with a diameter slightly greater than the calibre of the bullet. Furthermore, the explosive effect is also observed when a bullet is fired through a soft medium kept in a vacuum. But, on the other hand, the cavitation which occurs in a soft medium is almost certainly responsible for the drawing in of air, some of which may be pushed out again when the target returns to its previous shape. Air may be left in the track, as is shown by the subsequent presence of a few minute bubbles in the gelatin blocks. Small bubbles are also sometimes observed in splinter wounds in flesh.

The fact that the shadowgraphs of animal limbs are essentially similar to those of the gelatin blocks suggests that precisely the same changes occur in human or animal tissues that are traversed by high-velocity missiles. The distortion to which they are subjected can only be likened to that of an internal explosion, and at the height of the deformation, which occurs after the missile has left the part, the tissues must be stretched around a central cavity of relatively large dimensions. Under such conditions it is obvious that structures at great distances from the track of the projectile can suffer damage.

It is a common clinical observation, and one which we have confirmed experimentally, that minute puncture wounds, caused by small bomb splinters, in the skin on the entry and exit surfaces of a limb or other part of the body are often the only external signs of relatively serious internal injury. Our experiments with rubber-coated cylindrical blocks of gelatin provide a parallel to this observation in so far as only minute punctures are made in the rubber covering, in spite of the considerable immediate distortion of its contents. On the other hand, when the steel ball is fired at high velocity at the skinned limb of a dead rabbit or at a slab of meat a large crater is formed in the flesh on the entry side, and the destruction is much greater than in a corresponding part covered by skin.

The explosive character of the forces set up by the high-velocity ball in its passage is manifested not only by the amount of tissue destruction caused but also by the fact that we have often observed comminuted fractures of the femur of a rabbit even when the path of the projectile lay more than 1 cm. from the bone. These fractures can be explained by the fact that bone is relatively non-elastic, and that it fractures as a result of the stresses to which it is subjected by the explosive formation of the cavity along the path of the missile. In the same way we have found that heavy glass plates placed in contact with the gelatin targets, and at a distance of 2 cm. from the track of the ball, are shattered. It would be of interest to discover whether similar indirect fracturing of bone occurs in war casualties.

In contrast with bone, highly elastic structures such as arteries, veins, and nerves are apt to escape injury in wounds caused by high-velocity missiles. Thus post-mortem examination of exposed animals shows that larger vessels and nerves may run intact through regions in which muscle and smaller vessels are often much damaged. It is only rarely that we have observed relatively severe haemorrhage from larger arteries in wounds caused by the ball travelling at 2,500 f/s and upwards, whereas the impression so far gained in our work is that such haemorrhage is not uncommon in wounds caused by the ball when travelling at, for example, 1,500 f/s.

In further experiments we have found that a steel ball, travelling at a velocity of 2,400 f/s through a gelatin block in which is embedded an excised strip of artery containing fluid maintained at a pressure of 100 mm. Hg, will not rupture the vessel, in spite of the distortion of the block, except when the ball actually hits it.

Although larger nerve trunks appear to remain anatomically intact in high-velocity wounds, it should be remembered that they have momentarily undergone considerable stretching around the cavity caused by the missiles. This stretching may be a cause of the transient paralysis and analgesia which is sometimes said to occur as a result of bomb-splinter wounds, for it is known that a nerve can lose its conducting properties for some time after such distortion.

Summary

Experiments suggest that the disproportionate degree of tissue destruction caused by small high-velocity bomb splinters is due to the fact that particles lying in their path are thrown radially with sufficient violence to leave a central cavity around which tissues at some distance from the track are momentarily stretched. While blood vessels are usually elastic enough to experience this strain without anatomical and apparent functional injury, and nerves without obvious anatomical injury, bones are often broken at some distance from the track.

Our warmest thanks are due to Colonel P. Libessart, Free French Forces, whose design of the gun and assistance with the photographic technique made this work possible. We also wish to express our gratitude to Miss B. Hunt for her technical assistance.

REFERENCES

- Cranz, C. and Becker, K. (1921). *Handbook of Ballistics*, vol. 1. Translated from the 2nd German edition. H.M. Stationery Office.
Wilson, H. C. (1940). *British Medical Journal*, 2, 66.
Zuckerman, S. (1940). *Ibid.*, 2, 131.

BLOOD-PRESSURE-RAISING REFLEXES IN HYSTERICAL ANAESTHESIA

BY

J. VERNEY CABLE, M.D., M.R.C.P.

AND

F. H. SMIRK, M.D., F.R.C.P.

(From the Department of Medicine, University of New Zealand, Dunedin)

This paper is concerned with a study of two blood-pressure-raising reflexes in a case of hysterical anaesthesia. These are: (1) a reflex from skin described by Hines and Brown (1932), who showed that when the hand and forearm are plunged into water at 4° C. the blood pressure is raised reflexly as a result of the stimulus; (2) a reflex from muscle described by Alam and Smirk (1937), which depends on the fact that if ischaemic muscles are exercised the accumulation in them of metabolites leads reflexly to an increase of the blood pressure.

It was thought that it would be of interest to investigate a patient with hysterical anaesthesia by observing whether stimuli applied to an anaesthetic area gave rise to objective manifestations such as increase of the blood pressure. In the case described the skin was at first anaesthetic, later analgesic but not anaesthetic, and the muscle was hyperaesthetic.

The subject of our investigation was a married woman aged 35, with one child. There was a long history of various ill-defined abdominal complaints, which had been treated with little improvement by a number of gynaecological operations. The personal history revealed a background of much domestic friction, the patient having been twice married, and seemingly being little happier with the second husband than with the first. Following a domestic crisis she again became ill, and was admitted for investigation, when it was found that there was a complete cutaneous anaesthesia to pain, heat, and cold over the whole body surface supplied by spinal segments. The patient stated that she had been unaware of this condition until her attention was drawn to it during examination in hospital. There were no other signs to suggest any organic lesion of the nervous system. The Wassermann reaction was negative. Explanation to the patient

that the disorder was functional and suggestion that skin sensation would return were succeeded by a prompt renewal of the capacity to detect pin-pricks and some slight return of the capacity to distinguish differences of temperature; but the complete cutaneous analgesia remained undiminished, and neither deep pin-pricks nor prolonged contact with ice led to pain, discomfort, or change in facial expression.

Method of Investigation

With the patient lying in bed a series of measurements of the blood pressure were made on the right arm; the left arm (which in common with other parts was devoid of superficial sensation) was placed out of view of the patient. When the blood pressure had reached a steady level a sphygmomanometer cuff placed previously around the upper arm on the left side was inflated to 170 mm. Hg—a pressure well above the patient's systolic pressure—thus completely arresting the circulation through the left arm. For the elicitation of the Hines and Brown blood-pressure-raising reflex small blocks of ice were packed around the patient's left arm, taking care that the operation was inaudible as well as invisible. The general blood pressure was measured again in the right arm while the left arm was being stimulated by the application of ice. To investigate the effect of the blood-pressure-raising reflex from muscle the patient opened and closed the left hand with the circulation through the left arm completely arrested until pain of the intermittent claudication type prevented further movement. During the exercise and for some time afterwards measurements of the general blood pressure were made on the right arm.

Results and Discussion

It was found that after the application of ice to the left arm the blood pressure in the right arm began to rise, although the patient felt no discomfort whatsoever from the ice. The increases in blood pressure averaged 17 mm. Hg systolic and 11 mm. diastolic. The protocol of one of these investigations is here set out; three such investigations were made on different days, always with a rise of blood pressure. In order to ensure that the rises of blood pressure were not of psychological origin care was taken to prevent the patient seeing or hearing that anything was being done to the limb. During the investigation the patient's reports of her sensations were either that she felt nothing whatsoever or that something was felt, though not of a painful nature. In the normal person the pain arising from the application of several blocks of ice to the hand and forearm usually becomes almost intolerable

Protocol showing the Effect upon the Blood Pressure of the Application of Ice to a Limb with Skin Anaesthesia of Hysterical Origin

Time	B.P. Readings in Right Arm	Time	B.P. Reading in Right Arm
4.12 p.m.	138/105	4.17 p.m.	150/118
	142/104	4.18 p.m.	156/120
Sphygmomanometer cuff round left arm inflated to 170 mm. Hg			
4.13 p.m.	144/104	4.19 p.m.	138/106
4.14 p.m.	144/105	4.20 p.m.	144/110
Ice applied to left forearm and hand			
4.15 p.m.	148/98	4.21 p.m.	146/110
4.16 p.m.	147/110	4.22 p.m.	141/107
		4.23 p.m.	140/104

within less than one minute. In this hysterical patient no pain or discomfort whatsoever followed the application of ice to the hand and forearm, yet the normal reflex increase of blood pressure was not abolished by hysterical loss of the patient's capacity to feel this painful stimulus. It was concluded that the rises in blood pressure were of a reflex nature, since, with the circulation of the limb arrested, nerves form the sole channel of communication between the limb and the rest of the body. While eliciting the reflex from muscle it was observed that muscle pain was induced with unusual ease, since twenty-five contractions of the left forearm muscles, effected by opening and closing the left hand during arrest of the circulation in the left arm, gave rise to strong pain of the intermittent claudication type, which was associated, as is usual, with a reflex rise in blood pressure. In a normal person twenty-five

strong clenchings of the hand with the forearm ischaemic will not elicit appreciable claudication pain.

Investigations have shown (Alam and Smirk, 1938) that the blood-pressure-raising reflex of Hines and Brown (in which cold is applied to an arm) cannot be elicited from an area in which there is local loss of sensation of organic origin, and it would appear, therefore, that if the observation we have made is of general application the presence or absence of this blood-pressure-raising reflex from skin might provide evidence in doubtful cases as to whether an area of skin anaesthesia was the result of an organic lesion below medullary level or was hysterical in nature. The observation is of further interest in that it demonstrates the integrity of certain nervous pathways in a patient with hysterical skin anaesthesia, and indicates that a similar method of study is applicable to cases in which there is loss of muscle pain.

Should observations such as these be employed in the differential diagnosis of nerve lesions it is of importance to recognize that emotional stimuli also produce striking changes in blood pressure and that the degrees of reflex increase in blood pressure vary considerably, but are seldom less than 10 or more than 50 mm. Hg.

Summary

Observations have been made on a patient with superficial anaesthesia of a hysterical nature, including the skin of the left arm. It was observed that the application of ice to the left arm caused a rise of blood pressure which was shown to be of reflex origin.

If the patient is unaware of the application of the stimulus a rise of blood pressure on applying cold to an anaesthetic area may be taken to demonstrate the presence of a nervous connexion between the anaesthetic area and the central nervous system, and in some cases would suggest that the anaesthesia is of a hysterical nature.

REFERENCES

- Alam, M., and Smirk, F. H. (1937). *J. Physiol.*, **89**, 372.
 — (1938). *Clin. Sci.*, **3**, 247.
 Hines, E. A., and Brown, G. E. (1932). *Proc. Mayo Clin.*, **7**, 332.

TEMPORARY VASCULAR OCCLUSION ENDING FATALLY IN URAEMIA

BY

ALAN M. GLEN, M.B., Ch.B.

Senior House-surgeon, County Hospital, Lincoln

In view of the recent work on renal failure after compression injuries a case in which temporary occlusion of the vessels to the right leg was followed by uraemia and death seems worth recording.

Case Report

A workman aged 39 was admitted to hospital shortly after falling some twenty feet through a factory roof on to a concrete floor. He had not been unconscious, was only mildly shocked, and complained of pain chiefly in the right thigh. On examination little was found apart from a contusion over the right greater trochanter and marked limitation of movement of the right hip-joint. He was removed to the ward, and while waiting to be radiographed his condition began to deteriorate rapidly. The routine shock treatment was therefore supplemented by the rapid intravenous administration of two pints of blood plasma, with much benefit—the pulse rate dropping to below 100 a minute and the systolic blood pressure rising to 95 mm. Hg. A third pint was then given by slow drip.

At this time the right lower limb was noticed to be slightly blue and swollen and somewhat colder than its fellow. The inguinal ligament of that side felt tense and appeared to be pushed up from below. Above it the external iliac vessels