internal hypoblastic gill-sacs of the Frog, with their branchial processes, are probably equivalent to the gill-sacs of the Lamprey; and it is not improbable that the posterior openings of the gill-pouches of Myxine are equivalent to the original paired openings of the branchial sac of the Tadpole. Though the resemblances between the Lamprey and Tadpole are marked, there is no ground for supposing that the former is closely related to an ancestral form of Amphibian. Of the ancestral stock with a perioral suctorial disc, the Cyclostomata are, according to Balfour, the nearest living representatives; and the resemblances between the Tadpole and the Lamprey are probably due to a common descent from this stock, from which the Ganoids also give evidence of being descended.

ON THE ENTRANCE OF AIR INTO VEINS DURING OPERATIONS.

(THE TREATMENT OF THE ACCIDENT, WITH TWO ILLUSTRATIVE CASES.)

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AMONG the more serious complications of surgical procedures, and holding a high place in the list of surgical calamities, is the entrance of air into veins during operations. It is well known that in some of the simplest operations about the neck or axillæ this complication may lead to an abruptly fatal result, or may provoke at least a train of most alarming symptoms. The air in such cases is drawn into the thorax through a partly divided vein by the inspiratory movement of the chest, just as air is drawn through the trachea into the lungs. This aspiratory effect of the thorax upon the venous circulation does not appear to extend beyond the vessels of the neck and axilla; and the few reported cases where air is said to have been drawn through wounds in other veins (*e.g.*, the median and long saphenous veins) are open to considerable doubt.

From an examination of the sixty-seven cases collected by Green,* it would appear that the accident has occurred with greatest frequency during the removal of tumours from the cervical and axillary regions. It has been met with also, although in but a comparatively small number of instances, in cases of amputation at the shoulder, in resection of the scapula, in ligature of the subclavian artery, in venesection of the external jugular vein, and, in one instance, during the introduction of a seton in the neck. The cervical veins appear to have been much more frequently the seat of the trouble than have been the veins of the axilla.

That air may enter, it is necessary that the vein be only partly divided. If the vessel be entirely cut across, the limp walls of the divided vein are drawn together during the respiratory movement, and its lumen is more or less entirely closed. This closure is really effected, of course, by atmospheric pressure, and can be well seen in drawing air along a thin India-rubber tube, a part of whose wall has been divided. Veins whose walls are thickened are apt to favour the entrance of air, as are also such vessels as are bound up in inflammatory material, or in the substance of a new growth. The external jugular vein, moreover, is so related to the cervical fascia, and the axillary vein to the costo-coracoid membrane, that those vessels remain patent when cut across. Often the dragging upon the parts, as in removing a tumour, is such as to make some of the veins that have been divided gape and remain open.

Of the symptoms of the accident, it is only necessary to say that the entrance of the air is marked by a very distinct hissing noise, precisely like that heard when air and water are being drawn up by a syringe. The patient, if not anaesthetised, is seized with a sudden terror; there is severe dyspnoea, with hurried and violent inspirations; the action of the heart becomes irregular, and often tumultuous; the pulse sinks; there is more or less profound syncope, and, in some cases, convulsions of a tetanic character, or a violent cough. About two-thirds of the patients so affected die, the majority within a few minutes, the remainder after an interval of hours, or even days. On the other hand, recovery has taken place even after the symptoms have been very severe, and, in nine of the cases collected by Green, no visible ill effects followed upon the accident, although the hissing noise was distinctly heard.

As regards the pathology of the condition, it would appear that the fatal result depends rather upon the rapidity with which the air

is introduced, than upon the actual amount that enters, other things being equal.

The air is found to occupy the right auricle, and is often considerable in quantity. It may be found also in the right ventricle, and a little may even have passed as far as the pulmonary artery and its branches.

Death appears to be due to arrest of the pulmonary circulation, and to interference with the heart's mechanism, the mixture of blood and air in the right side of the heart being such as to render the proper working of the tricuspid and pulmonary valves impossible. The dyspnoea is probably entirely due to the sudden interruption in the circulation of blood through the lungs, and, as but little blood can reach the left ventricle, the brain must become anæmic, and thus the condition of faintness be produced.

In connection with the important subject of treatment, a great many very different expedients have been proposed by those who have dealt with the subject. The first step to be taken is obviously to prevent, as promptly as possible, any further entrance of air into the vein.

To attempt to effect this end by ligaturing the vessel—as some suggest—is certainly not advisable. The application of a ligature involves time; and if the operator were fortunate enough to be able to secure the vein during the inspiratory movement, he may have prevented some air from entering, but at the same time he will have certainly prevented its exit during the next expiration. To put a finger upon the wounded vein during inspiration, and remove it during the expiratory movement is certainly a better practice. But with regard to this it must be by no means easy to detect in a large wound the exact vein that is wounded. The hissing sound is the only guide; there is nothing to be seen. One surgeon advises that the finger should be applied at the spot where the bubbles are seen entering the vein. But unfortunately the air does not enter the vessel in the form of bubbles, and, indeed, any bubbles that may be seen represent air that is escaping from the vein. To wait until an expiratory movement had rendered the seat of injury obvious by the issuing of bubbles would not be the best mode of action. The advice of others also that the chest should be so firmly secured as to arrest for a while all respiratory movement, does not appear to be sound. In such a procedure the treatment would seem to be begun at the wrong end.

Without discussing other methods that have been proposed, I think the fact has been somewhat overlooked, that this accident can only occur in what may be termed dry wounds. The wounded vein must be either exposed to the air or be covered by but a slight amount of blood before it can permit of air being drawn into its interior. In a deep wound filled with blood, the accident is impossible, and the strange exemption of tracheotomy wounds from this complication may be in some way due to the free venous bleeding with which they are often associated. It appeared to me that the best precaution to adopt in cases likely to be attended with the aspiration of air into the veins was to have an attendant ready with a sponge filled with water, which could be squeezed into the wound at the first alarm. With such a measure, no time need be wasted in searching for the vein, the entrance of air would be at once arrested, and at the most, a little clean water drawn into the circulation. This plan I adopted in the two cases reported below. Bearing in mind that the wound is most dangerous when most "dry," it will be understood that the accident has often occurred while a tumour has been torn away from its attachments, and also after a deep wound has been well sponged out.

The second step in the treatment of the accident is to endeavour to remove the air that has already entered the chest. This, I think, can be best effected by waiting until the next expiratory movement, and then bringing forcible pressure to bear upon the front of the thorax. The air so expressed bubbles up through the water or blood that still fills the wound, and is obviously unable to re-enter so long as the wound is protected in the way indicated.

The ease with which a large quantity of air was expressed from the chest in the first of the cases below reported, would render it difficult to endorse Mr. Erichsen's statement when he says: "We cannot, by any compression that we may employ, squeeze the air out of the heart." The elasticity of the chest in the young, the superficial position of the right auricle, and the lax walls of that cavity, would appear to be facts opposed to Mr. Erichsen's conclusions.

The suggestion that the air should be sucked out of the auricle through a catheter passed down one of the main veins, cannot be too strongly condemned. One of the strangest proposals current is that artificial respiration should be resorted to in these cases. The

* *American Journal of Medical Sciences*, January 1884, p. 38. See also an excellent article by Marcus Beck in Quain's *Dictionary of Medicine*.

reasons for this proposal are not evident. There is not only quite enough air in the thorax already, but a great deal too much, and the dyspnoea depends not upon lack of air in the lungs, but upon lack of blood. The only probable effect of artificial respiration would be the introduction of more air into the veins.

Lastly, when all the air has been expressed, the wounded vein should be seized (most conveniently with a pair of Spencer Wells's forceps), and either entirely divided or ligatured. This procedure should be adopted during the expiratory movement. By the treatment advocated, the accident may be immediately dealt with, the entrance of air may be immediately arrested, and the parts placed in a convenient condition for the expression of the air drawn in. The following are the cases alluded to. I am indebted to my colleague, Mr. Adams, for being enabled to operate in each instance.

CASE I.—A child, aged 2, was admitted into the London Hospital with severe dyspnoea following the inhalation, some time previously, of a foreign body—a fragment of nutshell. All attempts to remove the substance from the larynx having failed, and the dyspnoea being severe, I performed tracheotomy. The child was very fat and the trachea deep. There was free venous bleeding. Just as the trachea was about to be opened, and immediately after the wound had been sponged out, a hissing sound was heard, and alarming symptoms at once appeared. The child became suddenly collapsed, the pulse became irregular and imperceptible, and the breathing very laboured. In a minute or so the child appeared to be dead. It was impossible to tell the position of the wounded vein. Water was poured into the wound, which was rapidly filling with blood, and forcible pressure was brought to bear upon the thorax. Some twenty bubbles of air at once made their appearance. The wound was kept carefully filled during the next inspiration, and then the chest was again compressed, bringing out more bubbles of air. Guided by the bubbles, the tissues were seized by a pair of clamp forceps about the region of the wounded vein during the next expiration, and the vessel so secured. The parts included in the forceps were cut across, no further trouble occurred, and the child made an excellent recovery. The improvement that followed upon the expression of air from the chest was very marked and immediate. The foreign body was coughed up on the third day after the operation.

CASE II.—In the case of this patient, a man about 50, I was ligaturing the common carotid as a preliminary step to the removal of a large sarcomatous growth of the tonsil. The patient was stout, and had a thick short neck. The tumour greatly embarrassed his breathing. Anticipating trouble, I had a sponge filled with warm water held ready at hand. Before the ligature was applied, a hissing noise was heard, and the wound was thereupon almost immediately filled with water. The patient, in this instance, exhibited no untoward symptoms. The wound being kept filled with water, the thorax was forcibly compressed during the next expiratory movement, and a surprisingly large number of bubbles appeared in the wound. The tissues were seized, and the vein clamped as in the previous case. No further trouble occurred. The operation was completed, and the patient left the hospital greatly relieved. It may be added that, in both cases, the patient was under the influence of an anæsthetic.

ANEURYSM OF THE POPLITEAL ARTERY: DIGITAL COMPRESSION: CURE WITHIN NINE HOURS.

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THE following case may serve to encourage many of us whose faith in the advantages of digital compression, as compared with other modes of treating aneurysm, has perhaps begun to languish of late. When the case first came under my notice, I am free to confess that I was not inclined to digital compression. Experience and observation had impressed me rather unfavourably as regards this method. It appeared, on the whole, to possess few advantages over immediate ligature of the femoral artery, now that the latter operation is deprived of almost all its dangers by the antiseptic treatment. It seemed, further, to have several disadvantages not inherent in the latter method, such as more discomfort to the patient and greater loss of time, together with the uncertainty of cure and the difficulty of carrying it out fairly. As to the treatment with Esmarch's bandage, I confess to being still less favourably impressed by it than by either of the methods mentioned, after trying it, and having seen it in the hands of others. I think, too, that these views were shared generally by my colleagues, who saw the case; and we all expressed the

opinion that, in our own persons, we would rather submit to ligature of the femoral at once than undergo the more tedious, painful, and uncertain methods alluded to. The patient, however, was a nervous, and, in these matters, somewhat timid man, who could only by much persuasion be induced to enter the hospital; and then only on condition that digital compression, of which he knew something, should be given a thorough trial. I therefore yielded to his wishes, and the result has been above all my expectations.

The clinical notes of the case are as follows.

J. H., aged 42, a sergeant in the Volunteers, served many years in the regular army, and was discharged at the end of his service in good health. In September 1882, while drilling, he caught his foot in a drain and stumbled, giving his right knee "a twist." He was able to continue his drill, but felt a pain in the knee from that time on, most marked when he attempted to kneel at the rifle-range, so that he was soon obliged to give up this practice altogether. This continued, and he was treated elsewhere in various ways for rheumatism, etc., until he presented himself among my out-patients, at University College Hospital, in April 1883. He then complained of vague sensations and pains in the right thigh and calf, and pointed out an erythematous rash over the same area, which, he said, had recently appeared. This rash I set down to the prolonged use of arnica lotion. On his next visit, about a week later, the rash having now disappeared, he drew my attention more closely to the knee, and gave the more definite history as above. I then examined the ham, and at once detected the aneurysm. He stated that his health-sheet was a good one when he left the army, but later we found scars on the genitals and legs, and obtained a history of treatment for venereal disease, almost positively constitutional syphilis. He now, however, appeared strong and well preserved, but had a marked arcus senilis. Nothing abnormal was found in the thoracic or abdominal organs, and his urine was normal.

The aneurysm appeared about the size of a hen's egg, and gave the impression of being of flattened saccular form, from the character of the pulsation and the shape of the area of the latter, which might have been about covered by the palm of the hand. The stroke in the sac could be easily controlled by pressure with the finger on the vessel above. The skin over the tumour was unaffected.

On admission into hospital, I directed the patient to remain in bed, enjoined quiet in every way, and regulated his diet. Then, on April 20th, volunteers having been obtained from among the students, digital compression was commenced at 4.15 P.M. The inner aspect of the thigh had been previously washed, shaved, and then dusted with French chalk. The students were told off in pairs, each pair to be on duty for two hours, and each one of these to compress for ten minutes at a time, while his companion observed the state of the aneurysm, and rested his hand. The pressure I directed to be made with the thumb of one hand, aided by the finger of the other hand, but without any weight or compression. The spot of compression was to be varied a little with each fresh hand, so as to prevent undue tenderness, but enough force was to be employed to completely control the flow of blood. Nothing could exceed the zeal and care with which the students threw themselves into this work, and to this, no doubt, the very successful issue is in a large measure due. The patient lay upon his right buttock, with both thigh and leg slightly flexed, the pressure being applied on the artery a little below Poupart's ligament. In this way, compression was maintained more or less completely, but without any change in the state of the aneurysm until midnight. Then the pulsation was observed to become much feebler, and soon afterwards had ceased entirely. This consolidation of the contents of the sac was accompanied by some cramp-like pains in the leg; but, beyond this, the normal condition of the limb seemed but little disturbed. At no time did it feel cold or numb, or require wrapping up. When the pulsation had quite ceased, I only directed that pressure should be continued for another hour, and that the patient should wear until morning a bag of shot over Poupart's ligament; also that he should have a little morphia to obtain a good sleep. Towards the end of the compression, he was becoming rather uncomfortable, but after the hypodermic injection he obtained some rest, and, when I saw him in the morning, looked very well, though rather tired. The aneurysm was then quite solid, and already considerably reduced in size. The limb was sensibly cooler than its fellow, but was otherwise normal, except for a trifling numbness in one spot in the calf. No arterial stroke could be felt anywhere below the knee.

There is little to be noted after this, except that the solid mass in the ham contracted steadily, and the patient was very comfortable, leaving hospital on the ninth day from the cure. I have seen him