The eye having been exposed by means of a self-acting wire speculum, a fine needle, with a stop to it, so as to prevent its passing too far, is introduced in the usual way, and is passed into the centre of the capsule; another needle is then introduced from the opposite point, and entered into the capsule as nearly as possible at the same spot as the other; the points of the two needles are then made to separate from each other, and the capsule is thus effectually torn through.

Cases now and then occur, requiring certain modifications of this plan. Thus, the capsule is sometimes so tough, and at the same time so floating, that the point of the needle introduced through the cornea will not penetrate it. When this is the case, the second needle must be introduced through the sclerotic, and pushed through the capsule from behind. This double action of the needles—one from before, and the other from behind—can be made to penetrate any capsule, however tough and moveable, and it can then be readily torn open. Sometimes a bar of capsule runs across the pupil, and is very difficult to divide. It may be accomplished by introducing the needles at right angles to it, passing the blade of one in front of it, and the other behind it, and then, by pressing them together, cut it through; or, if this is found impossible, by revolving one needle round the other, the band is gradually wound around one until it breaks through. It requires some little practice to manœuvre two needles with dexterity and efficiency; but when the requisite amount of facility is acquired, it is very seldom a case occurs for which it is not available.

Taking into consideration the frequency of these cases, and the insuperable difficulties that formerly existed in their management, I do not hesitate to pronounce this suggestion, simple as it may seem, as the greatest modern operative improvement in ophthalmic surgery.

It occasionally happens that a piece of tough capsule becomes entirely detached, and floats loose in the anterior chamber. When this is the case, it must be extracted. Very rare cases also occur, in which the capsule is attached on one side, and loose on the other, and it is impossible to bring the two needles to bear upon it. Under these circumstances, a small opening must be made in the cornea, and by means of a pair of canular forceps it must be seized and drawn out, great care being necessary, not to drag away the iris or the ciliary processes, and thus permanently damage the eye.

In my next lecture, I propose to describe the operation of extraction.

ON THE

EMPLOYMENT OF CHLOROFORM IN SURGICAL OPERATIONS.

BY JOHN SNOW, M.D.

(*Concluded from p.* 363.)

IT is unnecessary to say anything on the propriety and advantage of administering chloroform in lithotomy, in the larger amputations, and the removal of tumours of the breast, for I believe the whole of the profession agree on this point. There is still, however, some difference of opinion as to the propriety of giving it in lithotrity. It has been said that the surgeon requires the assistance of the patient's sensations, to prevent him from seizing the coats of the bladder in the lithotrite; but if this were the case, I believe that the operation could never have been performed at all. Some patients cry out when they are scarcely touched, whilst others will bear the greatest torture without a murmur. I believe there is very little danger, or even possibility of seizing the bladder with the lithotrite, and that, even if this should take place, the surgeon's sense of touch would be the proper guide to prevent mischief. The greatest sensibility of the bladder appears to be at the neck, and it may fairly be doubted whether seizing the mucous membrane of the cavity would cause much pain. It has always appeared to me that the operation of lithotrity is one in which chloroform prevents very great suffering, and is of the utmost advantage. I will, however, quote the opinion of one who has had much practice in lithotrity both before the introduction of anæsthetic surgery and since, and is therefore better able to judge. Mr. Fergusson says, in his "Practical Surgery,"* "I am of opinion that there is not any department in practical surgery in which anæsthesia has been of more service than in this. Since the earliest period of its introduction I have almost invariably used it on such occasions, and with the best possible effects; and now I no more think of performing the operation of lithotrity without this agent than I would that of lithotomy." Many other surgeons are of the same opinion as Mr. Fergusson, and some of those who are disinclined to use it as a general rule, practically admit its benefits by resorting to its employment in cases where the urinary passages are very irritable, or the patient very intolerant of pain. The operation of lithotrity requires a pretty full dose of chloroform, as, without this, the patient is apt to strain very much and move his legs about.

* Third edition, p. 800.

Some surgeons, and more especially those of Edinburgh, had an objection, at one time, to employ chloroform in large operations about the mouth and nose, and especially in the removal of tumours of the jaw, for fear the blood should flow into the windpipe during the state of insensibility and cause suffocation. However, I have given chloroform in a great number of such cases without any ill effects. Unless the effects of the chloroform are too deep or long-continued, the sensibility of the glottis is not impaired; if a little blood enters the windpipe, it is coughed out again; the patient can hold a little blood in his throat, and breathe through it with a gurgling noise, just as he would in the waking state; and if the quantity of blood begins to embarrass the breathing, the head must be leaned forward to get rid of it, and the same attention paid to the patient which would be paid if chloroform were not used. After the commencement of an operation of this kind, a little chloroform may be given from time to time, on a sponge, as opportunity permits, so as to keep up the insensibility to some extent. I prefer, under these circumstances, to have the chloroform diluted with spirit, in the manner and for the reason that I shall mention further on, in treating of its use on a handkerchief.

A case has been related by Mr. Prescott Hewett, in the Medico-Chirurgical "Transactions," (vol. xxxiv., p. 43,) in which a patient died about half an hour after the removal of the greater portion of a tumour of the upper jaw. He was previously much reduced by hæmorrhage from the tumour, and he fainted before the operation was concluded. He remained much exhausted till the period of his death, though quite conscious. The breathing was not embarrassed until he was moribund, at which time a little blood, which was still oozing from the remains of the tumour was drawn into the trachea, as I was informed by a surgeon who was standing by at the time. This circumstance gave rise to some small spots of ecchymosis, which were found in the lungs after death. It was suggested that in this case blood might have got into the lungs during the insensibility from chloroform, and so have been the cause of death. But, in the first place, the symptoms which were observed during the operation, and for some time afterwards, were simply those of syncope, and not of embarrassed breathing; and, again, the amount of blood met with in the lungs was not enough to cause death, or even acute symptoms of any kind.

Extraction of cataract is an operation in which surgeons hesitated for a long time before employing chloroform. They were afraid lest the vomiting which sometimes attends or follows the use of this agent might be injurious to the eye. Mr. George Pollock and Mr. White Cooper were, I believe, the first surgeons who adopted the use of chloroform in the extraction of cataract; and I have since administered this agent also in many operations of this kind for Mr. Lawrence, Mr. Bowman, Mr. Haynes Walton, and others. Several of the patients were considerably over eighty years of age. By taking care not to give the chloroform too soon after a meal, there has very seldom been vomiting; and although a little vomiting has taken place in a very few of the cases, it was not attended by straining, and, as I understand, did not do harm in any case. I have, indeed, been informed of a case, at which I was not present, where chloroform was given, and where the patient vomited and expelled the humours of the eye; but she was a person of bad constitution, and such accidents did occasionally happen before the use of chloroform. In some cases, where the patient is very nervous, and the eye very irritable, I believe that chloroform is essential to the success of the operation, but it is not necessary to use it in all cases. I understand from Mr. Bowman that his practice is to operate without chloroform in cases where the patient does not wish for it, and has resolution to lie still, and keep the eye steady. The operation is said to be not very painful, but it is one which has a great tendency to rouse the patient, if he is not very insensible; it is necessary therefore to induce complete insensibility, and to keep it up till the lens is extracted, as the least movement of the patient might be prejudicial.

Operations about the anus generally require a full dose of chloroform, as the part is very sensitive when in a state of disease, and the patient, if not quite insensible, has a tendency to move his legs, which is very embarrassing to the surgeon,

especially if there is no one to hold them. It was feared at one time that there would be a difficulty in operating for hæmorrhoids under chloroform, as the patient is often required to press them down; but it is found that if he do so beforehand, and whilst he is beginning to inhale, the bowel remains down; in fact, there is a great tendency to make a straining effort under the influence of chloroform, when the rectum is the seat of operation. Mr. Salmon thinks that the vessels of the rectum bleed rather more during operations under chloroform than without it, owing to the relaxation or diminished contraction of the sphincter; but I have not heard other surgeons make the same remark.

With respect to the deaths which unfortunately take place, now and then, from chloroform, many medical men have supposed that they are to be avoided by carefully selecting the cases for its administration, and declining to give it in certain affections, especially of the heart; whilst others, remarking that the deaths have often occurred in persons apparently the most healthy, acknowledge that they are not to be avoided by selecting the patients, but consider that they nevertheless depend on some peculiarity in the constitution which is not to be discovered beforehand. This is a more melancholy conclusion than the former, as it invests the chloroform with some amount of danger in all cases. It meets with apparent support at first sight, however, in the circumstance that some patients have died from a very small quantity of chloroform, whilst in numerous instances a large quantity has been used without ill effects. A little further inquiry shows, however, that several of the patients who died from chloroform had inhaled it previously in as great quantity without ill effects; and in the case of Samuel Bennett, which occurred in Westminster, in February, 1849, half an ounce of chloroform was used without causing insensibility, and when a fresh supply was obtained and administered, two hours afterwards, he suddenly expired. But it cannot be supposed that a person would have a peculiarity of constitution at one time which he did not possess at another, especially within the space of two hours.

In two papers which I had the honour to read to the Medical Society of London* a few years ago, it was shown that the deaths which had taken place from chloroform were occasioned by the sudden arrest of the action of the heart by this agent, and this is equally true of the deaths which have since occurred. To stop the action of the heart by the direct action of chloroform, there requires to be a larger proportion of it present in the blood than suffices to arrest the action of the muscles of respiration, and, therefore, if the vapour were always inhaled in a very regular and gradual manner, it would be impossible for it to paralyse the heart by its direct influence; for the breathing would first cease, and the action of the heart would only be brought to a close by the absence of the respiration, as in asphyxia. But as the heart is the first organ which the chloroform reaches after it is taken into the lungs, the coronary arteries being the first branches given off from the aorta, it is possible, if the vapour inhaled be too strong, that the heart may receive an overdose. When animals are made to breathe air containing four or five per cent. of vapour of chloroform till death ensues, the breathing ceases first, and the heart continues to beat for a minute or two longer. During this interval life can easily be restored by means of artificial respiration, and the animals sometimes give one or two gasps at the moment when the heart is ceasing to beat, which may restore the action of that organ, and bring about recovery, if the animal have been removed from the chloroform. On the other hand, when animals are made to breathe air, containing eight or ten per cent. of the vapour, death takes place suddenly, the motion of the heart ceasing at the same time as the breathing, or even before it. It requires a little contrivance to make the air on all occasions take up as much as eight or ten per cent. of vapour of chloroform, and this explains not only how accidents may happen, but also why they happen so rarely, even when no regard is had to the amount of vapour in the air breathed by the patient. According to experiments, which I related on a former occasion, the amount of chloroform required to stop the action of the heart is one-eighteenth part as much as the blood will dissolve, or one part of chloroform to about 5,184 parts of serum of the blood. The actual quantity of chloroform, therefore, which, by acting locally on the heart, arrests its motion, and causes a sudden accident, is very little more than a quarter of a minim. Consequently it need excite no surprise that the amount of chloroform which has been used in cases where accidents have occurred has been extremely variable. The danger from chloroform bears very little relation to the quantity used. In fact, to make an adult patient insensible with half a drachm is not so safe as to use a drachm in the process, if it be used judiciously; for in the former case the air must be more highly charged with vapour than in the latter. Exhalation of chloroform is always going on at the same time as inhalation, and to cause insensibility with vapour largely diluted, a larger quantity of it must be used than when it is less diluted.

I have already expressed the opinion that chloroform may be given to every patient requiring an operation without increasing the danger, whatever his condition may be; and I have now to add, that the danger from chloroform, when it does exist, is as great to the strong and healthy as to the feeble and diseased. In fact, it is precisely in the most strong and robust persons that, according to my belief, the greatest care is required in giving chloroform. Robust lean persons, accustomed to hard work or athletic sports, require the narcotism of the nervous centres to be carried further than in the feeble, fat, or sedentary, before they will lie still under the use of the knife; and they are also very apt to struggle and become rigid after they are made unconscious, but before being insensible. During this state of struggling and rigidity they often hold the breath for a considerable time, and then suddenly draw a deep inspiration; and, if the vapour of chloroform is not presented in a very diluted form, a large quantity of it may be drawn into the lungs all at once, at a time when the pulmonary circulation is probably much retarded from the temporary suspension of respiration. In this way the portion of blood passing through the lungs at the moment may be so overcharged with chloroform as suddenly to paralyse the heart. In a considerable number of the fatal cases of inhalation of chloroform, the patient has expired suddenly whilst he was struggling in an involuntary manner.

The danger which exists in giving chloroform is simply that the patient should be allowed to breathe air too highly charged with vapour; for when the vapour is sufficiently diluted its effects takes place so gradually that no medical man can mistake them, and proceed to give an overdose. A very prevalent error respecting chloroform is to suppose that the patient is safe as long as he gets sufficient air for the purposes of respiration, whilst the truth is that the more air a person breathes the greater is his danger, if the air happens to be over highly charged with the vapour. I have not space, in this paper, to enter on the mode of operation of narcotic vapours, but, in order to show that narcotics, in a gaseous form, do not produce their effects by mechanically excluding the air, it is only necessary to allude to two or three well known agents of this class. Thus, whilst air containing eight per cent. of vapour of chloroform cannot be inhaled without danger, air containing four or five times as much vapour of ether may be breathed with the utmost impunity. Nitrous oxide gas may be breathed when diluted only with the air which is present in the lungs at the beginning of the experiment; whilst the vapour of hydrocyanic acid requires to be diluted with several hundred times its volume of air before it can be inhaled without danger.

The means which I use to prevent the air breathed by the patient being too highly charged with vapour, is an inhaler which I have described on a former occasion. I cannot with a handkerchief regulate the amount of vapour and of air in the manner that is desirable; but I consider that those who prefer to give chloroform on a handkerchief may do so without danger, though with no great accuracy, if they dilute the chloroform with rectified spirit. Either two parts by measure of spirit to one of chloroform, as recommended by Dr. Warren, of Boston, in America, or equal parts of each, answer very well. Very little of the spirit is inhaled; it remains behind on the handkerchief, but it has the effect of lowering the elastic force of the vapour of chloroform, and thereby diminishing the amount of the vapour that the air will take up under the same physical circumstances.

In whatever way chloroform is given, it is necessary to begin gently at first, in order to accustom the mucous membrane of the air-passages to the pungency of the vapour, and to increase the strength of the vapour by degrees. I usually take two or three minutes in children and about four minutes in the adult to produce insensibility; but in robust, muscular subjects, who struggle much, it is sometimes desirable to proceed so cautiously as to take seven or eight minutes. In giving chloroform, it is best to observe every symptom exhibited by the patient; but the sensibility of the edge of the eyelid is the best test of the general sensibility. When the ciliary border may be touched without causing winking, or with very slight winking, the knife may in nearly all cases be used without causing a flinch or a cry. The state of the breathing is the best guide against carrying the effects of the chloroform too far. If it begins to

* See Edin. Med. and Surg. Journ., No. 180, and London Journal of Medicine, 1852.

be stertorous, it is advisable to suspend the inhalation. The pulse is of less consequence than many of the other signs; for if the chloroform be properly diluted with air, it cannot seriously affect the pulse, and if it be not the pulse might cease suddenly. Its last beat in some of the accidents which have happened has been equal in strength to any which went before.

It is impossible in a brief space to allude to more than a few of the points connected with the use of chloroform in operations. I have therefore passed over most of those points on which I believe the profession are entirely agreed, and have treated chiefly on those respecting which I considered that my views might differ from those of, at all events, some of my professional brethren, in order that there might be the more room for the expression of opinion and experience.

Sackville-street, October, 1855.

ON THE

ARTIFICIAL MEMBRANA TYMPANI.

BY JOSEPH TOYNBEE, F.R.S., F.R.C.S.,

AURAL SURGEON TO ST. MARY'S HOSPITAL, AND TO THE ASYLUM FOR THE DEAF AND DUMB; AND LECTURER ON AURAL SURGERY AT ST. MARY'S HOSPITAL MEDICAL SCHOOL, ETC.

THE use of an artificial membrana tympani is a subject, I trust, of sufficient importance to the profession to excuse my making some observations respecting it, in reply to certain remarks recently published in THE LANCET.

In the year 1848, Mr. Yearsley published a pamphlet, entitled "On a New Mode of Treating Deafness when attended by partial or entire Loss of the Membrana Tympani, associated or not with Discharge from the Ear," this pamphlet being a reprint of some letters which appeared in THE LANCET a short time previously.

The following extracts will convey an idea of the mode of treatment suggested in the pamphlet:—

"A small piece of wool, differing in size according to the case, and fully moistened in water, is introduced through the speculum to the bottom of the meatus, and adjusted superiorly, inferiorly, anteriorly, or posteriorly, according to the situation of the perforation and other circumstances connected with the case; but *care must be taken that the entire opening* (in the membrana tympani) *be not covered*, otherwise the experiment will not succeed. It is also indispensable to success, that the moisture of the wool should be preserved. It is not sufficient to merely pass it down to the site of the membrane, but, when there, *the spot must be found* which it is indispensable the wool should occupy and cover; for then only, and not till then, will success attend the application, and the patient regain the hearing." In speaking of the trial of the plan by others, it is added: "I will venture to say, that in not one instance in twenty, however appropriate and well adapted the case may be, would it succeed, solely from ignorance of the rules, the observance of which is essential to success. These rules more especially apply to the discrimination of the case, the preparation of the ear, the size of the pellet of wool, the precise spot on which to place the wool, under what circumstances to omit it, and when to assume it, &c. In the absence of such knowledge, circumstances might arise by which not only the patient, but the practitioner, would be puzzled, balked, and might possibly do some serious injury." The *rules*, the importance of which is thus dilated upon, are omitted; and the author even states that "it will be unnecessary to describe with minuteness the appearance which each ear presented, in which it (his mode of treatment) has been successful; *it is sufficient to say*, that in every case there was a partial or entire loss of the membrana tympani, with more or less otorrhœa, though it is not a *sine quâ non* that the latter symptoms of disease should be present." In his Preface, written a year after his papers, the author still gives no directions for the use of the cotton-wool, but adds: "it is far from my wish to discourage the attempt of others to place aright these *magical bits of wool*, but truth compels me to add, *that simple as it would appear, it is an operation requiring the most delicate tact to manipulate with success, which great experience only can confer.*"

The above quotations render it clear that Mr. Yearsley's discovery consisted?—

1. In introducing a portion of wet cotton wool down to *some undescribed or indescribable spot* near the site of the membrana tympani.

2. In leaving an aperture whereby the air in the tympanic cavity could communicate with that in the meatus.

It may also be remarked—

1. That there is no attempt to explain the *modus operandi* of the cotton wool.

2. That no rules are laid down for the use of the wool, although the operation is described as very difficult, and one which few surgeons could have the skill to perform.

3. That the terms "artificial membrana tympani," or "artificial tympanum," *are never used.*

It must be obvious also that thus far but little, if anything, had been added to the observation of Mr. Tod, who describes "the relief derived from the mere introduction of a little lint into the external meatus in those cases where the membrana tympani has been ruptured or destroyed by disease. So great, indeed, is the improvement which takes place from the application of this simple remedy, that patients will frequently appear astonished on being so easily relieved."*

I now come to my own researches, which ended in the suggestion of an artificial membrana tympani.

In the year 1850 I commenced some investigations into the structure and functions of the membrana tympani, the Eustachian tube, and the tympanic cavity. The results were laid before the Royal Society,† and may be thus briefly summed up:—

1. That the chief function of the tympanic ossicles is to act as the analogue of the iris in the eye.

2. That the faucial orifice of the Eustachian tube remains closed except during the act of deglutition or a forcible expiration.

3. That the tympanum is naturally a closed cavity, except when opened momentarily for the egress of mucus and the ingress of air.

4. That the sonorous undulations are not conveyed to the labyrinth through the chain of ossicles, but through the air of the tympanic cavity, to the membrane of the fenestra rotunda.

The closure of the Eustachian tube, except during the act of deglutition, can be experimentally proved without difficulty. To those accustomed to descend in the diving bell, it is well known that the unpleasant sensation of pressure in the ears, amounting sometimes to positive pain, is capable of instantaneous removal, by the act of swallowing, during which the levator and tensor palati muscles open the faucial orifice of the Eustachian tube, and the condensed air being allowed to enter the tympanum and come in contact with the inside of the membrana tympani, the pressure on the outer surface of the latter is counterbalanced. Again, if an attempt be made to swallow while the nostrils are closed by the finger and thumb, a sensation of fullness and pressure will be experienced in the tympanic cavity, in consequence of air having been forced, during the act of deglutition, through the open tube into the tympanum; and the sensation continues until, by another act of swallowing, the tube is re-opened, and the confined air escapes into the fauces. In one of the papers above alluded to, an account was given of the muscles which open the Eustachian tube, in mammalia, birds, and reptiles, and in every animal examined, the guttural orifice remained closed except during the muscular action.

Having, by a series of experiments, arrived at the conclusion that the sonorous vibrations are transmitted to the labyrinth through the air in the tympanic cavity, and that it is requisite for these vibrations to be confined to the tympanum, so that, by means of the membrana tympani and the osseous walls of the tympanum, they may be thrown with sufficient force upon the membrane of the fenestra rotunda, it appeared to me a natural consequence, that an orifice in the membrana tympani, by allowing the undulations to escape into the external meatus, would tend to diminish the power of hearing, and, if there co-existed besides, a thickening of the tympanic mucous membrane, considerable deafness might be the result. It also seemed probable, that as the sonorous undulations were not conveyed to the labyrinth by the ossicles, that where the entire membrane was absent, an artificial membrana tympani might be supplied, which, by rendering the tympanum once more a closed cavity, would cause the undulations to pass onward to the labyrinth, and thus restore the power of hearing. The difficulty in the way of making an artificial membrana tympani, which had arisen from a supposed necessity of attaching it in some way to the malleus, the long process of which was usually absent, at once vanished. My hopes of success in the construction and use of an artificial membrana tympani were further strengthened by some experiments performed upon cases of perforate mem-

* Anatomy and Physiology of the Organ of Hearing, pp. 105, 106. 1833.

† Philosophical Transactions, Part I., 1851; and Proceedings.