

of separate bleeding points, and even tying the carotid, etc. All these procedures are a source of embarrassment to the surgeon and to the patient, whether done for primary or for secondary hæmorrhage, and in restless children already weakened by loss of blood the further administration of an anæsthetic becomes a necessary evil. Our object, therefore, should be to reduce the chances of such contingencies to a minimum, and hence the importance of the method we adopt and now for the first time brought to the notice of practitioners by us. The advantages of this instrument have been proved by many months' employment by ourselves and by our colleagues in the Throat Department of St. Mary's Hospital.

Quite recently one of us came across in the January number of *The Laryngoscope* for the current year, an article by Dr. La Force, of Iowa, entitled "La Force Hæmostat Tonsillectome." The instrument is of the Ballenger-Sluder type and is not only provided with both a crushing and a cutting blade (thus anticipating in principle the instrument we have employed), but also had as a component part an ingenious ligature-carrier by which the stump can be ligatured in three sections. This would effectually prevent the gaping of the stump which invariably follows unless ligaturing is resorted to; and is an improvement on the single thick silk ligature previously suggested by us in this article. The instrument is a complicated one, as is also the technique of its employment when ligaturing is carried out, but it is obviously theoretically the most efficient hæmostatic guillotine as yet devised; though the number of cases in which the tedious process of tying the stump in sections is indicated is necessarily small.

We have also ascertained that Mr. Howarth has recently made use of a Ballenger-Sluder type of guillotine with a dull-edged blade and a sharp-edged blade combined in one shaft.

[NOTE.—Dr. Hill wishes it to be understood that though he has borne a considerably larger share than his collaborator in the compilation of this article, yet any credit which may be considered due for the independent inception and details of construction of the hæmostatic guillotine here illustrated belongs entirely to Dr. Elphick.]

DIFFICULTIES AND DANGERS OF EXPLORATORY PUNCTURE OF THE ANTRUM OF HIGHMORE.¹

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EXPLORATORY puncture followed by perflation and irrigation is the most reliable method of diagnosing antral suppuration and is, therefore, in daily use in rhinological clinics.

¹ Read at the meeting of the British Medical Association, Aberdeen, July, 1914.

The test is generally regarded as perfectly simple and safe, so that when, several years ago, I had some disquieting experiences in carrying it out, I considered them to be unique. That they are by no means so has been proved by subsequently published reports of somewhat similar cases. The subject has not been written upon or discussed, so far as I know, in this country, and in Austria and Germany, where it has begun to attract attention, no satisfactory explanation has been forthcoming. I, therefore, venture to bring it under the notice of British rhinologists, in the hope of eliciting further information which may throw light on the causation of certain mysterious occurrences.

ROUTE AND INSTRUMENTS.

It is not the object of this paper to weigh the relative advantages of the different routes by which one may gain access to the antrum. To most of us, the making of a perforation beneath the inferior turbinate commends itself as simplest, safest and most satisfactory, and it is to the test as carried out in this situation that my remarks will apply.

Nor do I wish to consider the instruments used. It might be mentioned in this connection, however, that Moritz Schmidt was the first to recommend the inferior meatus as a diagnostic route and employed a Pravaz syringe fitted with a bent needle in order to aspirate the contents of the cavity. Subsequently Lichtwitz practised exploratory irrigation by means of a straight trocar and cannula. Modifications in which the cannula is curved, or sharpened to serve also as a trocar, or furnished with a double streamway, have been recommended from time to time. Personally, I prefer and use almost exclusively Lichtwitz's instrument; this, when strongly made and provided with an extra cannula—the advantage of which is referred to below—should meet all requirements.

DIFFICULTIES AND MINOR ACCIDENTS IN MAKING PUNCTURE.

I shall refer only briefly to the difficulties and slighter accidents that are commonly experienced in making the exploratory puncture, and to the precautions that should be taken to avoid them.

Children.—In patients under twelve years of age puncture from the inferior meatus may be unsuccessful, as usually the floor of the antrum is still high. When it is necessary to employ the test in children it should be carried out from the middle

meatus, or the trocar should be directed obliquely upwards from the inferior meatus. Haike has investigated the accessory cavities in children by means of X-rays, and his results with reference to these points are of value. Zarniko and Onodi recommend that the antrum be opened only from the middle meatus up to the time of eruption of the first permanent molar.

Narrow type of face.—The configuration of the patient's face should be observed. When the nose is prominent and the anterior wall of the superior maxilla is sunken the puncture must be made further back than usual in the inferior meatus. If this precaution is not observed one may bore in front of the antrum or unwittingly traverse a narrow part of the cavity, and on inflation emphysema of the cheek may be produced, or severe phlegmonous cellulitis may follow infection of the tissues by pus carried from the antrum. Under such conditions it is possible also to injure the lower end of the nasal duct.

Ozæna.—The patients that have given me most trouble in boring have been those with atrophic rhinitis; as a class they seem to have a thick naso-antral wall or a small antrum. Zuckerkandl, Harke, Bergeat and Minder, have remarked upon the small size of the accessory cavities in persons with ozæna; and Haike states that in his X-ray examination of adults with ozæna he found in almost every case defective development of these cavities.

After the antrum is entered and the trocar withdrawn, serum or pus, if present in the cavity under pressure, *e. g.* in a cyst or closed antrum, may drop from the cannula. Aspiration may first be tried, but is usually omitted. Air is gently blown through and the effect observed in the middle meatus; the escape of clear fluid should not be overlooked. In rare instances, when the antrum is occupied by a dental cyst which has burst into the nose, the pus may be found to escape beneath the inferior turbinate.

CONDITIONS PREVENTING PERFLATION OF ANTRUM.

Not infrequently difficulty is at first experienced in blowing through the antrum. Assuming that the trocar is clear and the point free in the cavity, the following possible causes of obstruction may be considered.

(a) In acute cases the ostium may be blocked. If the application of cocaine and adrenalin to the neighbourhood of the ostium fail to reduce the swelling of the mucous membrane, a second cannula should be inserted alongside the first and made to serve as a counter-opening.

(b) A polypus in the antrum may also occlude the ostium. As a rule, it does so intermittently. For a time it may allow free escape, then suddenly prevent this, and the more the intra-antral pressure is increased the more complete does the obstruction become. The valve-like action of the polypus may sometimes be avoided by changing the position of the patient's head, especially by keeping the diseased side under the other.

(c) When the antral lining membrane is swollen or thickened—and occasionally its condition is such as almost to obliterate the cavity—the point of the cannula may readily be embedded in the œdematous tissue. If one has reason to suspect this, the instrument should be pushed forward until the point impinges on the opposite wall and then withdrawn slowly, meanwhile trying to blow through; a level is usually reached at which the air finds free egress.

(d) A dental cyst may fill the entire antrum or only its lower part. If the instrument pierce the cyst a few drops of translucent liquid with cholesterin crystals may escape from the cannula, but attempts to blow through will be futile. On the other hand, the point of the instrument may pass above the cyst into the remaining lumen of the antrum, and the test gives a negative result. In some cases it is possible to enter either the cyst or the antral cavity according to the direction given the instrument while boring.

(e) A cyst of the antral lining membrane may behave in almost the same manner as a dental cyst. The method mentioned under (c) should be tried.

(f) Caseous pus and very tough mucus may offer resistance to the passage of injected air, but usually this is overcome by moving the cannula to and fro and blowing at different depths.

DANGER OF FORCIBLE PERFLATION. FATAL CASE.

Whatever the intra-antral condition may be—and very often no opinion can be hazarded as to its nature—the tendency is to blow strongly enough to force a passage by the ostium. I would earnestly warn against any such attempt. A number of years ago I had an experience which demonstrated that this simple test of exploratory puncture may be fraught with the most serious consequences if air be injected into a presumably closed antrum under moderate pressure such as is capable of being exerted by a rubber syringe.

In the case to which I allude, the patient was a man aged about forty-five, who had symptoms suggesting suppuration in the right antrum. The naso-antral wall was easily pierced by Lichtwitz's trocar and cannula, and on trying to blow

air through the antrum a slight gurgling sound was produced, but nothing escaped by the ostium. This procedure was followed by very severe and prolonged coughing; the patient broke into perspiration and afterwards lay prostrate for three quarters of an hour.

A week later the test was repeated, and, as before, air could not be forced through the antrum. A second cannula was then introduced alongside the first. On further attempts at inflation a low gurgling sound could be heard such as might be produced by air passing through fluid in the antrum. He said that he had no pain, but that there was a tickling sensation in the right side of the larynx inclining him to cough. A few moments later he said that he felt it going to his arm, then without warning or any apparent change he became unconscious, his head fell forward, and he almost dropped from the chair. His breathing was loud, pulse feeble, and he perspired profusely. His own physician and several other medical men saw him within a sort of time of the onset of his illness, and various remedial measures were employed. In about three hours he seemed somewhat revived, but began to moan as if in pain. Subsequently, the moaning was continuous, the breathing rapid and shallow, the eyes wide open and sometimes turned far up to the left, and there was constant violent jerking of the right leg. Without developing any other outstanding symptom or regaining consciousness the patient died fourteen hours from the time the exploratory puncture was made.

SYMPTOMS CAUSED BY FORCIBLE PERFLATION.

This case naturally led me to be on the outlook for any untoward conditions that might arise during the performance of the test. Of the many hundreds of patients on whom I have since made the exploratory puncture and perflation, about a dozen have presented symptoms which, I think, are to be ascribed to the procedure. In these cases nothing unusual was noted as regards the thickness of the naso-antral wall, but on trying to blow air through none escaped from the antrum. After repeatedly changing the position of the cannula and trying to insufflate, the patient began to cough. This was attributed to a tickling sensation in the larynx, or to irritation, oppression, or even pain in the chest, usually opposite the middle or lower end of the sternum. The cough was dry, at intervals or in violent rapidly recurring paroxysms, and lasted from a few minutes to a quarter of an hour. The patient perspired freely and became faint; retching and vomiting were uncommon; considerable prostration might continue for about half an hour. One patient complained that his right hand felt paralysed (the puncture had been made on the left side). These symptoms in themselves are comparatively trivial, but they might have led to others of a graver nature had they not been regarded as a danger signal.

FATAL CASE FOLLOWING PERFLATION OF FRONTAL SINUS.

The following case probably belongs to the same category as those just described, but the cavity perflated at the onset of the fatal illness was the frontal sinus.

The patient, a strong, healthy man, aged forty-six, had nasal polypi and supuration in both antra, both frontal sinuses, and the right sphenoidal sinus. The polypi had been removed and the antra opened from the alveolus. The question under consideration was that of the treatment of the frontal sinuses. In order to estimate the amount of pus in these cavities a cannula was passed and the contents blown out. A communication existed between the two sinuses, for, on insufflating one, air-bells and pus appeared beneath the ostium frontale on the other side. This procedure had been carried out at several previous visits without any untoward results when, on one occasion, on removing the cannula the patient's head fell forward a little. When asked if he were well, he quickly raised it as if awaking, but again dropped it. As he was apparently helpless he was laid down. He complained of the heat and of his wrists feeling weak. In reply to inquiries he said that he had no pain and that he did not know what was wrong. When told to draw up his limbs he seemed unable to do so, but in about half an hour he moved the left leg, and later the right leg and left arm. In three quarters of an hour, when his own physician arrived, his pupils were dilated and reacted only sluggishly to light, and he answered "yes" to all questions. In three hours he was able to move all his limbs and to sit up in bed. At 10 p.m., six hours after the onset of his illness, the urine was drawn off and found to contain neither sugar nor albumen, the pulse and temperature were normal, and after consideration of a question he could answer "yes" or "no." The next morning, early, he was very violent and shouted, and was calmed only by morphia. At 9 a.m. he was comatose; occasionally during the day he became excited. At 3 p.m. the breathing was interrupted, and he seemed about to die, although the pulse was good. In the evening the temperature was 103° F., and pulse from 110 to 160; he was quieter and answered "yes" and "no" to questions, but it is doubtful if he understood them. There was occasional opisthotonos. About 3 the next morning he began to have convulsions, which recurred rapidly, and he died at 7 a.m., about forty hours from the onset of the attack.

A *post-mortem* examination of the head was made by Dr. John Anderson, Pathologist to the Victoria Infirmary, from whose report the following extracts have been taken: "The dura mater is not abnormally adherent to the skull: it is somewhat congested. The sinuses are filled with blood and *post-mortem* clot. There is no excess of fluid in the subdural space. The pia arachnoid shows congestion of the veins of the sulci and a few slight opacities due to areas of thickening; the Pacchionian bodies are unusually prominent. On section of the brain a general hyperæmia is met with, the white matter showing a pronounced condition of puncta vasculosa. The brain substance in addition to the hyperæmia is slightly œdematous, and the ventricles contain a slight excess of fluid. No gross lesion is found in the brain: there is no indication of cerebral hæmorrhage, embolism, thrombosis, focus of suppuration, or meningitis. On stripping the dura mater from the orbital plate of the frontal bone a small aperture is found on the left side in a line with the posterior end of the cribriform plate. The aperture is circular, about 3 mm. in diameter, with smooth edges, and leads to a recess in the bone large enough to contain half a pea. This is filled with a pulpaceous material, after

cleaning out which no exit from the recess can be detected with a fine probe. On removing the roof of the sinus and a small bridge of bone between its posterior end and the recess, a tortuous communication between the latter and the frontal sinus can be traced. The frontal sinuses are very large and communicate with one another; they are filled with pus and lined with a fleshy, congested, pyogenic membrane. The sphenoidal sinuses are also large and partly filled with granulation tissue." It should be clearly understood that although the roof of the left frontal sinus presented the small erosion noted, the latter was perfectly covered by normal dura mater.

Before commenting on the above experiences I shall briefly relate mishaps that have befallen others.

CESSATION OF RESPIRATION, CONVULSIONS AND PROLONGED UNCONSCIOUSNESS FOLLOWING WASHING AND PERFLATION OF ANTRUM.

In 1906, Neuenborn reported a case which he attributed to cocaine poisoning, but which closely resembles those under consideration.

A man, aged twenty-three, presented symptoms of double antral suppuration. The left antrum was punctured and washed out twice. At the third visit, a smaller quantity of cocaine than usual was applied to the right inferior meatus, the antrum was punctured for the third time, and a considerable amount of pus washed out. Air was then blown through the cavity to get rid of the excess of water, the thin trocar was withdrawn, and the patient was asked how he felt. While replying he fell to the ground as if struck by lightning. Respiration had ceased, the whole body was rigid, and he appeared to be dead. The heart's action, however, was found to be normal, so artificial respiration was begun and continued at intervals as required throughout the day. Injections of ether—although the pulse kept normal—amyl nitrite and applications of cold to the head were tried. Later, tonic and clonic spasms alternated. During the night he had a pure epileptic seizure and seemed about to die. Unconsciousness was complete. This condition lasted for three days. On the fourth day he began to rouse himself unwillingly when loudly called. On the fifth he was somewhat better, and on the sixth he recognised a friend. From then onwards he visibly improved. Neuralgic pains set in, especially in the sciatic and trigeminus, on the seventh day. For long afterwards he was weak and nervous.

Neuenborn at first thought that a communication existed between the antrum and cranial cavity through which he had driven air or water and so produced meningitis. This view was supported by the rise of temperature on the second day, stiffness of the neck and positive Babinski. He now believes that the whole course of the illness, especially the subsequent development of neuritis, shows that the case was one of severe cocaine intoxication.

The following considerations place the latter view in a very doubtful light. The amount of cocaine employed was small, and on two previous occasions the patient had had larger doses without bad effect, so that idiosyncrasy could be excluded. When cocaine does give rise to toxic symptoms these do not set in with sudden unconsciousness, and the course of the illness, even if it terminate fatally, is never so prolonged as in the case described.

DEATH AFTER WASHING OUT ANTRUM.

Neuenborn also relates that several years previously in the same town a patient died in a doctor's consulting room after having

had the antrum washed out. Death was supposed to have been due to cardiac failure, but Neuenborn now attributes it to cocaine poisoning.

In the present state of our knowledge, both Neuenborn's case and that of his townsman would probably be regarded as accidents occurring in the course of the exploratory perforation or washing of the antrum, and as having nothing to do with the toxic influence of cocaine.

TWO CASES, ONE FATAL, OF EPILEPTIC SEIZURES FOLLOWING SYRINGING OF ACCESSORY CAVITIES.

In the discussion following Neuenborn's communication, Henrici reported two cases in which an epileptic seizure had followed the syringing of an accessory cavity; the patients were neither nervous nor had they had epilepsy previously.

The first patient had been having his antrum and frontal sinuses syringed out daily for about a month; blunt cannulas were used. One day during the washing the patient suddenly fell from his chair apparently in an epileptic fit with heavy breathing, blue aspect, small irregular pulse, and firmly clenched teeth; he soon recovered. A few days later, when he was quite well, the syringing was resumed, and again he had a seizure; the breathing soon ceased and later the pulse; artificial respiration and tracheotomy were employed, but death supervened; the *post-mortem* examination was negative.

Henrici's second patient was beginning to have her antrum washed from the middle meatus when an epileptic attack set in. Under artificial respiration and heart massage she came to herself again. Paresis of the extremities with disturbance of consciousness persisted for long afterwards.

FATAL APOPLEXY AFTER ANTRAL PUNCTURE.

Hajek, at the meeting of the German Laryngological Society in 1907, reported two serious cases. The first was that of a man, aged sixty-six, who was diabetic and had marked arterio-sclerosis. Eight days previously acute empyema of the left antrum had set in. After perforating from the inferior meatus, the patient became unwell and seemed unconscious. Paralysis of the left half of the body and face indicated cerebral apoplexy, from which he died in thirty-six hours.

SUBPERIOSTEAL ABSCESS WITH METASTASIS AFTER ANTRAL PUNCTURE.

Hajek's second case was that of a woman, aged thirty-five. After the antrum was punctured, air blown through escaped by the nose, but on trying to syringe there was resistance which could not be overcome. The patient had a rigor on each of the following three days. Swelling developed over the left temple and on the left wrist. On opening the antrum the greatly swollen mucous membrane beneath the anterior wall was found to be raised by a subperiosteal abscess, so that the lumen of the cavity was quite obliterated. After incising the abscess and draining the antrum the condition cleared up. In this case probably the needle crossed the very narrow antrum and, by infecting the subperiosteal tissue, gave rise to an abscess. The pus under great pressure infected a perforating vein, hence the swelling of the cheek and the later metastatic inflammation of the wrist.

In the discussion that followed the reading of Hajek's paper Moritz Schmidt, B. Fränkel, Kümmel, and Kayser recounted the undernoted interesting experiences.

SWELLING OF CHEEK AND EYELIDS.

Moritz Schmidt referred to two cases in which, on beginning to syringe, swelling of the cheek and eyelids set in. He considered that the accident was due to the antral cavity not extending to as low a level as usual, and that in consequence the trocar passed directly from the outer wall of the nose to beneath the skin.

TRANSIENT HEMIPLEGIA AFTER PERFLATION OF (?) ETHMOIDAL CELL.

In a third case the patient was a medical man who had been greatly inconvenienced for years by crusting in the nose. Schmidt examined him carefully and at length found a very sensitive area behind the middle turbinate. The posterior end of this body was removed, and a sharp needle was pushed outwards and entered a cavity which may have been the sphenoidal sinus but probably was a much distended ethmoidal cell. Pus immediately oozed out. Some air was then pumped in. At the same moment the patient collapsed with complete paralysis of the left arm and leg. Fortunately this passed off in about an hour, and next morning he was quite well. Schmidt was unable to explain how the paralysis had arisen. He thought that he had entered the brain, but this

was not possible, as he had operated on the left side, and the paralysis also was left sided.

SWELLING AND ABSCESS OF CHEEK.

B. Fränkel stated that he always made the puncture in the middle meatus. Shortly before, he had had a case in which on washing there was immediate swelling of the cheek. An abscess formed which took long to heal. He thought that a fissure must have been present through which the pus was driven into the cheek.

TRANSIENT HEMIPLEGIA AFTER INSUFFLATION OF FRONTAL SINUS. CASES OF COMA.

Kümmel related the case of a man whose frontal sinus was easily entered and washed out. Air was afterwards blown in, and the patient became paralysed on the opposite side of the body but recovered perfectly in two or three hours. On several subsequent occasions he had had a similar experience. Twice certainly on blowing in air patients who had borne all previous manipulations suddenly fell and remained in a comatose state without paralysis for two or three hours.

HYSTERO-EPILEPSY AFTER ANTRAL PUNCTURE.

Kayser, lastly, told of a lady, who, on having her antrum punctured, fainted, became convulsed and remained unconscious for thirty-six hours; then gradually recovered. He had regarded the illness as an attack of hystero-epilepsy.

Claus in 1910 contributed a paper entitled, "Four Mishaps, two with Fatal Termination, from Puncture of the Maxillary Sinus."

CYANOSIS AND DYSPNŒA ON PERFLATING ANTRUM.

Claus's first case was that of a girl, aged nineteen, who had been operated upon for suppuration in the left antrum. Subsequently recurrence was suspected, and Claus made an exploratory puncture. While blowing in air obstruction was suddenly experienced, and at the same moment the patient became dyspnoëic and cyanosed. She continued so for about ten minutes and had a feeling of depression for some hours. Hysteria and fear could be excluded as causes. An air embolus was suspected. Probably

while the point of the instrument was in the thick spongy wall of the antrum air was forced into a vessel, but as the amount was small it was quickly absorbed.

UNCONSCIOUSNESS, PARTIAL PARALYSIS, AND APHASIA SETTING IN
DURING ANTRAL PUNCTURE.

In the second case, a man, aged sixty-eight, became suddenly unconscious while the antrum was being punctured with the Lichtwitz needle. The right arm was flaccid, right leg moved fairly well, there was no facial paralysis, but sensation on both sides was abolished excepting below the left eye. He was very restless and did not reply to questions. The following day he was quieter, but still almost aphasic. He gradually improved, and the paralysis passed off in six days. The seat of the lesion here must have been in the internal capsule of the left hemisphere. Claus thinks that an embolus or hæmorrhage is improbable from the course of the illness, and that one may assume closure of a vessel from arterial spasm due to novocain and adrenalin, although the doses used were only moderate.

CYANOSIS, HEART FAILURE, AND DEATH AFTER WASHING ANTRUM.

In the third case, a young woman had the right antrum washed out from the inferior meatus, as had been done on two previous occasions. Immediately after the procedure she complained of feeling faint and became cyanosed. Pulse and breathing gradually failed. All efforts at resuscitation were in vain. At the necropsy no disease was found in the organs. Death was evidently caused by paralysis of the heart.

UNCONSCIOUSNESS, COLLAPSE, AND DEATH AFTER PERFLATION OF ANTRUM.

The fourth case was that of a woman, aged thirty-six. The antrum was easily punctured with the Lichtwitz needle and air blown in. The patient thereupon collapsed and lost consciousness. The coma deepened, and she died the same evening. The result of the *post-mortem* examination is very fully reported. Briefly, numerous hæmorrhages were found in the heart muscle and in the grey cortex of cerebrum and cerebellum.

Claus is inclined to attribute death in these two cases to novocain poisoning.

SYMPTOMS OF SHOCK OBSERVED AFTER EXPLORATORY PUNCTURE.

Uffenorde, in commenting on Claus's paper, states that not infrequently exploratory puncture of the antrum is followed by disquieting symptoms of shock, which are to be regarded as due to reflex inhibition of the vagus. There may be syncope, rolling of the eyes, clonic convulsions, cyanosis, irregular, weak, slow pulse, and very slow respiration. In his experience women are oftenest affected. Judging from two cases which he observed in robust subjects, he is convinced that such attacks may terminate fatally if camphor and digitalis are not injected.

ABSCESS IN CHEEK AFTER EXPLORATORY PUNCTURE.

Kronenberg, in 1911, wrote a paper on accidents arising from boring into the antrum and their prevention. He reported a case in which after exploratory puncture an abscess formed in the cheek, causing considerable general disturbance. It ultimately burst into the mouth and discharged for about a week.

VARIOUS MISHAPS AFTER EXPLORATORY PUNCTURE.

In the large *Handbuch der speziellen Chirurgie des Ohres und der oberen Luftwege* which is now being published, Boeninghaus, the author of the section on the accessory cavities, states that exploratory puncture of the antrum is accompanied or followed by mishaps much oftener than is known, and that Hajek rendered special service in opening up this question. Boeninghaus has seen abscess in the orbit, and in several instances rise of temperature with pain in the jaw, follow the procedure.

RISE OF TEMPERATURE AFTER FIRST WASHING OF ANTRA FILLED WITH PUS.

Killian read a paper at the meeting of the Society of German Laryngologists in May, 1913, on accidents from washing out the antrum. As a rule, he washes from the middle meatus through the accessory or an artificial opening. Although little or no injury is produced, a rise of temperature occasionally takes place a few hours later. During the past ten years he has met with a number of such cases. In every instance the complication was after the first washing, and the antrum was full of pus which had been retained for long and was more or less decomposed. A case illustrating

the course of events was that of a man whose antrum was washed out with salt solution through the natural opening; two and a quarter hours later he had an acute rigor, and the temperature rose to 37.9° C.; after three hours it slowly fell again; next day he was quite well; the antrum was frequently washed out subsequently, but without giving rise to any similar disturbance. It is not easy to account for such occurrences. There is no question of infection from instruments or a wound. Probably the explanation lies in the bacterial toxins present in the antrum which had been absorbed in inappreciable amount until disturbed by the first washing.

DISTURBANCE OF VISION AFTER OR DURING WASHING ANTRUM.

Killian also relates the case of a woman who occasionally experienced during or after washing the antrum, which was carried out regularly, sudden disturbance of vision in the corresponding eye. At first she could see nothing, after a few minutes there was a faint glimmer of light which travelled from right to left, and in ten to fifteen minutes fair vision was re-established. At home she had rigors, and the temperature rose to 38.3° C. Next morning all had passed off, excepting that for some days the pupil was wider than the other. The ophthalmologist who examined the patient stated that he had several times observed a similar sequence of events. He was inclined to attribute the disturbance of vision to a small embolus of the central artery of the retina. Killian questions this view and regards a reflex contraction of the vessel as more probable.

FATAL SYNCOPE WHILE WASHING ANTRUM.

Killian states that there is no doubt as to reflexes originating in the antrum, and that attacks of collapse and fainting while the cavity is being washed are thus explained. The irritation probably passes to the vagus. A case occurred in his clinic in which irritation of the vagus led to syncope, and the patient fell dead from his seat. The antrum was merely being washed out, as had been done often previously. The only explanation he can offer is that the water used was probably cold, and that some individuals are specially susceptible to strong vagal reflexes. The *post-mortem* examination was negative; the heart was healthy.

COLLAPSE, PARAPLEGIA, AND AMAUROSIS ON INSUFFLATING ANTRUM.

In the discussion that followed the reading of Killian's paper,

Streit related the case of a medical student in whom the first washing out from the middle meatus led to no complication, but some days later, when about to undertake a second washing, on beginning to exercise pressure with the double bellows, the patient immediately became pale and pulseless. It was also found that he had a paresis of the lower extremities. During the next two hours there was repeated complete amaurosis with momentary intervals of slight perception of light. Prof. Bruckner, who found the fundus normal, thought that most probably an air embolus had lodged in the occipital lobe. The patient remained weak till the evening and then gradually recovered.

RIGORS AFTER SYRINGING ANTRUM. PARAPLEGIA AND BLINDNESS.

Walliczek referred to two cases in which rigors followed not only the first but also subsequent washings. He had also had a case resembling Streit's, and was inclined to attribute the paralysis of the legs and the blindness to a concentrated adrenalin solution.

Siebenmann had also observed severe rigors and high temperatures of short duration after the injection of boric acid lotion into the antrum through an accessory or artificial opening. With reference to attacks of giddiness on syringing the antrum, he pointed out that there are connections between the trigeminus and vagus which explain the frequent occurrence of vertigo in acute antral suppuration.

TWO CASES OF AIR EMBOLISM, ONE FATAL, AFTER EXPLORATORY PUNCTURE.

Bowen reported in 1913 two cases of air embolism following this test.

The first was that of a woman in whom the puncture was made with difficulty owing to the unusual thickness of the bone. After inserting the needle it was found impossible to force air through with the syringe, so the needle was withdrawn slightly for a second attempt, which was also unsuccessful. During the third attempt the patient, without the slightest warning, became rigid and cyanotic, and a moment or so later convulsive movements of the extremities, foaming at the mouth, and stertorous breathing set in. She remained thus for seventy-two hours. The first night the temperature was 101.4° F., pulse 75, and respirations 20. The temperature remained about 100° until the third day. She vomited the first evening and again on the third day. There was profuse perspiration, especially at night, and muscular twitching almost continuously. Occasionally she became quite violent and required the use of a restraining sheet. During the fourth day a partial paralysis of the left arm was apparent. She was able to

sit up in bed on the fifth day, and would converse when spoken to. She was discharged on the seventh day.

The second case was that of a man, aged twenty-four. The right antrum was washed out from the inferior meatus with negative result. The left side was punctured in the same manner, but as the air was being injected, no unusual force being used, the patient became rigid with half closed eyes and eyeballs rolled backward; relaxation followed with profound cyanosis and slight muscular twitching. He was placed in the recumbent position, and beyond a few gasping respirations, at the rate of about three per minute, there was little evidence of life. Hypodermics of strychnine, adrenalin (15 m.), and whisky were given, and artificial respiration was carried on continuously. At the end of about twenty minutes the cyanosis cleared somewhat, and it was thought that the danger was over, but in a few minutes it deepened again, and death took place about an hour after the puncture.

At the *post-mortem*, on removing the sternum the pericardium immediately bulged forward into the opening. Incision into the pulmonary artery was followed by the sharp, hissing sound of escaping air and collapse of the distended heart. On opening the antrum, the mucous membrane of the outer and inner walls and nearly all the roof was found detached. There was no indication of the needle having penetrated beyond the antrum, and there was no trace of hæmorrhage in the cavity.

Bowen considers that the only explanation of the passage of air into the general circulation is that the needle penetrated the mucous membrane of the roof and air was forced between the lining membrane and bone, thus opening up numerous capillaries. In exploring the antrum he advises the injection of solution without preliminary perflation.

ENTRANCE OF AIR INTO JUGULAR VEIN DURING SUPPOSED PERFLATION OF ANTRUM.

In a case in which I believed the point of the cannula to be in a good-sized antrum, on insufflating, a low gurgling sound was produced, apparently in the cavity; on again blowing, gurgling was heard in the neck, and on repeating this a loud gurgling sound unmistakably passed down the side of the neck. The patient remarked that she felt this in the neck, but she was in no way affected. On removing the cannula it was found to contain a little blood. The antrum was now opened from the alveolus and proved to be empty. In this case the trocar must have crossed the antrum, pierced its thin outer wall, and reached the pterygo-maxillary fossa. Here the point of the instrument probably entered the pterygoid plexus of veins, and the air injected found its way into the internal or external jugular vein, both of which communicate with the plexus. It is surprising that this accident has not been

previously reported, for it may readily occur, owing to the thinness of the outer wall of the antrum.

LIST OF ACCIDENTS DUE TO PUNCTURE, PERFLATION, OR WASHING OF ACCESSORY CAVITIES.

The accidents referred to in this paper may be grouped as follows:

(1) Trocar traverses narrow antrum or passes below high antrum, and reaches canine fossa. Air blown through causes emphysema (common occurrence); solution, or pus from antrum, forced through produces infiltration or abscess with constitutional symptoms (Kronenberg).

(2) Pus driven through fissure in antral wall causes abscess in cheek (Fränkel).

(3) Trocar infects subperiosteal tissue in antrum, causes abscess, pyæmia and metastasis (Hajek).

(4) Trocar enters orbit, emphysema (Hajek) or abscess (Boeninghaus, Nager, Gerber) results.

(5) Trocar traverses antrum, pierces outer wall, and enters pterygoid plexus of veins in pterygo-maxillary fossa; air blown thence into communicating internal and external jugular veins (Brown Kelly).

(6) Puncture supposed to give entrance to infection leads to fatal septic pemphigus (Culbert).

(7) Washing out pus causes rigor and rise of temperature (Killian, Walliczek, Siebenmann), with pain in the jaw (Boeninghaus).

(8) Disturbance of vision accompanies or follows washing out antrum (Killian) or insufflating air (Streit, Walliczek).

(9) Hystero-epilepsy (Hajek, two cases, Brown Kelly), hysterical mutism (Brown Kelly).

(10) Symptoms of shock (frequent) (Uffenorde, etc.), fatal cases reported or referred to by Claus, Neuenborn, and Killian.

(11) Insufflation causes cyanosis and dyspnoea (Claus), cyanosis, rigidity, stertor, and convulsive movements of limbs (Bowen, two cases, one fatal).

(12) Epileptiform seizure, paresis of limbs and unconsciousness (Henrici); epileptiform attack, cyanosis, cessation of respiration and heart's action, death (Henrici); cessation of respiration, convulsions and unconsciousness (Neuenborn); fainting, convulsions, unconsciousness for thirty-six hours (Kayser); unconscious-

ness, stertor, jerking of right leg, death (Brown Kelly); from insufflating frontal sinus—collapse, loss of intelligence, maniacal excitement, opisthotonos, convulsions, death (Brown Kelly).

(13) Unconsciousness, left hemiplegia, death (Hajek); transient hemiplegia from insufflating (?) ethmoidal cell (Schmidt), or frontal sinus (Kümmel, several cases); unconsciousness, hemiparesis and aphasia (Claus); unconsciousness, collapse, death (Claus); collapse, paraparesis and amaurosis (Streit, Walliczek).

DEATHS.

Nine fatal cases as indicated above have been referred to or reported by Neuenborn, Henrici, Hajek, Claus (two), Killian, Bowen, and Brown Kelly (two).

CAUSES ASSIGNED FOR ACCIDENTS.

Faults in technique and anatomical abnormalities account for groups 1-6. Dehiscence of the walls of the antrum and frontal sinus is commoner than generally supposed and should be kept in view in this connection.

Explanations have been already offered of groups 7 and 8.

The temperament of the patient probably underlies group 9.

Groups 10-13, which include the more serious accidents and the deaths, are of chief interest. It should be mentioned that the classification here adopted is largely arbitrary and is based mainly on the prominence given to the various symptoms in the original reports. Why is this simple little operation of exploratory puncture and insufflation followed occasionally by such disasters as just related, while much severer procedures in the nose and accessory cavities do not give rise to symptoms at all comparable in gravity? The explanations offered will be briefly considered.

Coincidence.—In Hajek's case the onset of apoplexy after antral puncture may have been merely a coincidence, as the patient was aged sixty-six and had diabetes and marked arteriosclerosis. It is evident, however, as Boenninghaus has remarked, that the many severe conditions reported cannot be regarded as accidental complications.

The local anæsthetic.—In most instances this could be positively excluded as the cause of the accident. Neuenborn attributed his patient's prolonged illness to cocaine poisoning, but the improbability of this ætiology has been already discussed. Claus assigned

his two deaths to novocain poisoning, but aptly remarks that it is strange a fatal issue should occur twice in puncturing or washing out the antrum, while no bad effect has followed the innumerable applications of novocain in other rhinological procedures.

Air embolus.—In several of the cases (Antrum: Claus, 2; Bowen, 2; Brown Kelly. Frontal sinus: Kümmler, several cases; Brown Kelly. Ethmoidal cell: Schmidt) the grave symptoms set in during, or immediately followed, insufflation, and air embolus has been suggested as an explanation. The probability of this occurrence might be better gauged if the exact cause of the accident—puncture, insufflation or injection of fluid—had been mentioned in all the cases reported; in many, however, this information is lacking. Claus thinks that while the point of the trocar was in the spongy bone air may have been forced into a vessel. Bowen assumes that in his fatal case air penetrated the capillaries, for the mucous membrane was detached from the bony wall of the antrum and air was present in the pulmonary artery. I have mentioned another accident which may readily occur and lead to pulmonary embolism, namely, if the trocar pierces the outer antral wall and enters the pterygoid plexus of veins which communicates with the jugular veins. Air cannot pass from the venous circulation through the lungs and be arrested in the brain; in order, therefore, to produce a cerebral air embolus air must be injected into the carotid or one of its branches.

Spasm of cerebral arteries.—Claus attributes his case of apoplexy, which completely recovered within six days, to arterial spasm caused by novocain and adrenalin, although only a moderate amount was used. It appears to be an established fact that cerebral angiospasm is sometimes focal, and that the site is very frequently the motor pathway in or above the internal capsule (Russell). If this condition existed for a short period it might account for temporary paralysis with or without aphasia. Claus's patient was sixty-eight years of age and may have had degenerated arteries, but it is impossible to determine whether the exciting cause was the circulation in the blood of the substances mentioned or nervous disturbance due to the puncture; in the latter case the apoplexy could be regarded only as a coincidence.

Reflex irritation of vagus.—Hajek states that he has repeatedly seen patients become unwell for a considerable time when on making an exploratory washing the injected fluid was dammed in. The symptoms were sweating, great palpitation, and pulse 45 to 60. He considers the cause to be reflex irritation of the vagus through

the second branch of the trigeminus which supplies the antrum. Uffenorde and Siebenmann have also referred to reflexes of antral origin; and Killian thinks that these may be excited by injecting a cold solution. I have alluded to my experiences in about a dozen cases in which, when unable to blow air through the antrum, on persisting in the attempt, the patient began to cough, owing to irritation felt in the neck or chest, and became prostrate.

SIMILARITY OF ACCIDENTS ARISING FROM ANTRAL AND PLEURAL PUNCTURE.

The grave symptoms which have been mentioned as resulting from exploratory puncture of the antrum are strikingly similar to those which occasionally arise during the production of artificial pneumothorax. The following symptoms have been observed after the latter procedure: Pallor, dyspnoea, cyanosis, unconsciousness, rapid pulse and respiration, diplopia, amblyopia, tonic and clonic contractions of groups of muscles, general convulsions, maniacal excitement, pareses, and paralyses. These symptoms have been attributed in some cases to gas embolism (pulmonary or cerebral) and in others to reflex irritation of the pleura, and, while it is occasionally possible to assign the exact cause, "it is now generally admitted that the symptoms of pleural reflex are not clinically distinguishable from those of gas embolism; and even necropsy may not be decisive, for a fatal dose of gas may have escaped from the blood-vessels of the brain before these could be examined" (Lillingston). As an indication of the frequency and gravity of pleural reflex it may be mentioned that Zesas in 1912 had collected fifty-four cases of convulsions following operative measures on the pleura, of which twenty-one proved fatal.

INADEQUACY OF THEORIES ADVANCED TO ACCOUNT FOR ACCIDENTS.

In the present state of our knowledge the significance of the symptoms and course of illness in the cases reported does not admit of interpretation. I have consulted several prominent physicians in regard to my own cases, but none has offered an explanation. In my first patient cortical irritation was manifested, but why was so small an area (the leg) involved? If an air embolus were present, how did the air enter the circulation? And how is the attack of coughing and prostration experienced when the test was tried the week previously to be explained? On the other hand, if the theory

of air embolus be put aside and that of reflex action favoured, are we entitled to assume that a minor operation on the antrum is capable of exciting reflexly a grave train of symptoms which terminates fatally? At the necropsy of my second patient only piararachnitis was found. Why did this set in so suddenly, or to what condition was it secondary? The similarity of accidents caused by antral and pleural puncture has been referred to, and as those due to the latter are the commoner they are likely first to afford a solution of the problem.

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