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The Conceptual Basis of Modern Surgery

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Abstract
The broad pattern of surgical practice as we know it to-day was largely designed in the fifty years that centred on the turn of the century. This was a time of great vigour and high accomplishment, when surgical adventurers the world over were ready to exploit to the full the twin discoveries of anaesthesia and antisepsis. It was the era of the "anatomical" surgeon, and speed and manual dexterity wedded to courage and imagination were the qualities that led to success and fame—and fortune. It is small wonder that some came to believe that with their definition of the possible and impossible the ultimate goal of surgery had been attained.
The truth is otherwise; for though much was achieved, surgery was still largely a craft and much of its practice was empirical and ill-conceived. Nevertheless, the debt of the modern surgeon to his immediate ancestors is a substantial one. The experience and the knowledge that they gathered and disseminated has become for all time an important part of the fabric of surgical practice, though in our pride and our satisfaction in the surgery of to-day we are apt to forget it or ignore it or minimise it.

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THE CONCEPTUAL BASIS OF MODERN SURGERY

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The broad pattern of surgical practice as we know it to-day was largely designed in the fifty years that centred on the turn of the century. This was a time of great vigour and high accomplishment, when surgical adventurers the world over were ready to exploit to the full the twin discoveries of anaesthesia and antisepsis. It was the era of the "anatomical" surgeon, and speed and manual dexterity wedded to courage and imagination were the qualities that led to success and fame—and fortune. It is small wonder that some came to believe that with their definition of the possible and impossible the ultimate goal of surgery had been attained.

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The surgical endeavours of the early decades of this century were in general mainly concerned with the removal of diseased structures and the correction of simple deformities. But since then, and especially during and since the war, a revolution has occurred in both the concepts and the practical content of surgery. This is the result of the permeation of surgical thought and practice by a scientific and experimental outlook, and in consequence fundamental advances both in the ancillary disciplines and in scientific clinical research have enormously increased the scope and the direction of surgical enterprise.

The surgery of to-day may, for want of a better term, be described as "physiological". Possibly biological is more apt, for biophysics and biochemistry, pathology and bacteriology have each made distinguished and important contributions. It is sometimes claimed, indeed, that the surgeon himself has added least; but this is a charge that is easily rebutted. In the event, and almost without exception, it has been the surgeon who has recognised the potential significance of new discoveries in the collateral sciences, and who has integrated them into current surgical practice. Furthermore the ambition—or the inquisitiveness—of the surgeon has often provided a spur to the research worker in the basic scientific departments.

It is manifestly impossible in short compass to scrutinise the many new facets of present day surgery. In this brief contribution I propose only to glance for a moment, and in a general way, at some of the newer concepts on which it is founded, and that have contributed to the greater safety as well as the increased scope of the modern surgical operation.

The most fundamental of these concepts is that no matter how imperative, no matter how life-saving, every operation is in fact itself a form of injury and as such evokes a characteristic disturbance in the physiological and metabolic equilibrium of the patient. Claude Bernard laid the foundations of this knowledge with his definition of the *milieu intérieur*, but it was the fertile brain of Leriche that completed the concept of a *maladie post-opératoire*, with its implications that to cure by surgical means we are condemned to inflict a hurt that can be insupportable if the disease itself has already exerted a maximum toll. It is the principal object of our pre-operative management to anticipate it and prepare for it; it is our duty, in the course of operation, to minimise the extent of this inevitable injury; and in the days after operation it is our concern not to embarrass the efforts by which the body seeks to compensate, and to effect its own repair.

Fortunately, the biochemical and endocrine resources of the body are well able to restore metabolic balance unless the disease itself, or some post-operative complication, renders the situation difficult. The dangers as well as the benefits of blood—of water—of salt—of potassium—would each make an admirable topic for surgical homily; and such a therapeutic slogan as "push fluids", a not infrequent catchword of a year or two ago, is dangerous counsel, unless fluids represent the particular need at the particular moment.

The mechanisms by which these post-operative metabolic changes are brought to pass are by no means clear. The evidence suggests that the pathways are endocrine—the posterior pituitary and its antidiuretic hormone in the case of water, the adrenal cortex and its hormones in the case of sodium, potassium and nitrogen. On the other hand the purpose of the metabolic response to surgery is reasonably clear. The alterations in electrolyte and nitrogen metabolism conserve the body fluids and establish the conditions necessary for the formation of the inflammatory exudate, and for the processes of repair. There is no call for therapeutic interference, therefore, unless the "normal" losses of fluid and electrolyte are increased by such abnormal losses as by intestinal suction, or unless for any reason the resumption of a balanced diet is delayed.

After much heart-burning, we have in fact reached a safe and satisfactory working policy. We have relearned that if we do not interfere, the average patient recovers from operation without our assistance, unless the circumstances of his illness or his convalescence are in some way abnormal—as in the case of intestinal fistula, prolonged gastric suction, or the continued discharge from a suppurating lesion.

I suspect that some of our "problem cases" have been and are of our own making; and it is common experience that a satisfactory technical operation is not often followed by serious difficulty. For my own part, I subscribe whole-heartedly to Maddock's dictum—"that with the best of experimental evidence at hand to-day, the immediate post-operative period calls for only moderate amounts of fluid, and no electrolytes unless abnormal extrarenal losses are occurring."

Apart from these inescapable metabolic disturbances the most evident of the other effects of surgery is to cause the loss of a variable quantity of blood; and blood loss—excessive, or, in the previously anaemic, even within the usual limits—is fundamentally the cause of surgical shock. It would be idle to pretend that we know all there is to know about shock, or that it has been abolished from the surgical scene; but our concepts of its effective management are gradually being clarified. Obviously it is desirable to correct anaemia and blood deficit before operation, when they are detected; but in some circumstances the volume of circulating blood may be seriously reduced without appreciable change in the results of our standard blood examination. This is especially so in the elderly, and in those with malignant disease, especially of the alimentary tract. It has been shown that in them—and they form an increasing number of our surgical patients—that blood counts, haemoglobin estimations, and haematocrit readings do not always accurately reflect the *mass* of blood in the circulation, which can only be determined by measurement of the total blood volume.

Until recently, estimation of blood volume was by tedious and unreliable dye methods; but the use of isotopes such as I131 tagged to the serum albumen or of chromium-labelled red cells has made its assessment simple and reasonably quick. Using these techniques it is obvious how often in the past our pre-operative preparation has been inadequate in respect of blood restoration. Clinical instinct has suggested this, for surgeons of experience have often paused by a bedside, convinced that a patient was in need of blood, only to be confronted with laboratory evidence apparently to the contrary.

The amount of blood spilt during operation is largely a matter of operative technique. Dissection in correct anatomical planes, control of the main arterial supply at an early stage of extensive procedures—of the internal iliacs in abdomino-perineal resections, for example—and patient, gentle and unhurried haemostasis, will reduce blood loss to an inevitable minimum, and operative shock to consequent insignificance.

It should be simple to calculate and to replace the blood lost during operations; and yet our estimates are almost always too low. In the course of an uncomplicated gastrectomy, the average loss is something of the nature of half a litre per hour, and the circulatory volume is further depleted by sweating and by insensible excretion. Deficits of this order are easily and rapidly compensated for without assistance; greater losses in more extensive procedures demand energetic replacement, not later, but at the time of operation. If this is not done the body does its best to compensate by constriction of the peripheral vessels—a dangerous remedy, since the consequent ischaemia and hypoxia, if protracted, may cause permanent damage to the brain or the viscera, particularly in the elderly. There is some evidence that the ischaemic liver releases a vaso-depressor substance, which causes widespread vascular paralysis and irreversible shock; but even if the immediate shock appears to be relieved by later transfusion, death may take place within a few days from suppression of renal or hepatic function.

Naturally the difficulty of estimating blood loss is greatest after injury. Experience in the Korean War confirmed the impression of World War II that enormous quantities of blood were necessary after severe trauma—much more than appeared necessary by former standards. Under-assessment, in fact, is almost invariable; the corollary is important, namely that lack of response to apparently adequate quantities of blood should usually be the signal for even more energetic transfusion.

The limited "life" of stored blood, the difficulty of its transport over long distances and the realisation that the amounts needed to restore a "depleted" peripheral circulation can be considerable have together stimulated a search for substitutes and alternatives. The development of methods of separating and drying the plasma of effete stored blood seemed to provide the ideal "plasma expander". Unfortunately, the high incidence of serum-transmitted diseases such as infective hepatitis in those transfused both by wet plasma and rehydrated dried plasma caused its use to be abandoned, and provoked a successful search for artificial plasma substitutes, such as Dextran. But the recent demonstration that even virus-infected plasma can be rendered safe by exposure to room temperature at intervals appears to make its use justifiable again.

Developments in the art and practice of anaesthesia have greatly assisted the modern surgeon in his efforts to stabilise the physiological status of the patient undergoing operation. Relaxants have made deep anaesthesia unnecessary and allowed the use of anaesthetic agents which are much less toxic, less productive of shock and less attended by post-operative crises.

In the prevention of shock the anaesthetist of to-day can contribute enormously towards the diminution of blood loss by inducing a state of deliberate hypotension during the operation. This he can accomplish in one of several ways—by hypotensive drugs, by high spinal anaesthesia that blockades the vasoconstrictor government of the peripheral vessels or by arteriotomy and the actual withdrawal of blood.

My own experience has been mainly with the second of these methods. High spinal anaesthesia results in a state of generalised vascular dilatation; the peripheral resistance is accordingly eliminated, and a fall in blood pressure results. By suitable postural adjustments—so that the operative field is at its highest level—the tissues can be rendered virtually bloodless, and surgical dissection is made easier as well as safer.

Enlightened management of the metabolic sequelae of operation, the advances in the techniques of anaesthesia, our ability, for most practical purposes, to control shock, and the elimination, for the most part, of the hazards of infection by chemotherapy and antibiotics have made possible surgical intervention in diseases formerly beyond the surgical horizon; and the opportunities have expanded for increasingly extensive surgery in malignant disease—of the pancreas, the pelvic organs, the lung, the stomach and the liver. Once on the frontier of surgical endeavour these mighty enterprises have become almost commonplace.

The importance of adequate nourishment in furthering healing and promoting recovery has long been appreciated, and yet the nutritional care of the surgical patient has become the subject of serious study, only in recent years; and this despite the fact that in most diseases, the protein reserves of the body are more often and more seriously depleted than water and salts. The effects of protein deficiency are diverse, and threaten the success of operation at many points—a predisposition to shock, an increased vulnerability of intestinal and external suture lines, and a tendency to the development of wound sepsis. It is not always possible to restore the undernourished victim of malignant disease to positive nitrogen balance, or to compensate for the phase of nitrogen catabolism after operation. But much can be, and is being accomplished in the management of the seriously burned, the gravely injured, and those suffering from such wasting diseases as ulcerative colitis, in all of which there is a continuing long-term drain on the body stores of nitrogen, potassium and fat.

In burns, a regimen of supplementary feeding by mouth or tube with specially prepared diets, reinforced by fat emulsions, has been used by my Edinburgh colleagues, Anne Sutherland and A. B. Wallace. They have shown that if this programme is started as soon as the initial period of fluid replacement is completed, it is possible to have such patients at or above their normal weight on discharge; and during their time in hospital, their general condition is excellent, grafts "take" better, epithelialisation of raw surfaces is more rapid, and the need for blood transfusion is reduced.

Burns best typify the metabolic problems of severe injury; in ulcerative colitis the surgeon encounters an essentially similar problem as a sequel to disease. Formerly the emaciated, querulous and dispirited patient was ill-equipped even for operation in stages, and the mortality from surgery was forbidding. To-day the situation is quite changed, and largely because we have come to conceive the problem as one almost entirely of restoring electrolyte balance, and satisfactory nutritional status.

Thus, measurement of the volume of the stool, a useful and neglected examination, may reveal a fluid loss of more than 2 litres a day, with corresponding deficits in electrolytes, and especially potassium. But the extent of the protein loss is even more important. This loss is two-fold. As in any febrile disease, there is the usual loss of nitrogen from protein breakdown, except that in ulcerative colitis the fever may be protracted. Coupled with diminished intake of protein, this means a negative nitrogen balance and an inevitable fall in weight. But there is a second loss whose extent has been overlooked in the past, and that is the protein exudate from the inflamed bowel itself. The amount of this may be very great, and goes far to explain the rapid deterioration that accompanies the florid stages of the disease. Measurement of the stool protein as an index of this loss has been little used, but in our hands it has become an indispensable investigation. We have recorded losses in the stool of well over 50 g. of protein in 24 hours; and the nutritional problem therefore is almost identical to that of the severe burn. Remission is impossible, and the ulcerated bowel cannot even begin to heal, until the negative nitrogen balance is corrected; and resort to operation in such circumstances is foredoomed to failure. There is no doubt that cortisone therapy often imitates the process of remission; but part at least of its good effect is to induce an euphoric state in which the conduct of an energetic campaign of protein feeding is simplified.

So far, my report is of a steady advance in the direction of increased safety in the technical exercises of surgery. But surgical progress has not been confined to this; there have been notable developments in relation to the cause and management of certain of the diseases that seemed to offer an almost insoluble challenge.

Of particular interest are the newer concepts of cancer. In the last few years it has become abundantly clear that the growth of some cancers of the breast and of the prostate can be influenced by the administration of naturally-occurring hormones, or by altering the hormonal status of the individual by the removal of certain endocrine glands. In other words, a disease for long regarded by the pathologists as the autonomous, unfettered and uncontrolled proliferation of cells that had become "lunatic" is now discovered to be subject at times to mechanisms or influences that arise naturally within the body. It is certain that as knowledge advances such crude attempts to adjust the endocrine status as adrenalectomy and removal of the hypophysis will pass into limbo. But what an exciting avenue of research these tentative efforts have opened! Will it ultimately transpire that other tumours are dependent on other body secretions, or other hormones? Will the property of malignancy in cells ultimately prove to be only a small qualitative difference—chemical or enzymatic—from the normal? Is this a gleam on a horizon for long obscured in gloom? If so, we must

> "Adventure on, for from the littlest clue
> Has come whatever worth man ever knew."

The perimeters of surgery are in fact steadily widening; but in addition there are exciting salients in advance of the expanding front. These have as their objective not the removal of more and more diseased tissues—the surgery of ablation—but their repair, or their substitution when past salvage.

The replacement of damaged or lost or destroyed tissues by counterparts from another individual or by artificial substitutes is hardly new. Blood transfusion and bone-grafting are well-established methods of tissue-replacement. So too is skin-grafting. But skin-grafting has unleashed a host of problems of fundamental biological importance. Skin transplanted from one individual to another survives for a short period and then dies, unless the transplant is from one identical twin to another. The mechanisms responsible are obviously immunological, for a second transplant from the same donor to the same recipient is even more quickly destroyed. That the rejection of such homografts is a matter of genetic architecture is evidenced by the survival of grafts between individuals of the same genetic constitution (identical twins); and a difficult though hopeful field of research has been opened up in an attempt to determine the mechanisms involved and the means by which they may be circumvented. This is obviously a matter of great practical importance. Skin can now be stored in banks as readily as bone and blood, but its usefulness is limited to providing a very temporary epithelial cover in severe skin loss, or in burns. Its permanent survival would greatly extend its range of usefulness. There is at least an indication that we are coming to grips with the problem. My colleague Professor Woodruff has shown that in rats tolerance to homografts can be induced by injecting the newborn with cells from the future donor, and this work has been confirmed by others. Indeed, it seems that tolerance to heterografts can also be increased by this technique; and although at the moment these studies have no immediate practical application, they indicate that the difficulties of homografting are within reasonable sight of resolution.

Organ transplants behave in a similar fashion to skin. But if they can be given a blood supply, they may function for a time (or indefinitely in the case of identical twins), and there are now several cases on record in which a kidney has been donated from one twin to another. The place of such heroic measures in surgery is probably very limited; but one form of homograft appears destined to have a permanent place in our repertoire. Excision of segments of diseased or damaged blood-vessels has now an established place in the management of peripheral vascular disease and injury. Cadaver vessel grafts (and even artificial prostheses) are for a time, at least, both effective substitutes for the resected segment, though their ultimate place in surgical therapy has still to be determined.

The most fascinating of the growing edges of surgery is that of the operative treatment of disease of the heart and the great vessels. This has already made rapid strides; for though it is more than 30 years ago since Henry Souttar of the London Hospital first relieved a mitral stenosis by digital dilatation, and though Beck and O'Shaughnessy in the 1930's had striven to relieve the ischaemic heart by establishing a new blood supply, the foundations of the modern surgery of the heart were laid by Alfred Blalock and Helen Taussig only a decade ago. Blalock's operation for the blue babies of Fallot's tetralogy was catalytic; in its train has followed the surgery of the mitral valve, the aortic valve, and to crown all the surgery of the congenital intra-cardiac deformities.

The manner in which this last advance has been achieved is proof of the virility of modern surgery. The manipulations demanded for the correction of most intra-cardiac lesions require arrest of the heart and of the circulation through it for too long a period to be compatible with the survival of the brain, and the avoidance of hurt in other vital organs. The solution of this difficult problem has followed two main lines—refrigeration, and the development of an extra-corporeal circulation.

The practice of refrigeration depends on the fact that the lower the temperature to which they are exposed the smaller the amount of oxygen required for survival by living tissues. The organs most vulnerable to hypoxia are the brain and the heart itself; but when exposed to a temperature of 26° C, their circulation can be arrested for up to 20 minutes which is long enough for most corrective procedures within the heart cavity.

Unfortunately hypothermia has the serious drawback of tending to retard or prevent the recovery from ventricular fibrillation, which is one of the most serious of the hazards of cardiac surgery. And so it will probably prove inferior to methods of bypassing the heart by means of "heart-lung" machines. But for operations on the great vessels, when it may be necessary (in the excision of an abdominal aneurysm, for example) to arrest for a time the blood supply to the kidney, the liver, or the spinal cord, refrigeration is ideal, since these procedures do not carry the same risk of fibrillation.

The "heart-lung" apparatus represents a triumph of co-operation between the clinician, the physiologist and the engineer. The principle behind the several bypass machines is to withdraw the venous blood from the great veins near the heart, pass it through an artificial oxygenator that replaces the function of the lungs, and then pump it back into the aorta, thus making it possible to exclude the heart during the time required for intra-cardiac manipulations. Not all the problems posed by these complicated techniques have been resolved, but already the scope of cardiac surgery has been notably extended, and it is only a matter of time before the present difficulties are overcome.

There is much else one could say about contemporary surgery but limitations of space allow only a final reflection. It is this: that though there are many dark places to be illumined and much still to be accomplished the physiological approach to surgical problems has already inspired concepts and principles that are fundamental, and accurate, and destined to find a permanent place in surgical thought and practice.