when the simulation or self-injury is frankly acknowledged and discussed, will do well and become useful and effective rather than neurotic and dependent members of society. A few seem prepared to take matters to extremes, and one of us has experienced elsewhere a case of this type, not included in our series, which terminated fatally. However, we feel in no doubt that the great majority of these patients fully justify every effort made on their behalf despite the deliberately produced nature of their lesions.

Summary

Reference is made to 19 patients referred from other departments of the United Birmingham Hospitals for psychiatric assessment on account of deliberate illness or injury.

Relevant factors in these cases are tabulated, and five, including two of anorexia nervosa, are described at greater length.

Consideration is given to the nosological status of such patients, with particular reference to the diagnosis of anorexia nervosa and of hysteria.

The diagnosis and prognosis are described and suggestions made for treatment.

We are indebted to our medical and surgical colleagues for referring these cases and for their patient help, and also to the nursing staff and psychiatric social workers for their invaluable contributions. We also wish to thank Mr. T. F. Dee, of the clinical photographic department, Queen Elizabeth Hospital, Birmingham.

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THE AIR-CONDITIONING MECHANISM OF THE NOSE*

BY

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It has been the custom to regard the nose of man as designed especially for the protection of the respiratory tract. In fact, the greater part of the mucous membrane with which the nasal fossae are lined is known as respiratory epithelium, because of its similarity to that lining the tracheo-bronchial tree. The remaining area is olfactory; in man this specialized membrane is extremely limited in extent.

A study of the nose of representative species of vertebrates has shaken my belief in the interpretation of nasal anatomy for various reasons, which are elaborated later

Cold-blooded animals such as lung-fish have no ability to use the nose for warming air, since their temperature approximates to that of their surroundings. As to moistening of inspired air, consideration is required in the case of lung-fish, the only examples of fish with a pulmonary apparatus. I regret that I have no experimental data on which to form an opinion except to observe that in lung-fish and also in amphibia the area of nasal mucosa is limited and does not appear to be designed for the giving off of water vapour.

*Read in the Section of Otolaryngology at the Joint Annual Meeting of the British Medical Association, Canadian Medical Association, and Ontario Medical Association, Toronto, 1955.

Olfactory Organs of Fish

It is important, however, to refer to the olfactory organ of fish, which I have studied in some detail, particularly in the carp (*Cyprinus carpio*). A superficial examination of the nasal organ of these and other fish shows that it is devoted entirely to the function of olfaction. It is a deep recess with a number of projecting lamellae; the number and disposition of these lamellae vary in different species (Fig. 1).

By cutting serial sections and making an enlarged transparent reconstruction, detailed examination shows that the greater part of each lamella is covered with columnar epithelium of non-olfactory type; the olfactory mucosa is very limited, and lies at the base of the lamellae. Investigation of the non-olfactory area reveals a number of clear vacuolated cells, which on special staining are found to contain mucus. These clear cells are arranged some below and some near the surface of the epithelium, and are discharged in varying number; similar clear cells are found in the skin, with the recognized function of discharging mucus, as a protection against fungoid infection, among other reasons.

Mucus is obviously not required for moistening, since the fish lives in a watery medium; it may contain lysozymes, in the case of man.

A consideration of this simple nasal organ discloses an anatomical arrangement comparable to that of most mammals, although dissimilar to that of man. There is, in fish, an aperture to the recess, as in mammals, with various mechanisms to carry in a current of water; in both types the superficial part of the recess is lined by epithelium with a protective function, while the olfactory area is placed deeply.

Structure of the Nose in Mammals

One is immediately faced with the possibility that the protective area of the nose of mammals is intimately concerned with the welfare of the olfactory region; this is only natural, since olfaction is the reason for which the nasal organ was evolved.

On examining the nose of amphibia and reptiles there is found to be a plentiful supply of mucous glands somewhat similar to the goblet cells of mammals; their disposition is generally anterior to the olfactory area.

When mammals are studied it is found that the structure of the nose follows a common pattern: close to the orifice or nares there is an air-conditioning plant made up of a more or less complicated body projecting from the lateral wall, the maxillo-turbinal. In the hinder or deeper region there lies the olfactory mucosa carried on projecting conchae known as ethmo-turbinals. To form a considered judgment on the reason for the varying degrees of complexity of these two portions of the nose, it is essential to examine all species. It will be best to consider a simple type first, and one of the primates will serve well for this purpose; in man various secondary changes have occurred, which somewhat confuse the issue.

The nose of a baboon or orang shows a flat maxillo-turbinal in the form of a single scroll, as in man. Somewhat above and behind there is a single ethmo-turbinal body (Fig. 2). Whatever protective function the nose fulfils as an air-conditioning plant for a respiratory tract is efficiently carried out by this simple nasal structure; so it is in man. There is anteriorly an area of mucous membrane with numerous vascular spaces; a good blood supply is required to provide heat for warming incoming air if much moisture is to be taken up. Consideration of the physics of absolute humidity shows that cold air can carry very little moisture, while warm air can take up a considerable amount; it is almost impossible to saturate hot air.

In the apes and man, part of the ethmo-turbinal area also is capable of giving up heat and of supplying moisture, but the total area is small in comparison with that of many mammals to be described later. It must be emphasized that this relatively simple arrangement allows the respiratory tract to maintain its health.

Relation between Olfactory and Humidifying Areas

Examination of the warming and moistening capabilities of man shows that the nose supplies a considerable amount of heat and moisture, but does not bring inspired air up to body temperature, nor to saturation point. Measurements given by Greville Macdonald in 1889 showed that with chilled air varying from −7° C. (20° F.) to 12° C. (54° F.) the air after passing through the human nose was raised in the first instance to 28.8° C. (84° F.) and in the second to 35.6° C. (96° F.); figures given by Perwitzscky (1927) are:—inspired air: room 25° C. (77° F.), nasopharynx 32° C. (90° F.), larynx 34° C. (93° F.), trachea 36° C. (97° F.); expired air: trachea 36° C. (97° F.).

In the nasopharynx of man there is a deficiency of heat and also of moisture, both of which are corrected as the air passes down the respiratory tract, until in the terminal bronchioles it is at body temperature and is saturated with moisture. To achieve this saturation of warm air, so as to bring it up to 100% relative humidity, requires the addition of much moisture, since relative humidity varies inversely with the temperature.

The source of supply is in part the secretion of goblet cells in the epithelium and of racemose glands in the submucous layers of what is called respiratory epithelium, together with secretion from Bowman's glands beneath the olfactory mucosa; there is, in addition, water vapour given off by transudation from the capillaries through the walls of the epithelial cells, with evaporation into the air current. A considerable amount of warmth and moisture is conserved by the nose during expiration, so that it is not necessary for a completely fresh supply to be added at each inspiration.

It has long been recognized that for patients with a tracheostome or laryngostome a protective covering over the artificial opening is required, to act as a means of retaining heat and moisture from the expired air stream; use has been made by some mountaineers of a finely perforated copper shield over the nose and mouth with a similar object. Cole (1953) has shown that breathing through a tube held in the mouth and filled with balls of blotting-paper, with the nose inactive, will serve for air conditioning as efficiently as during nasal respiration.

On examining the nose of animals, it is found that variations occur both in the maxillo-turbinal and in the ethmo-turbinals. The former show varying degrees of complexity, from the single scroll of many primates and man, to the double scroll of most ungulates and some rodents, the folded or furrowed structure of some marsupials, and, finally, the branching turbinal of most carnivora and some rodents (Fig. 3). In the branched type the total area is very large and capable of engorgement.

There are also considerable differences in the length of the maxillo-turbinal, dependent in part on the length of the snout; this is long in animals which have to seize food with the mouth, and shorter in those that make use of the fore limbs for grasping (Wood Jones, 1916). The available area of epithelium depends on the degree of convolution and on the length of the maxillo-turbinal.

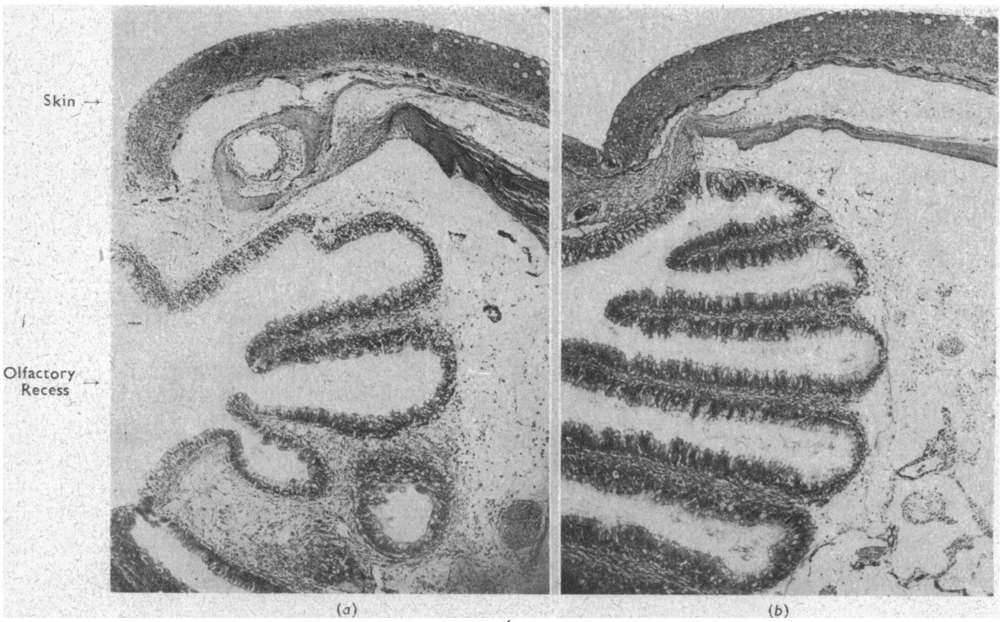

FIG. 1.—Olfactory recess of carp, *Cyprinus carpio*. (*a*) Normal: Many mucus-secreting cells on lamellae, some being cast off. There are similar but less numerous cells in the skin. (*b*) Carp kept in distilled water for two hours: Increased extrusion of cells with distension by intake of fluid, some distended cells being cast off, giving the lamellae ragged edges. No obvious change in the skin.

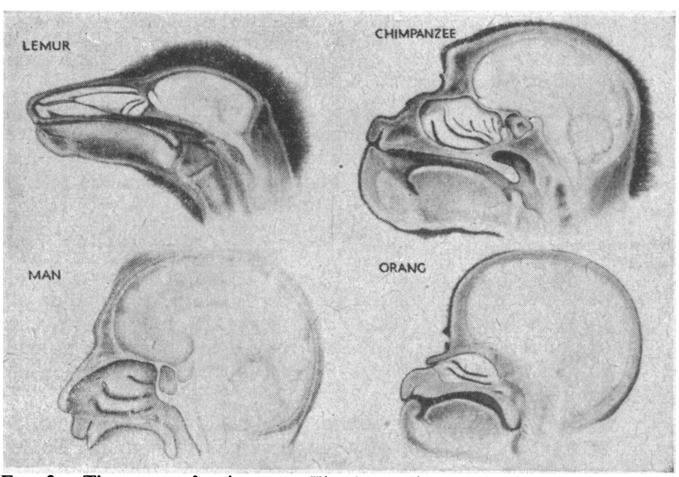

FIG. 2.—The nose of primates. The lemur has a maxillo-turbinal with a double scroll; the ethmo-turbinals are large and the olfactory bulb well formed. The chimpanzee (*Anthropopithecus troglodytes*) has a single scrolled maxillo-turbinal and a single ethmo-turbinal partially divided by furrows. Man (*Homo*) has a partially divided ethmo-turbinal system and a single scrolled small maxillo-turbinal. The orang-utan (*Simia satyrus*) shows regression of both maxillo- and ethmo-turbinals; the olfactory bulb is extremely small, with a feeble sense of smell.

Types of Specialized Epithelium

Study of the olfactory region shows an increasing area of specialized epithelium in many animals, in some cases with extensions into the frontal and sphenoidal sinuses; this increase is roughly proportionate to the air-conditioning surface of each species (Fig. 4). On analysing a whole series, the conclusion reached is that it is the keen-scented carnivora that have a very extensive system for warming and moistening purposes (Negus, 1954) (see Table). The reasons for this association are that saturation of inspired air with moisture provides a means of entrapping olfactory molecules and depositing them on the olfactory mucosa; the physical process is thought to depend on variations of electrical charge, but the details cannot be entered into here.

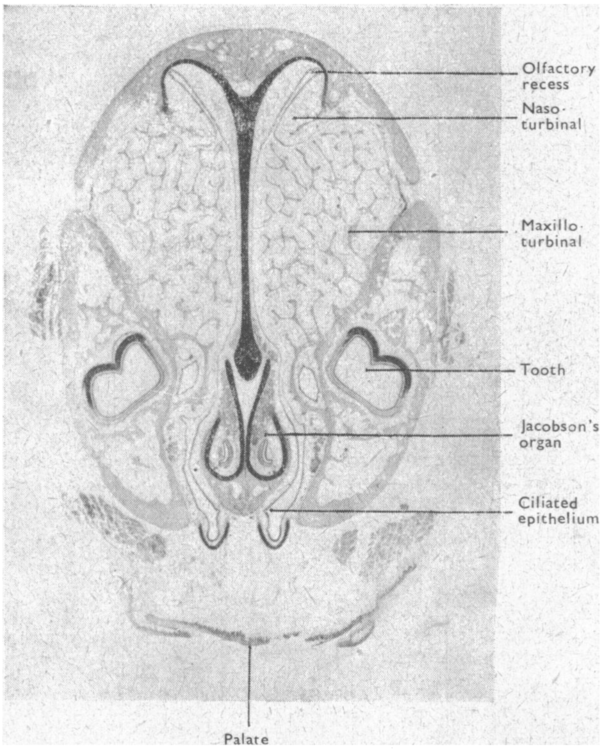

FIG 3.—Coronal section of snout of a rabbit (*Lepus cuniculus*). The anterior half of the nose is devoted to air-conditioning. The maxillo-turbinal shows extensive branching; the surface epithelium is very thin, admitting free passage of heat and moisture. Ciliated epithelium is present only on the nasal septum and in the lower part of the nasal fossae. Superiorly, the anterior end of the naso-turbinal is shown; it has wide vascular spaces.

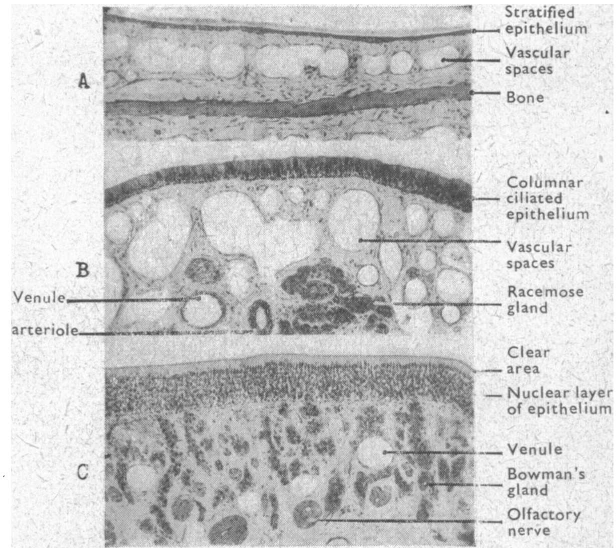

FIG. 5.—Sections of the mucosa from the nose of a rabbit for comparison of the structure. A. Mucosa from the surface of the maxillo-turbinals supported by a bony framework. There are wide vascular spaces and an epithelium which is extremely thin, consisting of two layers only. B. Ciliated epithelium from the septum, showing the large vascular spaces and a big racemose gland. The number of goblet cells varies in different areas. C. Olfactory mucosa, very thick and made up of many cells with nuclei at different levels and with a clear area traversed by filaments leading from the olfactory vesicles. Beneath the epithelium many Bowman's glands are to be seen. There are also olfactory filaments of different sizes.

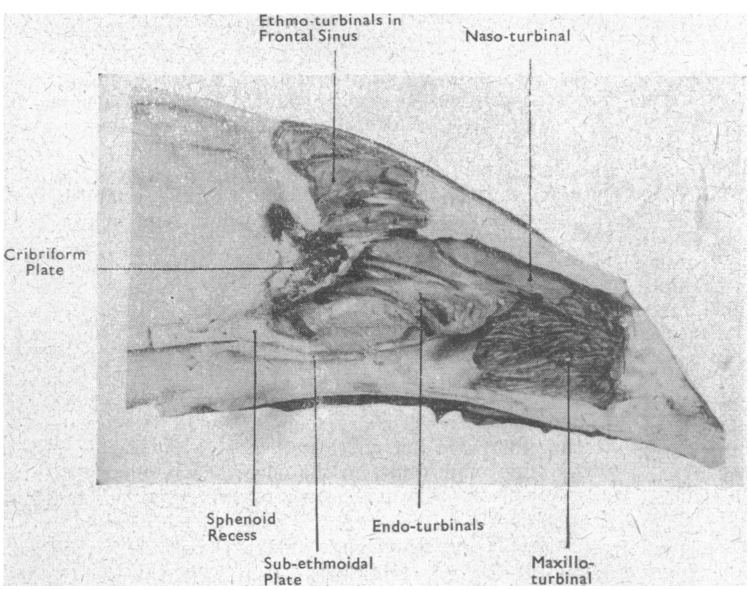

FIG. 4.—Sagittal section of skull of a badger (*Meles meles*). In addition to a big ethmo-turbinal system in the snout, there are large olfactory extensions into the frontal sinus and also into the excavated sphenoid bone. The maxillo-turbinal is of branching type and very extensive in area. There is a large sub-ethmoidal plate with recessing of the olfactory area. The cribriform plate is very large in area. The olfactory sense is very acute.

Careful examination of the structure of the mucous membrane in certain species shows that the highly branching maxillo-turbinal of the rabbit, for example, is covered with an extremely thin epithelium, truly stratified and of only two cells in thickness. There are no cilia on this membrane nor any goblet cells or mucous glands; wide and extensive vascular spaces lie beneath the epithelium. The conclusion is that this highly specialized structure is designed to give up heat by radiation, and moisture by transudation and evaporation (Fig. 5).

In man there is no similar epithelium. It is obvious that the designation of respiratory epithelium in the nose requires modification, as being a term applied to the columnar ciliated epithelium of man; the presence of two dissimilar mucous membranes in the rabbit, one columnar ciliated and the other stratified and non-ciliated, must receive appropriate consideration. Furthermore, if the deductions drawn from the studies described are correct, and if nasal humidification is designed rather for the olfactory than for the respiratory function, then the description of the mucous membrane lining part of the nose as respiratory is incorrect and must be rectified.

Transudation Problems

This communication has been confined to a consideration of the nose, without reference to the moistening and warming capabilities of the mouth and pharynx, trachea, and bronchi;

Showing the relative area of the maxillo-turbinal. It is least in those with a short nose and a single scroll, and greatest in those with a long snout and a branched maxillo-turbinal. The microsmatic primates are in the former group and the macrosmatic carnivora in the latter. Rodents and ungulates are in an intermediate position. The area of maxillo-turbinal, according to these observations, bears a direct relation to the powers of olfaction.

	Monotremes Marsupials	Edentates	Rodents	Ungulates	Hollow Horned Ungulates	Chiroptera Insectivora	Marine Carnivora	Dogs, Bears, Racoons, Weasels	Cats, Civets, Hyenas	Primates
Single scroll:										
Short ..	Koala									Sifaka, orang, chimpanzee, gorilla, man
Medium ..						Fruit bat, vampire bat,				
Long ..				White-lipped peccary		Leaf-nosed bat				Lemur, baboon
Very long ..		Great ant eater								
Double scroll:										
Short ..		Sloth	Dormouse, guinea-pig							Loris, capuchin, gibbon
Medium ..				Syrian hyrax					Jaguar, hyena, lion, leopard	Howler monkey
Long ..			Water rat, coypu, paca, agouti, brown rat	Hippopotamus, wild boar, pig, collared peccary	Chamois, ox, sheep, muntjac, mouse deer, roe deer, antelope, pronghorn				Caracal	
Very long ..	Echidna, bandicoot					Mole				
Grooved or folded:										
Short ..			Marmot, red squirrel, flying squirrel							
Medium ..									Binturong	
Long ..	Wallaby, opossum, platypus									
Branching:										
Short ..								Panda, kinkajou	Cat, ocelot	
Medium ..	Tasmanian wolf		Rabbit				Seal	Badger, otter		
Long ..	Dasyure					Hedgehog, tenrec		Ferret, racoon, coati, weasel, bear, dog, fox mongoose	Civet, genet	

in point of fact the mouth and pharynx take little or no part in humidification in keen-scented animals, since the former is shut off from the respiratory tract by the epiglottis and the latter is almost non-existent in the majority of mammals.

The question of transudation raises various problems, connected with passage of water through the semi-permeable epithelium lining the nose and respiratory passages. Useful information can be derived from a study of fish and amphibia, some of which have a semi-permeable skin; they have the necessity of preventing passage of water into or out of their bodies by osmosis. It is said that teleostean fish inhabiting fresh water live in danger of death by flooding, while those in sea-water fight against death by desiccation (Baldwin, 1941). The reason depends on the ionic concentration of blood plasma and intercellular and intracellular fluids; these are in ionic balance one with the other, but they vary considerably from the medium in which the fish lives. The salt content of the body fluids of teleostean fish, of amphibia, and of mammals corresponds to that of sea-water in the relative proportion of anions and cations, but varies in total amount, being between three and four times less than sea-water and considerably greater than river or estuarine water (Gamble, 1951).

It is said that the skin is partly waterproofed by a covering of mucus, secreted by goblet cells distributed over the surface of the body and especially numerous in the olfactory recess, with its exposed epithelium. It is said that if the covering of mucus is removed the animal will absorb water (Baldwin, 1941). I have been unable to confirm this in experiments with carp and xenopus toads; eels have been used by others. If the recorded observations are correct, it would suggest that the covering of mucus throughout the respiratory tract, except in the atria and air sacs, might be of help in preventing passage of water by osmosis through the epithelium. The physical conditions are complicated and require further study, since the factors of transudation, osmosis, and hydrostatic pressure have to be considered.

On the epithelial side the extracellular and intracellular fluids have a high osmotic pressure, while in the lumen of the nasal cavity and tracheo-bronchial tree there is air saturated with water vapour; the moisture derived from the atmosphere has no salt content, and if it condensed on the surface of the epithelium it would establish conditions of osmotic imbalance and would tend to pass into the submucosal tissues.

Conclusion

No reference has been made to the interesting arrangement of blood vessels in the turbinal bodies, to the supply of moisture from the sinuses, or to the function of swell bodies. Disturbances of humidification and deranged viscosity as a result of living in dry rooms or after tracheostomy or laryngectomy are not considered, nor is the mechanism of distribution of moisture in the nose: the peculiarly limited arrangement of cilia in the nose of most mammals requires a separate study.

Ciliary action, for which a supply of moisture is required, again requires separate study: it is sufficient to say that the warming of inspired air is not essential for efficient working of the cilia.

The main purpose of this paper has been to point out certain features of considerable interest in the realm of comparative biology and to relate them to the difficult question of nasal physiology.

Summary

A study has been made of the nasal organ of fish, with particular reference to the distribution of olfactory mucosa and of secretory epithelium. A comparison is made with the nose of mammals, in which there is typically an anterior air-conditioning part and a posterior olfactory region.

Observation of a representative series of mammals reveals a correspondence between the olfactory and the humidifying areas and indicates a relation between the two, both areas being small in species with feeble powers of scent and extensive in keen-scented animals.

The epithelium generally known as respiratory is found to be of two types, one ciliary and the other thin and permeable.

The conclusion is that the present views on nasal physiology require readjustment.

Figs. 1, 2, 3, and 5, and the Table, appeared in *Annals of Royal College of Surgeons of England,* 1954, vol. 15, Sept., and Fig. 4 in *Acta Oto-laryngologica.* 1955, vol. 44, Fasc. 5–6.

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ACUTE PERIPHERAL CIRCULATORY FAILURE IN SURGICAL CASES

TREATMENT WITH L-NORADRENALINE

BY

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The term "peripheral circulatory failure" is often used to describe a clinical state in which there appears to be widespread stasis of blood in the small cutaneous vessels, with a noticeable reduction in the speed of reflux into the capillaries after finger-tip pressure. It is associated with a patchy cyanosis, particularly marked at the extremities, with a rapid thready pulse, and with hypotension. This type of response may be observed clinically in many different conditions. Among these are coronary thrombosis, fulminating infections, extensive burns, intestinal strangulations, grave electrolyte upsets, peritonitis, acute pancreatitis, and after aspiration of vomitus. It has been thought that various agents such as vasodepressors and bacterial toxins may be responsible for the phenomenon, but convincing proof is lacking. For a complete understanding of this condition, further work remains to be done on the response of the peripheral vessels, and on blood-volume shifts.

Clinical observation suggests that dilatation and stasis occur in the vessels of the skin. It seems likely, also, that blood is sequestrated in the subcutaneous tissues, which are seen to contain sluggishly moving, poorly oxygenated blood if operation is undertaken during this phase. The appearance of the seromuscular coat of the bowel suggests that therein also the vascular bed has dilated and stagnation is occurring. If these observations are correct one might anticipate improvement after administration of a peripheral vasoconstrictor.

Studies of the pharmacological properties of L-noradrenaline have suggested that it may be capable of increasing peripheral vascular tone. It has been shown that this drug is an overall vasoconstrictor in man, producing secondary increases in both systolic and diastolic pressures, but without directly increasing cardiac output, and having none of the untoward central effects of adrenaline itself (Goldenberg *et al.*, 1948; Swan, 1949; Churchill-Davidson, 1951a). Vasoconstriction has been observed in the vessels of the seromuscular coat of the colon in man after L-noradrenaline (Grayson and Swan, 1950). Swan (1952), after a study of blood flow through various organs, concludes that it would be the drug of choice in peripheral circulatory collapse.

The Investigation

An attempt was therefore made to assess the effect of L-noradrenaline on acute peripheral circulatory failure occurring in surgical cases. I have used the drug in 14 such cases of varying aetiology. In all but one of these a response was obtained. All had systolic blood-pressure levels of 60 mm. Hg or below, and levels of 90–100 mm. Hg were attained within one to five minutes. These levels were maintained for periods of up to 48 hours. It is, however, difficult to control such an investigation. Peripheral circulatory failure is not a disease entity in itself, but is a vascular phenomenon which may arise during the course of many different illnesses. It is not, therefore, possible to treat it as a single pathological condition, and so to estimate the efficacy or otherwise of treatment. The underlying causal process must always modify and cloud the evaluation.

This difficulty can to some extent be overcome by confining the study to cases of one specific type, preferably where treatment of the primary lesion is possible only if the failure can be relieved. For that reason a group of four of these cases are considered in some detail where failure had come on rapidly after gross faecal or purulent contamination of the peritoneal cavity. This gives the added advantage that the degree of circulatory collapse was profound and surgical correction could be attempted only if this was overcome. This group includes that case in which no response was forthcoming.

We have regarded acute peripheral circulatory failure as being present in this group when, within a few hours, the skin had become cold, blue, and blotchy, when the speed of reflux into the cutaneous vessels after digital pressure was greatly reduced, when the pulse was faint and rapid or imperceptible, and when the systolic blood pressure was below 50 mm. Hg or not recordable. From the fact that this state developed rapidly after a proved abdominal catastrophe and that clinical and E.C.G. confirmation was lacking both then and later, we have assumed that coronary thrombosis was excluded.

Case 1

A man aged 52 was admitted to hospital at 8 a.m. on January 4, 1954, complaining of hypogastric pain which had come on suddenly 10 hours before. He gave a history of intermittent constipation and loss of appetite for one month. Clinically he showed signs of diffuse peritonitis. His pulse was weak and rapid, B.P. 50/30 mm. Hg, and marked signs of peripheral circulatory failure were present. At 8.30 a.m. an L-noradrenaline drip was started at 4 μg./min. This was increased to 8 μg./min. as the response was poor, and by 9 a.m. his B.P. had risen to 90/50 mm. Hg.

Laparotomy was carried out and the peritoneal cavity was found to be full of faecal material. This had come from a perforation of a carcinoma in the distal part of the pelvic colon. Exteriorization was not possible, as the patient's condition was giving rise to concern. The proximal part of the pelvic colon was brought out as a defunctioning colostomy and a drain was inserted into the pelvis. During operation the response to the drug lessened and the dosage