Blood Pressure during Operations on the Wounded Abdomen.

During the course of an ether vapour anaesthetic the blood pressure shows a tendency to rise, but if there is much manipulation of gut and mesentery, it will gradually fall. The process may be continued for hours without the pressure falling to a dangerous level. Exposure of gut

CHART VIII.—Anaesthesia by intravenous ether. Wounds of both thighs fifteen days. Left thigh amputated thirteen days. Severe sepsis, persistent hiccup and vomiting. Amputation lower third right thigh. Recovered.

outside the abdominal cavity produces a much more serious effect. If more than two or three feet are exposed, the blood pressure will commence to fall after a few minutes, and will continue to fall rapidly until the gut is replaced. This effect is seen when stomach and omentum are exposed, and even with great omentum alone. The indication is that surgeons should make big incisions, and work as far as possible with the gut lying inside the abdomen. Covering the exposed gut with pads wrung out in hot saline does not prevent the fall of blood pressure.

Exposure of gut produces far less effect if the patient is not under an anaesthetic. We have seen men arrive from

CHART IX.—Anaesthesia by chloroform vapour. Wound of leg seven days. Secondary amputation lower third thigh. Death ten hours after operation.

the line with several feet of intestine prolapsed through a wound, yet their blood pressure was within normal limits. In one case more than two-thirds of the small gut had been outside the abdominal cavity for at least four hours, and this man's blood pressure was 142 mm. of mercury, and his pulse rate only 108. The patient recovered.

Apart from copious haemorrhage, there is one other procedure which causes rapid fall of blood pressure in abdominal operations. This is turning the patient on his

side. The effect is only seen if the patient has been under the anaesthetic for a considerable time before being turned. At the end of an abdominal operation the patient may be in good condition. He is then turned on the right or left side so that the surgeon may excise a wound in the back. In a few minutes there is a great fall of blood pressure, and the radial pulse disappears. It may be hours before the patient recovers this lost ground. If possible, wounds of the back should be dealt with before laparotomy, as turning the patient has no ill effect during the first half-hour of an ether anaesthesia.

If chloroform be used in these abdominal operations, the blood pressure will fall during administration and for some hours afterwards. This drug is therefore to be avoided except where ether is contraindicated, as in cases in which projectiles have penetrated the chest as well as the abdomen.

The intrathecal administration of stovaine is unsafe, and should not be employed.

III. PATIENTS WITH SEPSIS.

The patient whose condition is rendered grave by sepsis will stand an amputation far better than the man who is suffering from shock. In the septic case, gas and oxygen again gives excellent results, but spinal anaesthesia, warm ether vapour, and intravenous ether are also comparatively safe. Chloroform, however, is to be avoided, as it is often followed by a slow fall of blood pressure which ends in death during the twelve hours succeeding operation.

THE COLOUR CHANGES SEEN IN SKIN AND MUSCLE IN GAS GANGRENE.

[WITH COLOURED PLATES.]

BY

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A SHORT time ago¹ I ventured to support Kenneth Taylor's statement that gas gangrene was primarily and mainly a disease of muscle. Further work and observation have only strengthened this belief. It is the object of this paper to describe the naked-eye alterations in the appearances of the skin and muscle in the sequence in which they occur.

Through the kindness of the Medical Research Committee I am able to illustrate some of the changes by the reproduction of coloured drawings made by Sergeant A. K. Maxwell, R.A.M.C. I should like to take the opportunity of congratulating him on the skill he has displayed in catching the delicate tints in the colour changes.

Colour Changes in the Skin.

The changes in the skin of an affected limb may share in the general icteric tint that affects the whole body in some cases. This has been well portrayed elsewhere,² and need not detain us here. Coming to the more local lesions, it is first necessary to state that the skin of an affected limb may appear, and usually is, perfectly normal in the early stages; even under a normal skin, however, the disease in the muscles may be so far advanced as to necessitate amputation. The first essential change in the colour of the skin is due simply to the swelling of the limb. At this stage the skin looks somewhat tense, just as it does over any deep-seated swelling, and is paler than normal, owing to the blood being driven out of it by pressure. Resonance to percussion, and even crepitations, may be perceptible at this stage. Simple pallor of the skin is succeeded by a dirty cream tint, which may be taken to indicate that gangrene is certainly established. Up to this stage examination through an incision may reveal only partial or complete involvement of a single muscle, or of a limited group of muscles, so that the condition may be suitable for treatment by local excision.

The subsequent changes in the skin are quicker and more dramatic. Areas of purple staining appear, which enlarge and coalesce. The margins of these are fairly distinct but irregular, and the intervening skin is greyish-white in colour. Soon there appear blebs filled with fluid

which is stained by altered blood; removal of the cuticle from these exposes a shiny purple-red area of dermis. When this condition of the skin is reached it may safely be inferred that the gangrenous process is so far advanced as to necessitate amputation.

In the last stage to which reference need be made, the purple is succeeded by a dark yellow-green tint. It will be seen that these later changes are identical with what may occur in any limb after death, and are essentially *post-mortem* phenomena due to bacterial action. The late colour changes may be influenced according to the relative parts played by bacterial action on the one hand and by arrest of blood supply on the other. Thus, near an infected wound the yellow-green tint may develop early, whereas in a segment of limb infected only after its blood supply has been cut off, the stage of purple discoloration may still predominate at operation.

Figure I is a drawing made from a forearm which was amputated on account of gas gangrene. The projectile passed across the flexor aspect of the forearm, causing great laceration of the muscles. The whole of the muscles on the flexor aspect were gangrenous, the change being most advanced in the deep flexors and the supinator brevis, which were diffuent. There was in this case ample opportunity for direct infection of the different muscles. The main arteries were intact, so that the gangrenous process was entirely due to infection; in other words, it was not a case of infection after arterial death, but of infection producing total destruction of the muscles and consequently of the skin and subcutaneous tissues. The drawing speaks for itself and requires but little explanation. It shows the purple mottling of the skin, and the contrast between the infected flexor muscles seen through the wound and the normal-coloured muscle by the side of the cut humerus.

There is another change in the skin—namely, “bronzing,” to which allusion must be made because it has attracted considerable notice. It is regretted that no example of this could be obtained while the artist was present, but a coloured drawing of the condition has been published elsewhere.³ The plate was merely described as “multiple shell wounds,” but the bronzed area can be well seen over the hollow part of the man’s back. This colour change is not common, in my experience, on the limbs, but is seen more often on the body, especially in connexion with wounds of the extraperitoneal part of the colon. Sometimes it is accompanied by crepitations of the subcutaneous tissue, but is often found without this manifestation. The tissue beneath is sometimes normal, or only slightly oedematous, sometimes distinctly oedematous, sometimes yellow-green in colour. At one time this discoloration is the herald of a violent infection which cannot be controlled by incisions, at another time it will disappear without treatment. The causal agent is, so far as I am aware, unknown.

Colour Changes in the Muscles.

Figure II represents a dissection of the thigh of a man who died from multiple injuries and gas gangrene of the thigh. A wound is present over the vastus externus, part of which has been carried away. The resulting dirty cavity can be seen, as can also the infected subcutaneous tissue, which is of a dirty yellowish-green hue. The vastus externus, although wounded, did not become gas-gangrenous; this may be attributed, perhaps, to the open nature of the wound. The missile passed behind the rectus tendon, and was found lodged against the fibres of the vastus internus. The point of interest lies in the condition of the latter muscle, which was gas-gangrenous throughout. The change in the colour of the muscle is a subtle one, but can be easily seen. Although not so apparent in the reproduction, the same change was present in the outer edge of the lower part of the sartorius, just where it lay in apposition to the vastus externus. The colour of the vastus externus is altered from the normal red-purple to a brick-red. The whole muscle was dead and non-contractile, and some bubbles of gas were visible between the fasciculi. It is to this stage that I have given the name “red death.” The other muscles of the thigh were not affected. Death occurred in this case fifty-six hours after the wound was received, and the condition of the thigh was found at the *post-mortem* examination.

The intermuscular connective tissue showed but little alteration in this specimen. This is often the case, but at other times there are distinct alterations. Gas may be found abundantly along the great vessels, and also commonly in the subcutaneous tissues. It is important to note that cultures from such gaseous tissues may prove sterile. At other times the connective tissue is oedematous without being discoloured, and occasionally the appearance is distinctly gelatinous. Later, the oedematous tissue takes on a yellow or yellowish-green colour, but still remains transparent.

Figure III exhibits the changes in the subcutaneous tissues in a striking degree.

In this case there was a compound fracture of the humerus just above the elbow-joint, and, in addition, a penetrating wound of the chest. The patient’s condition was so precarious that amputation was considered the best course, especially as there was no radial pulse.

The case is a beautiful example of the involvement of a single wounded muscle, and would have been an ideal one for a local excision had not the arm been shattered and the man’s condition dangerous. The supinator longus is seen in the diffuent stage of gas gangrene. The muscle was yellowish-green in colour, and quite devoid of form or tone. It was so soft that it could be moulded or dented with the finger. The greenish-yellow coloration and oedematous state of the subcutaneous tissue are well seen, although before the skin was reflected the external appearances were not marked. The other muscles of the forearm, as can be seen in the drawing, were normal and still readily contractile when examined.

In the small segments of muscle shown in Figures IV, V, VI, and VII it is possible to trace the colour changes in greater detail. All the pieces shown were taken from the gluteus maximus muscle, except one (Fig. VII), which is a portion of a tibialis anticus muscle.

Figure IV is drawn to represent the normal colour of gluteus maximus muscle, the actual specimen being taken soon after death from a patient who died of acute peritonitis. The normal colour, sharpness of outline, and general appearance of the fasciculi, show that the muscle was healthy.

Figure V shows a piece of muscle which was dead, non-contractile, crepitant to the touch, and brick-red in colour. The bubbles of gas, or rather the spaces once occupied by them, are distinctly seen. In this stage the muscle is very friable, and the gas can, by gentle stroking, be pushed about from place to place between the fibres.

Between the normal contractile muscle, as represented in Figure IV, and the condition of “red death” seen in Figure V, there occurs a zone of demarcation which it has not been possible to portray. Here, at the limit of the advancing gangrene, the muscle is simply lighter in colour than normal, but not definitely red. It is firmer in consistence than the normal, and no crepitation can be made out. This advancing edge is more fully discussed in the paper by Captain J. W. McNee and Captain J. Shaw Dunn.

Figure VI shows a piece of muscle from the tibialis anticus at a further stage in the gangrenous process. The colour is now passing gradually from brick-red to an olive-green. The tissue has become more friable, and the consistence may almost be described as “putty-like.”

Figure VII exhibits an end-stage, which is not often seen at operation. The colour of the muscle is a greenish-black, and the surface is glistening. Such a piece of muscle is so soft that it tends to flatten out and spread over the surface on which it is placed.

In Figure III the condition of the supinator longus is intermediate between the stages depicted in Figure VI and Figure VII respectively.

I must thank Captain J. W. McNee and Captain J. Shaw Dunn for the care and trouble they have taken to prepare the specimens from which the drawings were made.

Lieutenant-Colonel Frank and Captains Neligan and Drummond in their paper demonstrate the clinical use that can be made of the pathological fact—namely, the involvement of single muscles in early cases of gas gangrene.

REFERENCES.

- ¹ BRITISH MEDICAL JOURNAL, September 16th, 1916. ² *British Journal of Surgery*, vol. iii, No. 9. ³ *Ibid.*, vol. iv, No. 13, p. 57.

FIG. 1

FIG. II.

FIG. III.

FIG. IV.

FIG. V.

FIG. VI.

FIG. VII.