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HIPOTERMIE EN EKSTRAKORPOREALE SIRKULASIE BY OOPHART-CHIRURGIE

Operasies binne die oop hart word uitgevoer met behulp van òf algemene liggaamsverkoeling en stilstand van die sirkulasie, òf ekstrakorporeale sirkulasie met 'n meganiese pomp en oksigenator. Van hierdie twee metodes was laasgenoemde eerste in die veld, maar kort na 1950, toe Bigelow in Kanada en Boerema in Holland algemene liggaamsverkoeling vir die doel aangewend het, het hierdie metode in die kliniese toepassing veld gewen en tydelik die meganiese kunsmatige hartlong verbygesteek. 'n Paar jaar lank was daar 'n nieamptelike wedren tussen die ‚pompers' en die ‚verkoelers', waarin nou die een dan die ander 'n voorsprong geniet het. Op die oomblik het die ‚pompers' hulle, tweede wind' gekry en die ‚verkoelers' ver agtergelaat. Sal verkoeling in die toekoms heeltemal in onbruik raak en net van geskiedkundige belang word? Moontlik wel, maar dit is ewe moontlik dat verkoeling weer op die voorgrond sal tree.

Die gebruik van algemene liggaamsverkoeling berus op die verminderde metaboliese eise van die liggaamsweefsels by lae temperature, as gevolg waarvan die weefsels langer as by die normale temperatuur sonder bloedsomloop kan klaarkom. Harsingselle, wat die gevoeligste vir stilstand van die sirkulasie is, kan by 37·5°C omtrent 3 minute stilstand verdra, maar by 28°C omtrent 8-10 minute. Op grond hiervan is 'n tegniek van oophart-chirurgie uitgewerk waarvolgens sekere eenvoudige aangebore afwykings soos atrium septumdefekte van die *secundum*-tipe en aangebore pulmonale klepstenose met goeie resultate herstel kon word. Die voordeel van hierdie tegniek bo die meganiese ekstrakorporeale sirkulasie is dat die benodigde apparaat heelwat eenvoudiger en goedkoper is, en dat daar in 'n heeltemal ‚droë' hart gewerk kan word. Die nadeel, wat oorweldigend is, is die kort tyd wat binne die hart tot die beskikking van die chirurg is, naamlik omtrent 8 tot 10 minute (wat deur afwisselende afsluiting heelwat verleng kan word, maar tog lastig bly). Hierdie kort tyd is alleen vir die genoemde eenvoudige afwykings toereikend. Pogings om die beskikbare tyd te verleng deur lae temperature te gebruik, het tot kort gelede op verskeie moeilikhede, soos die verhoogde gevaar van ventrikulêre fibrillasie en die moontlike gevaar van beskadiging van lewensbelangrike selle (nog 'n betwisbare punt), skipbreuk gely. Omstreeks 28°C is tot onlangs beskou as die redelike veilige laagste temperatuurgrens.

Die ekstrakorporeale sirkulasie, wat van 'n pomp (kunshart) en 'n oksigenator (kunslong) gebruik maak, is in die afgelope 5 jaar tot so 'n mate verbeter en verfyn dat dit nou die groot voordeel bied dat die sirkulasie tot 1½ of selfs 2 uur oorgeneem kan word, wat genoeg tyd toelaat om die meeste intrakardiale operasies te doen wat tans oorweeg word. Die benodigde apparaat is ten spyte van baie vereenvoudiging nog ingewikkeld genoeg om die hulp van 'n tegniese assistent te vereis—en dit bly nog maar duur.

Die tegniek van perfusie het geweldig vooruitgegaan, maar is op sigself nog nie heeltemal vry van gevaar nie. Hierdie ‚sputnik' van die chirurg het dus nog verdere verbetering en vereenvoudiging nodig.

Een van die moontlike rigtings van vordering in die toekoms is die gesamentlike gebruik van die ekstrakorporeale sirkulasie *en* verkoeling. Met die eerste oogopslag lyk so 'n voorstel onbevredigend omdat die nadele van albei metodes saamgevat sou word. Aan die anderkant kan daar teoreties voordele daaraan verbonde wees, byvoorbeeld, die verlenging van die beskikbare operasietyd binne die hart. Ondersoeke na die gesamentlike gebruik van hierdie twee metodes[1,2] dui op die moontlikheid dat daar nie alleen groter voordele nie, maar ook minder nadele as aan elke metode afsonderlik verbonde mag wees, byvoorbeeld: ventrikulêre fibrillasie kom selde voor, vermoedelik omdat die hart se werk grotendeels deur die pomp oorgeneem word. Gollan[3] het hierdie tegniek nog verder gevoer deur diere met behulp van 'n pomp-oksigenator tot temperature na aan vriespunt te verkoel. Van 13 honde wat tot tussen 3 en 8°C verkoel is (op welke temperatuur die hart gewoonlik heeltemal stilstaan) en 'n halfuur lank op hierdie temperatuur gehou is terwyl die linker-atrium oopgemaak en weer gesluit is, het 9 gelewe. Dit lyk dus of die lae temperatuur op sigself nie noodwendig noodlottig is nie. Dit is interessant dat by sulke lae temperature hemoglobien onnodig en trouens byna nutteloos vir die vervoer van suurstof is. Die hoeveelheid suurstof, wat in fisiese oplossing in die plasma gedra word, is vir die verlaagde metabolisme voldoende.

Verdere oorwegings ten gunste van die onskadelikheid van die lae temperatuur as sodanig word in 'n heel onlangse artikel deur Drew *et al.*[4,5] aangebied. Deur van 'n pomp gebruik te maak om die werk van die ventrikels te doen, maar met gebruik van die dier of pasiënt se eie longe vir oksigenasie, het hierdie navorsers diere en pasiënte tot 13 en 15°C afgekoel en toe die sirkulasie tot stilstand gebring—tot so lank as 45 minute. Hoewel verskeie van die eksperimentele diere nie herstel het nie, was daar wel oorlewendes. Van 7 pasiënte was daar 2 sterfgevalle, in wie se gevalle daar redelike alternatiewe verklarings vir die dood was. In die oorlewendes was daar ten spyte van sirkulasiestilstand wat 42 minute geduur het geen harsingskade nie, en ventrikulêre fibrillasie het meesal nie plaasgevind nie.

Daar skyn dus redelike goeie hoop te wees dat verdere navorsing ons in die toekoms sal leer hoe om pasiënte tot heel lae temperature te verkoel en dan weer tot die normale te verwarm sonder om hulle weefsels te beskadig. Dit lyk waarskynlik dat by hierdie heel lae temperature sirkulasiestilstand wat 'n uur of meer duur, moontlik sal wees. 'n Mens se verbeelding kan jou maklik oorweldig wanneer jy aan die moontlike toepassings van so 'n prosedure dink, bv. meer uitgebreide en deeglike oophart-operasies, 'n wyer veld vir operatiewe eksisie van aneurismas van bv. die aortaboog; moontlike uitbreiding van neurochirurgiese ingrepe vir vaatryke letsels, veiliger operasies op die lewer en poortaar-

stelsel, en vermindering van chirurgiese skok. Onder hierdie omstandighede sal die chirurg nie meer die patoloog-anatoom hoef te beny vir die stilte en slapte van sy ‚pasiënt' en vir die byna bloedlose veld waarin hy werk nie, want sy eie pasiënt sal gedurende die operasie tydelik ‚dood' wees.

Ons moet die saak egter nugter beskou. Op die oomblik lyk dit baie waarskynlik dat die blote lae temperatuur op sigself nie onherstelbaar skadelik is nie. Indien ons kan leer om lae temperature op die regte manier te gebruik, kan daar in die toekoms belangrike en miskien selfs revolusionêre ontwikkelings in die chirurgie ontstaan. Miskien het die Amerikaner gelyk gehad toe hy by 'n onlangse mediese kongres gesê het: ‚Maybe the cold boys are getting hot again.'

1. Gollan, F., Phillips, R., Grace, J. T. en Jones, R. M. (1955): J. Thorac. Surg., **30**, 626.
2. Sealy, W. C., Brown, I. W. Jr. en Young, W. G. (1958): Ann. Surg., **147**, 603.
3. Gollan, F., Grace, J. T., Schell, M. W., Tysinger, D. S. en Feaster, L. B. (1955): Surgery, **38**, 363.
4. Drew, C. E., Keen, G. en Benazon, D. B. (1959): Lancet, **1**, 745.
5. Drew, C. E. en Anderson, I. M. (1959): *Ibid.*, **1**, 748.

HYPOTHERMIA AND EXTRACORPOREAL CIRCULATION IN OPEN-HEART SURGERY

Open-heart surgery is carried out by the use of generalized cooling of the body and cessation of the circulation, or by employing extracorporeal circulation maintained by a mechanical pump and oxygenator. Of these two methods, extracorporeal circulation was employed first. However, shortly after 1950 when Bigelow in Canada and Boerema in Holland introduced hypothermia for this purpose, this method temporarily surpassed the artificial heart-lung machine in the clinical field. For a few years unofficial rivalry existed between the 'pumpers' and the 'coolers' with now the one group and then the other in the lead. At present the 'pumpers' have gained their 'second wind' leaving the 'coolers' far behind. The question arises whether cooling will in future fall into disuse and retain historical significance only. This is possible, but it is equally possible that hypothermia may once more gain ground.

The theory of generalized cooling of the body rests on the diminished metabolic demands of the tissues of the body at low temperatures, which enable these tissues to survive without the circulation. Brain cells, which are extremely sensitive to cessation of the circulation, can tolerate cessation for 3 minutes at 37·5°C, but for 8-10 minutes at 28°C. A technique for open-heart surgery has been evolved on the basis of the findings mentioned making it possible to repair successfully certain uncomplicated congenital conditions such as atrial septal defects of the *secundum* type and congenital pulmonary stenosis of the valves. The advantage of this technique over the mechanical extracorporeal circulation is that the apparatus required is considerably less complicated and expensive, and that it is also possible to operate in a completely 'dry' heart. The overwhelming disadvantage, however, is the brief period of time available to the surgeon for working inside the heart, viz. 8-10 minutes. This period of time can be lengthened by intermittent interruption, but the problem remains formidable. Only the simple defects mentioned above can be adequately treated during this brief period of time. Until recently, attempts to prolong the available time when using low temperatures have failed, because of various difficulties, such as the increased danger of ventricular fibrillation and the possible danger of damaging vital cells (still a controversial point). Until quite recently 28°C was accepted as the lowest relatively safe level.

Extracorporeal circulation, in which a pump (artificial heart) and oxygenator (artificial lung) are employed, has been improved and refined to such a degree during the past 5 years that it can now take over the circulation for 1½ to 2 hours. This leaves enough time for the performance of most intracardial operations which are attempted today. In spite of much simplification, the required apparatus remains, however, complicated enough to necessitate a technical assistant, and the cost of the procedure remains high.

The technique of perfusion has developed rapidly, but is in itself not yet quite free from danger. This surgical 'sputnik', therefore, still requires further improvement and simplification.

One of the possible lines of progress is the combined employment of extracorporeal circulation and hypothermia. At a first glance a suggestion of this nature appears unsatisfactory, because the disadvantages of both methods may *also* be combined. On the other hand, theoretical advantages may result from the combination of the two methods, for instance, the available time for operation inside the heart may be prolonged. Research into the combined use of these two methods points, not only to the possibility of greater advantages, but also to fewer disadvantages than are separately associated with each method.[1,2] Ventricular fibrillation, for instance, occurs infrequently, presumably because the work of the heart is largely taken over by the pump. Gollan[3] carried this technique further by lowering the temperatures of animals almost to freezing point and then making use of a pump oxygenator. Of 13 dogs cooled to between 3 and 8°C (when the heart usually stops) and kept at this temperature for half an hour while the left atrium was opened and closed again, 9 survived. It would appear, therefore, that low temperatures, as such, are not necessarily fatal. It is interesting to note that at very low temperatures haemoglobin is not necessary and may even be useless for the transport of oxygen. The volume of oxygen which is carried in physical solution in the plasma is sufficient for the lowered metabolism.

Further evidence pointing to the harmlessness of low temperatures is presented by Drew *et al.*[4,5] in a recent article. By using a pump to do the work of the ventricles, whilst making use of the lungs of the animal or patient for oxygenation, these investigators lowered the temperatures of the animals and patients to 13 and 15°C and then brought the circulation to a stop for periods of 45 minutes. Although several of the experimental animals died, there were some that survived the experiment. Of 7 patients 2 died, but there were reasonably acceptable alternative explanations for the death. Those patients who survived showed no evidence of brain damage in spite of cessation of the circulation for 42 minutes, and in most cases ventricular fibrillation did not occur.

It would appear, therefore, that it can be expected that in the future research will show us how to lower the temperature of patients to a very marked degree, and then to restore them to normality without causing damage to the tissues.

It is probable that cessation of the circulation for an hour or longer might be effected at low temperatures. Great possibilities arise from a procedure of this nature, e.g. extensive and adequate open-heart operations, a wider field for the excision of aneurysms, possible extension of neurosurgical procedures for vascular lesions, safer operations on the liver and portal system, and diminished surgical shock. Under these circumstances the surgeon need no longer envy the pathologist-anatomist the quietness and relaxation of his 'patient' and the almost bloodless field in which he works, because his own patient will be temporarily 'dead' during the operation.

At present it would appear that low temperatures in themselves need not be irretrievably harmful. If we could learn how to use low temperatures correctly, important, and possibly even revolutionary, developments in surgery might arise. It is possible that the American doctor may have been right when, at a recent medical congress, he said: 'Maybe the cold boys are getting hot again'.

1. Gollan, F., Phillips, R., Grace, J. T. and Jones, R. M. (1955): J. Thorac. Surg., 30, 626.
2. Sealy, W. C., Brown, I. W. Jr. and Young, W. G. (1958): Ann. Surg., 147, 603.
3. Gollan, F., Grace, J. T., Schell, M. W., Tysinger, D. S. and Feaster, L. B. (1955): Surgery, 38, 363.
4. Drew, C. E., Keen, G. and Benazon, D. B. (1959): Lancet, 1, 745.
5. Drew, C. E. and Anderson, I. M. (1959): *Ibid.*, 1, 748.

ATOMIC MEDICINE

Dr. Charles F. Behrens and his 25 specially chosen contributors set themselves a threefold task during the past decade (the first edition of *Atomic Medicine* appeared in 1949), viz.:

To gather in one volume the answers to numerous problems related to the use of atomic energy, involving nuclear physics, physical chemistry, radiation biology and therapy.

To keep abreast of the rapid advances in all fields of research and development, as well as the advent of thermonuclear weapons with the fantastic increase in the order of magnitude of violence and perils from radiation hazards, in regard to which there is much keener and more disquieting appreciation of large-scale evils to the human race.

To assemble such of this material as is appropriate to the needs of the medical and allied professions, and to present it as clearly as possible, steering a middle course between a presentation suitable only to specialists in the fields of radiation biology and physics and, on the other hand, one unduly elementary.

In this third edition of *Atomic Medicine*[1] the authors have succeeded in a remarkable way in fulfilling the mission they set out to achieve. The book provides authoritative information concerning ionizing radiation, its potential dangers, and its applications in peacetime medical practice, as well as the potential horrors of atomic warfare.

This publication is one that will be of the greatest value to the medical and allied professions and is recommended for inclusion in every library which is accessible to medical practitioners and all others concerned with Civil Defence.

1. Behrens, C.T., ed. (1959): *Atomic Medicine*, 3rd. ed. Baltimore: Williams and Wilkins Co. London: Baillière, Tindall and Cox Ltd.