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## EXTRACORPOREAL CIRCULATION

A recent report[1] in this *Journal* by a team of workers at the Postgraduate Medical School represents a milestone in this country in the history of operations which can be performed only with the help of a heart-lung bypass machine. This paper, by W. P. Cleland and his colleagues, is on the treatment of ventricular septal defect, and it describes the first series of any size reported in Great Britain. The results clearly show that the machine developed over many years by D. G. Melrose[2] in London can satisfy the requirements of heart-lung bypass quite as well as machines in use in other countries. Although work on heart-lung bypass machines was started as long ago as 1937 by J. H. Gibbon[3] and continued by T. L. Stokes and Gibbon[4] and by C. Dennis and his colleagues,[5] it is only in the last four years that these machines have come into successful and reliable clinical use. The results reported by J. W. Kirklin and his co-workers[6] from the Mayo Clinic and H. E. Warden and his colleagues[7] from Minneapolis have encouraged other surgeons, and now every major centre for cardiac surgery finds it necessary to have one or other of the heart-lung machines available, and reports on the treatment of series of patients are appearing with increasing frequency.[8] The rate of progress in Britain has of necessity been dependent on the allocation of staff, equipment, and money to forward research in this field. However, nearly every major thoracic unit in Britain is now working with one or other of the machines, and their clinical use has started or is about to start in most of them.

By far the most important part in developing the successful clinical application of these machines is the training of a competent team. Operations which require the use of the heart-lung bypass are not and never can be a "one-man show." The surgeons, anaesthetists, and pump operators must all work together from the start in the experimental laboratory.[9] Only when the whole team knows what to do in any given emergency should they consider perfusing a patient. As experience of perfusion grows and the difficulties are successfully met, the whole procedure may become more straightforward, but no substitute for good team-work can possibly be devised. This is underlined by the fact that the variety of successful machines in use throughout the world is now quite large, but it is always the centres with the thoroughly trained teams that achieve the best results. An idea of the number of people necessarily included in a team at one centre is given by the list of Cleland's co-authors, eleven in all.

Success depends on three main conditions. The first is accurate diagnosis. The second is the employment of the correct surgical technique for treating the known defect, and also the ability to correct hidden and undiagnosed abnormalities, such as the patent ductus arteriosus mentioned by Cleland and his colleagues as a silent but relatively common coexisting lesion with a ventricular septal defect. The third condition necessary for success is the ability to carry out a successful perfusion not only under ideal conditions but, more important, when some difficulty such as unexpected haemorrhage complicates the issue. It is this last which makes the pump operator such an important member of the team. The surgeon is fully occupied during perfusion in dealing with the heart itself, and he must feel confident that his pump operator can maintain a satisfactory equilibrium and take the necessary decisions without adding to the surgeon's burden. It may be that highly trained technicians will eventually undertake this work, as they do already in one or two centres, but most units prefer the responsibility to be carried by a doctor with special training. The function of the anaesthetist is as important, or more so, in perfusion as in any other chest operation, and he must maintain the closest liaison with the pump operator, particularly in so far as the maintenance of a steady blood volume and the administration of intravenous fluids and drugs are concerned. The presence of a cardiologist as a member of the team in the operating theatre is highly desirable. Biochemists and haematologists, in reporting on changes in blood chemistry and in preparing blood for perfusion, also play a vital part in the success of an operation.

For an operation on an adult about 16 pints (9 litres) of blood will be required during the perfusion and in the post-operative period. This of itself is going to raise fresh problems for the blood transfusion service when perfusion becomes a common procedure. The storage of blood in plastic bags may prove helpful. I. W. Brown and W. W. Smith[10] have devised a new anticoagulant preservative mixture, and

[1] Cleland, W. P., *et al.*, *Brit. med. J.*, 1958, **2**, 1369.
[2] Melrose, D. G., *et al.*, ibid., 1953, **2**, 57 62.
[3] Gibbon, J. H., *Arch. Surg. (Chicago)*, 1937, **34**, 1105.
[4] Stokes, T. L., and Gibbon, J. H., *Surg. Gynec. Obstet.*, 1950, **91**, 138.
[5] Dennis, C., *et al.*, *Ann. Surg.*, 1951, **134**, 709.
[6] Kirklin, J. W., *et al.*, *J. thorac. Surg.*, 1957, **33**, 45.
[7] Warden, H. E., *et al.*, ibid., 1957, **21**, 33.
[8] Gerbode, F., *et al.*, *Lancet*, 1958, **2**, 284.
[9] Drew, C. E., *et al.*, *Brit. med. J.*, 1957, **2**, 1323.
[10] Brown, I. W., and Smith, W. W., *Ann. intern. Med.*, 1958, **49**, 1035.
[11] Bahnson, H., *Extracorporeal Circulation*, 1958, Springfield, Illinois.

suggest that when this is used blood can be drawn three to five days before perfusion and, if suitably heparinized, used in the pump; but it will also last two weeks if stored for use as ordinary transfusion blood.

The selection of cases for surgical treatment with the use of a pump oxygenator is a matter for the most careful investigation by the cardiologist, who will require all the information that can be given by such techniques as cardiac catheterization and angiocardiography. As Cleland and his colleagues point out, the height of the pressures on the right side of the heart and evidence of increased pulmonary vascular resistance, which can lead in some cases to reversal of the shunt, have to be taken into consideration before an operation to correct a septal defect is decided upon. In the most severe cases of pulmonary hypertension and increased pulmonary resistance surgery at present has a high operative mortality. Published reports show that the best results with the heart-lung bypass are obtained in the correction of atrial and ventricular septal defects and that these should if possible be treated in childhood before any serious strain on the heart has developed owing to the shunts. The curative correction of Fallot's tetralogy is possible only by the use of a pump oxygenator, but the operative mortality is still high even in the most experienced hands. No team should attempt this operation until it has been thoroughly trained in perfusion technique and has gained experience in the repair of the simpler defects. Almost every other congenital heart lesion may be open to radical cure, or at least improvement, by this technique, and as knowledge is gained even the difficulty presented by transposition of the great vessels should be overcome. In the surgical treatment of acquired valvular disease, particularly mitral incompetence and aortic stenosis and regurgitation, no fully satisfactory operations have yet been developed, and the advent of cardiopulmonary bypass may enable much more progress to be made. The major difficulty here that a pump oxygenator does not overcome is that of gross destruction of valve tissue. Much experimental work is being devoted to the fabrication of prosthetic valves: with the co-operation of manufacturers physiologically satisfactory valves may soon be available, and their insertion in the correct position becomes a practical proposition with the use of extracorporeal circulation.

The preparation of a machine for perfusion has to be undertaken with the greatest care. The most exacting cleanliness and sterility are vital, and experience has taught perfusion units to use fresh materials so far as possible each time and to clean the rest with strong solutions of caustic soda to remove any persisting fibrinoid deposit.[11] The effect of pump-oxygenators on the blood circulating through them still needs study, and although post-perfusion bleeding steadily decreases in all units with increasing practice it remains a major source of worry. Brown and Smith[9] discuss the influences that may encourage bleeding and suggest that the extracorporeal heart-lung circuit may activate systemic coagulation through liberation of thromboplastic substances and thus exhaust essential clotting factors. While haemolysis due to mechanical fracture of red cells in the machine does occur, it is not sufficiently severe to cause trouble; but the survival of red cells after perfusion does appear to be shortened in some cases. Brown and Smith put forward the theory that circulation through the pump oxygenator may enhance in some way certain red-cell antigens, so that antibodies to them are provoked when these cells reach the circulation of susceptible recipients.

Since the heart-lung bypass is quickly becoming a standard clinical method in centres where cardiac surgery is undertaken, a decision may soon be needed on how many centres for this work the country needs and can afford. Very relevant to this decision are the numbers of patients suitable for operation now, and the numbers likely to present in the future when all those on the initial waiting-lists have been treated.

## ENDEMIC GOITRE

Goitre occurs with varying intensity in almost every country in the world: it is seen in those who live in the heat of the tropics and in those who inhabit the icy wastes around the Poles. The most severe endemics of goitre are in high mountain regions—the slopes of the Himalayas, the Swiss Alps, and the Cordillera of the Andes being probably the best-known examples. However, goitre also occurs in low-lying areas, such as the Netherlands, and is often found near the sea as well as inland. A recent issue of the *Bulletin of the World Health Organization* has been devoted to this subject, and the opening article by F. C. Kelly and W. W. Sneddon[1] provides the best account of the prevalence and geographical distribution of endemic goitre which has so far appeared. Their long review brings knowledge of this subject fully up to date, providing almost a thousand references to the literature.

Largely as a result of the pioneer work of Sir Robert McCarrison in India much is now known about simple goitre, but much still remains to be discovered. Geochemists point out that the type of terrain in which goitre abounds is that which has been subjected to flooding or glaciation and from which most of the iodine has