinary              | 86  |
|       |   | before administration | 120 |
|       |   | when under            | 100 |
|       |   | during vomiting       | 120 |
|       |   | later                 | 100 |

Highest limit of indicator, early part of administration 6, ~~later~~ later part 6.

Recovery slow -

After effects headache and giddiness.

Remarks The shallow breathing delayed the disappearance of the lid reflex. This patient evidently had her Gastric digestion inhibited through fear of the operation, the food she brought up being mainly her dinner of the day previous.

After resuming the inhalation the Anaesthesia was quite satisfactory during remainder of operation.

Case XXV.

E. L. Healthy with florid complexion - Operation removal of warty growths from feet. Duration 15 minutes.

Time to go under  $2\frac{1}{2}$  minutes. The breathing was so shallow that the expiratory valve was scarcely raised and I kept her breathing through the airway for 60 seconds before the Anaesthetic was turned on.

Anaesthesia satisfactory.

|            |   |                    |
|------------|---|--------------------|
| Cyanosis   | - | present at times.  |
| Rigidity   | - | rather persistent. |
| Excitement | } | absent.            |
| Stertor    |   |                    |
| Phonation  |   |                    |

Respiration shallow but regular

Pupils contracted.

|              |                       |     |
|--------------|-----------------------|-----|
| <u>Pulse</u> | before administration | 80. |
|              | when under            | 120 |
|              | after 10 minutes      | 140 |
|              | at 14 minutes         | 80  |

Highest limit of indicator 5, air given 5 times during the administration.

Recovery rather tardy and accompanied by retching.

After effects headache.

Remarks This was an anxious case owing to the very shallow breathing. Air was given to prevent any tendency to Asphyxiation from this cause, and not on account of any actual bad symptoms.

Case XXVI.

E. W. aet 17 - placid healthy looking girl.

Operation - dilatation of bladder and injection of Silver Nitrate Solution.

Duration 15 minutes Position lithotomy.

Time to go under 2min. Character of Anaesthesia highly satisfactory.

Cyanosis )  
Stertor ) absent throughout.  
Rigidity )  
Excitement )

Respiration deep and slow, tended to be snoring at times.

Pulse { Before administration 116  
During early stage 116  
After 10 minutes 100  
After 14 minutes 80

Limit of indicator 5, later 7. Pupils slightly dilated at first, later contracted to normal size.

Recovery rapid.

After effects vomited once - This was not accompanied with any distress and the act was not repeated.

Case XXVII.

J. E. aet 38 - wiry robust man.

Operation amputation of crushed finger -

Duration 5 minutes - Position supine Time to go under 2m.

Character of Anaesthesia very satisfactory

Cyanosis occasional very slight, relieved by giving breath of air.

Stertor ) absent throughout.  
Excitement )

Rigidity considerable at intervals.

Respiration regular and snoring - at one period tended to be stridulous from reflex muscular spasm - This was at once relieved by giving a breath of air.

Highest limit of indicator 6 throughout.

Recovery accompanied with vomiting.

After effects none - no distress on regaining consciousness and patient walked home a few minutes after termination of administration.

Remarks I expected trouble with this case as he was obviously an alcoholic, and was surprised to find him take the Anaesthetic so well. He was not conscious of having vomited and said he felt no distress whatever during the inhalation.

Case XXVIII.

E. G. 14 - Delicate girl Operation <sup>Removal of Adenoids</sup> ~~of adenoids from~~  
from Nasopharynx. Position supine - head brought

just to edge of table - afterwards brought over the

edge - Hutchisons spring mouth prop was introduced

between teeth. Time to go under 2 minutes -

Duration of Anaesthesia 45 seconds -

Character of Anaesthesia very satisfactory -

Cyanosis }  
Stertor } absent throughout.  
Rigidity }  
Excitement }

Respiration soft and tranquil - After effects none -

Remarks This was an experimental case to see how the Anaesthetic answered for removal of adenoids and it was found in every way satisfactory.

Case XXIX.

E. P. 12 - pale and delicate child, very nervous,

Operation - opening large abscess in side of neck.

Position supine - Duration 8½ minutes. Breathing very jerky and shallow. Kept inspiring air through airway till respirations got more regular - The Anaesthetic was turned on, but breathing again became <sup>so</sup> shallow and jerky, that I removed face piece and let her come out.

I explained to her that she would have to take full and slow respirations and then resumed the administration. She went under in 2 minutes on this second attempt.

Character of Anaesthesia - very satisfactory.

Cyanosis }  
Excitement } absent.  
Stertor }

Phonation slight towards close of operation.

Respiration full and regular when under.

Pulse before administration 134  
during administration 130  
tension improved steadily during inhalation.

Highest limit of indicator 5 Recovery rapid -  
After effects none - walked home immediately after operation .

Case XXX.

E. W. 17 Same subject as in Case XXVI. Operation dilatation of bladder and injection of silver nitrate solution. Position lithotomy - Duration 11 min.

Time to go under 1½ min Character of Anaesthesia satisfactory.



Cyanosis }  
Stertor } appeared after 6 minutes Anaesthesia.  
Muscular Spasm }

Phonation }  
Excitement } absent throughout.

Respiration snoring in character at first, later be-  
came stertorous and then very faint.  
Deep and regular at close.

Pulse before administration 120  
when under 120  
when Cyanosed 140  
at close of inhalation 120

Recovery slow - After effects headache.  
Highest limit of indicator 5, later 7.

Remarks When muscular spasm came on I did not give  
enough air and failed to raise the indicator  
to a sufficiently high figure - The patient thus  
became partially Asphyxiated, the breathing was very  
faint and the pupils widely dilated for 15 seconds.  
The face piece was removed for a few seconds till the  
breathing improved and the pupils contracted, when  
the inhalation was continued without further trouble.

Case XXXI.

A. J. 12 Operation amputation of crushed finger.

Duration 9 minutes - position supine.

The face piece was too large for the boy's face and  
air was sucked in under it. There was some  
excitement in consequence and he did not go thoroughly  
under for 5 minutes. At the end of this period he  
was breathing quietly and the lid reflex was gone.

Character of Anaesthesia satisfactory.

Cyanosis }  
Rigidity } present during first 3 minutes of  
Anaesthesia.

Respiration - slow and tranquil after 5 minutes.

|              |                        |     |
|--------------|------------------------|-----|
| <u>Pulse</u> | before administration  | 100 |
|              | when lid reflex gone   | 110 |
|              | at close of inhalation | 90  |

Highest limit of indicator 5 later 7.

Recovery slow and accompanied with vomiting of solid food.

After effects none.

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The method I have adopted in describing the above cases may require a few words of explanation. I have not given any details of the Anaesthesia prior to the disappearance of the lid reflex because the phenomena observed during this period were the same in all instances, the only variation being in the time that elapsed before consciousness was entirely lost.

As a rule the lid reflex disappeared in from 110 to 120 seconds. In all the cases described the Anaesthetic was received quietly and without any indication of discomfort.

The character of the Anaesthesia has been described as satisfactory or otherwise according to the absence or presence of phonation, excitement, rigidity or other signs of imperfect Anaesthesia. Even when those phenomena were present to a troublesome degree there did not appear to be any actual consciousness

of pain on the part of the patient.

By the "limit of the indicator" I mean not the highest number at which it was placed during the administration, but the highest number at which it could be allowed to remain without producing signs of imperfect Anaesthesia. In all the administrations **I** have had the indicator at 10 but did not allow it to remain there for more than a few inspirations.

It will be noticed that in all the more prolonged administrations the indicator could be kept at a higher figure after the first 10 minutes, showing that the Anaesthetic has a better lasting power after the patient has been inhaling it for some time.

In 4 cases vomiting occurred during the administration; in only one of these did this occurrence render it necessary to remove the face piece, in the others the tendency to retch ceased on pushing the Anaesthetic.

In two cases there was trouble with the respiration.

The determining cause in each case was shallow breathing and a tendency to reflex muscular spasm.

The temptation, when there is unsatisfactory

Anaesthesia is to push the Anaesthetic so as to render the patient more deeply unconscious, but if the breathing be shallow and an insufficient quantity of Oxygen be entering the lungs there is considerable risk of the Patients receiving an overdose and becoming Asphyxiated.

This was the cause of the temporary failure of respiration in those two instances and I would recommend Anaesthetists to avoid this complication by giving a breath of air and then to allow the indicator to remain at 8 or 9 till the Cyanosis passes off.

I have recorded after effects as occurring in 11 cases out of the 31. In four of those there was vomiting on returning to consciousness but this was not repeated after the patient had left the operating theatre. In four cases headache was complained of after the administration but this symptom did not persist for more than an hour or two.

Three patients complained of slight giddiness for a short time after recovery. In all the other cases there was rapid and complete recovery with no discomfort at all.

From what has been stated it will be seen that Nitrous Oxide and Oxygen continuously administered is an Anaesthetic still on its trial, and that, there

are several serious disadvantages connected with its use. There are also distinct limitation to its application in Surgery as a universal general Anaesthetic. On the other hand its advantages are numerous enough to justify us in using it in preference to Chloroform and Ether in a certain class of cases and when used in those cases it is found to be a useful, safe and reliable Anaesthetic.

In the rapidity with which it produces unconsciousness, the absence of unpleasant sensations on the part of the patient while inhaling it, the rapid recovery and general immunity from unpleasant after effects following its administration, this agent approaches very close to the ideal Anaesthetic and in this respect leaves Ether and Chloroform far behind.

The question of its safety has been fully discussed and I have shown that on Physiological grounds and as far as can be judged from the recorded cases of its administration it is at least as safe an Anaesthetic as Ether.

I have not recommended the use of Nitrous Oxide and Oxygen in the major operations of Surgery because in those cases there is nothing to be gained by a rapid

recovery from the Anaesthetic and, owing to the greater ease with which the subject is kept under and entire muscular relaxation secured, one is inclined to employ an agent such as Chloroform, which is less evanescent in its effects and more under the control of the administrator.

In its own place, which is in the casualty department and wards of our Hospitals, in general practice, for examinations previous to major operations, and in cases where other Anaesthetics are contra - indicated, this agent will be found instrumental in relieving a large amount of suffering hitherto regarded as unavoidable, as the Surgeon by its means will be able to render his patient rapidly unconscious during proceedings for which he would hesitate to employ Chloroform or Ether owing to the discomfort and constitutional disturbance attending their use.

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