

REFERENCES

1. Gibbon, H.H., Jr. Artificial maintenance of circulation during experimental occlusion of pulmonary artery. Arch. Surg., 34:1105, 1937.
2. Gallett, P.S. and Brecker, G.A. Heart Lung Bypass: Principles and Techniques of Extracorporeal Circulation, Grune and Stratton, New York, 1966.
3. Kolff, W.J., Effler, D.B., Groves, L.K., Peereboom, M.D. and Moraco, P.P. Disposable membrane oxygenator (heart-lung machine) and its use in experimental surgery, Clev. Clin. Q.; 23:69, 1956.
4. Lande, A.J., Edwards, L., Bloch, J.H., Carlson, R.G., Subramanian, V.A., Ascheim, R.S., Scheidt, S.S., Fillmore, S., Killip, T., III, and Lillehei, C.W. Clinical experience with emergency use of prolonged cardiopulmonary bypass with a membrane pump oxygenator. Ann. Thorac. Surg., 10:409, 1970.
5. Brecher, G.A.: Venous Return, Grune and Stratton, New York, 1956.
6. Phillips, S.J. and Romanowski, E.A. newly designed venous cannula for cardiopulmonary bypass. J. Thorac. and Cardio-vasc. Surg., 5:769, 1972.
7. Borst, H.G., Beer, R., Gehl, H., Loeschke, G., and Schmidt-Mendi, M. Pathophysiologische veränderungen bei anwendung eines extrakorporalen kreislaufes. Langenbech Arch. Dlin. Chir., 291:467, 1959.
8. Peirce, E.C., II. Regulation of blood volume and venous pressure during partial and total cardiopulmonary bypass. Trans. Amer. Soc. Artif. Int. Organs, 4:80, 1958.



Reflections: On the Quality of Perfusion

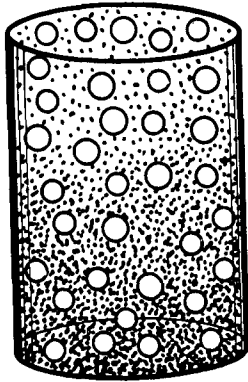
The philosophy of a
former technician

By Frank Fitton

(Reproduced as written for your perusal and consideration.)

During the past couple of years we have seen the more obvious emergence of many new gas exchange devices with no direct blood/gas interface. Namely membrane oxygenators. The controversy regarding the values of pulsatile flow have briefly re-emerged into the limelight and drifted back into the twilight for re-emergence at a later date. We have been given "proof positive" that the filtration of aggregates from bank blood is an absolute necessity. The search for better blood substitutes for use in haemodilution continues at full steam with more sophisticated (and more expensive) physiological solutions appearing from time to time. We have finally acknowledged the fact that micro-bubbles are probably here to stay. This is because methods have been utilised for detecting the little devils and many people have realized that this fact alone is worthy of scientific investigation. We are even more uncertain to-day whether 'tis better to perfuse the coronary arteries or utilise ischaemic arrest. The list goes on and on.

What has happened to the art of perfusion? To-day so called "routine" cardiopulmonary bypass (I have put "routine" in quotes because there is no such thing as a routine cardiopulmonary bypass) for the repair of surgical defects seem to be getting more of a science and less of an art. I remember a few years back when cardiopulmonary bypass was 75% an art and 25% a science. To-day the reverse seems to be true and I sometimes wonder whether this "scientific progress" is really contributing to an improved quality of perfusion or whether a sort of unerring faith in scientific progress is dulling the brain and hazing the eyes.



**“ . . . there is a basic set of
physiologic guidelines that
must be considered.”**

Having read that sentence you are probably expecting me to go into a profound and verbose scientific treatise to make my point. However, you should also have realized by now that I am a proponent of less science and more art. My words from now on will be a little philosophical and very personal as befits a retired pump technician (sorry you are called Extra-corporeal Technologists to-day) who retired early in order to retain sanity of mind and a bank balance that was always written in black ink.

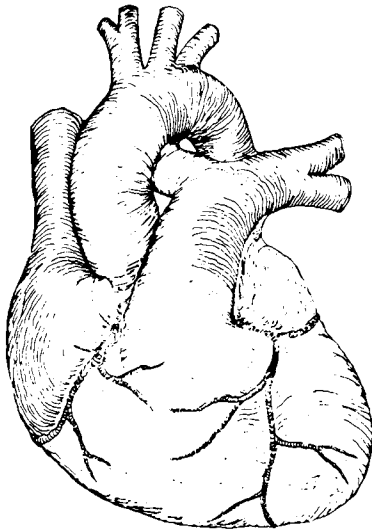
Cardiopulmonary bypass for the surgical correction of defects and short comings in the heart and great vessels is commonly a relatively short term procedure. By this I mean a period of total circulatory and respiratory replacement for about 2 or 3 hours. It has been suggested that, from a biochemical and bio-physical point of view, and within certain practical considerations, the type of oxygenator used plays a very small role in the quality of perfusion for a 2-3 hour period of cardiopulmonary bypass. There is one aspect of cardiopulmonary bypass that sort of negates all the newer and more physiological gas transfer devices. Namely cardiotomy suction. Until such time as better methods are found to handle this, I suggest that the quality of perfusion lies in the sum total of attention to small details paid by the perfusionist rather than the equipment used. The quality lies in the brain, hands and eyes of the man (or woman) who sits behind the machine. I was once told by a very eminent surgeon (whom I happened to be working for at the time) that cardiopulmonary bypass was like playing a game of chess. The meaning may be obscure to you so I will translate this piece of wisdom. What he meant was that the end result, in terms of success, is totally dependant on the quality of the number of moves that together provide the end result. The reason that you win a game of chess is that you make each of your moves as a direct result of your anticipation of your opponents moves and as a result of your opponents unexpected moves. There are however certain basic rules which must apply to both yours and your opponents actions. In cardiopulmonary bypass, as in chess, there is also a basic set of physiological guidelines that must be considered. No two perfusions are ever alike (in chess no two games are ever alike). The more you play chess the better you will become, providing you learn from your mistakes and learn to

anticipate the possibility of your opponents moves. The same is true in cardiopulmonary bypass. Anticipation of the problems and knowing when and how to take the correction action is the name of the game. If you take the chess game and replace your opponent with the patient, and the chess board and pieces with the equipment you have at your disposal, then I think the parallel is obvious.

I would like to pass on to you, as if you weren't already fully aware, some of the details that I had obsessions about and that invariably would drive my surgeons out of their minds. These are in no particular order of importance (or unimportance in to-days scientific atmosphere!!!)

I have always had a fetish about the occlusion settings on blood pumps. I had a standard, reproducible and stable calibration of my stroke volumes with different tubing diameters. My pumps were just under occlusive and my standard setting for my flow charts was as follows. I would set up an arterial line pressure monitor at the end of my normal arterial line (which happened to be 66 inches long). I would then slightly over occlude the pump visually and pump into the arterial line until my pressure monitor reached 200 mm/hg. I would then start reducing the occlusiveness until the pressure monitor dropped 100 mm/hg in 10 seconds. My rationale for using the initial pressure of 200 mm/hg was that my line pressure during an actual perfusion never exceeded 200 mm/hg under normal circumstances. My arterial pump, therefore, within the confines of actual operating conditions, was to all intents and purposes "load insensitive" thereby giving me a high degree of accuracy on my blood flow delivery rate. I also never trusted "pre-





cision wall tubing" and "precision occlusive settings" on the actual pumps. For this reason I checked my occlusibility before every pump run and not surprisingly was frequently rather pleased that I did!! Probably the greatest single cause of friction and disharmony myself and my surgeons was their use of suction and my control of the sucker pumps. Looking back on the verbal barrage that crossed the operating room is now rather amusing but at the time it was a battle of personalities and principles which caused us all some pain and certainly aged me prematurely. My obsession and my rationale behind it were very simple. When any particular sucker was not actually sucking blood, which happens frequently, I would turn that particular sucker pump down to a very low idling speed, thereby eliminating much unnecessary trauma. As we used three suckers and three pumps, it was a battle of anticipation on my part, and an exercise on the part of my surgeon to catch me out; this was particularly the case when we had visiting surgeons in the operating room as it gave my surgeon the opportunity to demonstrate his questionably superior status in life by querying my birthright, my visual acuity and my auditory awareness. From a technical standpoint I knew I was right and fortunately (or unfortunately) was prepared to stand by my professional principles.

Another frequent cause of light discussion between myself and my surgeons was my insistence on having a recirculation line between the arterial line and the cardiomy reservoir. I should add that this discussion ended rather abruptly when I used it once to good effect to extricate myself from a potentially dangerous situation when I had cause to change the oxygenator in the middle of a perfusion. The original rationale for putting the recirculation line into the circuit was because of my unhappiness at the length of time that frequently occurred between division of the A-V loop and the onset of perfusion. I had a fetish about going onto bypass with a prime temperature of within 5° C of the patients temperature. With a recirculation line I was able to recirculate continuously at a blood flow rate of about 500 ml/ minute even when the lines on the table were divided, thus

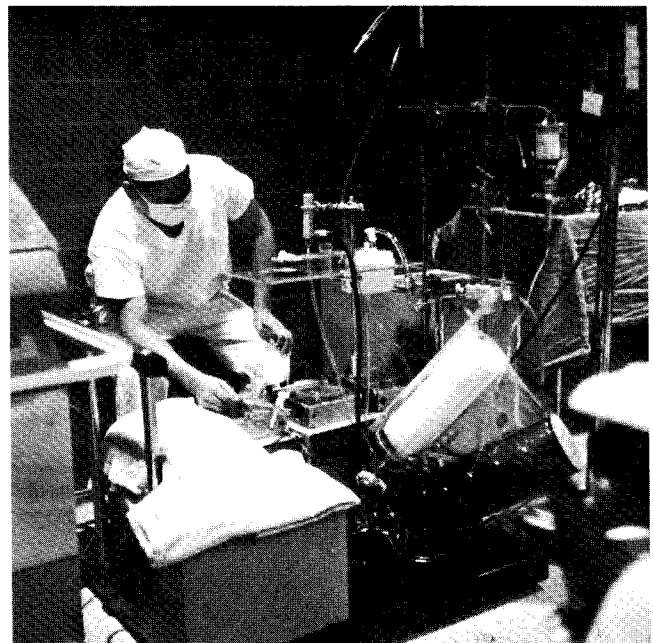
“ . . . to achieve a physiologically stable and adequate bypass

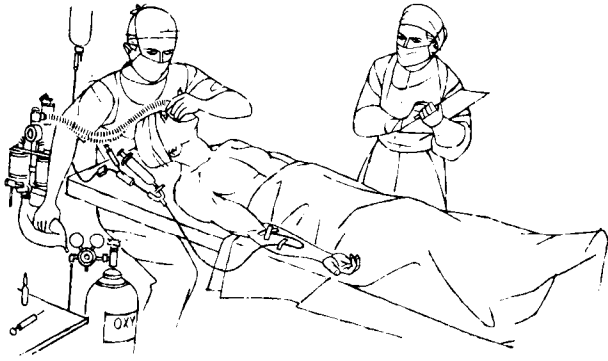
was my whole aim . . . ”

enabling me to keep the temperature of the prime at the level I desired. This I felt was more physiological.

I was always acutely aware of the gas/blood flow ratio to the oxygenator and spent many hours trying to devise a method of coupling the arterial pump tachometer to the gas gauge. Unfortunately my expertise as an engineer was totally inadequate and consequently I never did find a way of doing this. What I wanted to achieve was a coupling method which altered the gas flow when my blood flow increased or decreased. I always tried to give the very least amount of gas that would achieve the partial pressures that I felt were adequate to give me a satisfactory perfusion from the blood/gas point of view. In fact this principle of doing and giving the least amount possible to achieve a physiologically stable and adequate bypass was my whole aim during a perfusion.

Another aspect of my "weird thinking" was to have a fluid loss/replacement chart made up for me by the circulating nurse in the operating room about 10 minutes prior to the expected onset of bypass. If the patient was hypovolaemic, as indicated by disharmony between fluid loss (urine was included) and fluid given (intravenously by the anaesthesiologist), then the disharmony in milliliters was added to the extracorporeal circuit and transfused to the patient either just prior to going onto bypass or whilst going onto bypass. I was acutely aware of the potential problems of volume shifts into or out of the patient at the onset of bypass, and the need for volume stability. These, then, were just a very few of the small details to which I paid an almost unhealthy amount of attention. Individually they might be insignificant but add them all up, and add a few others, and



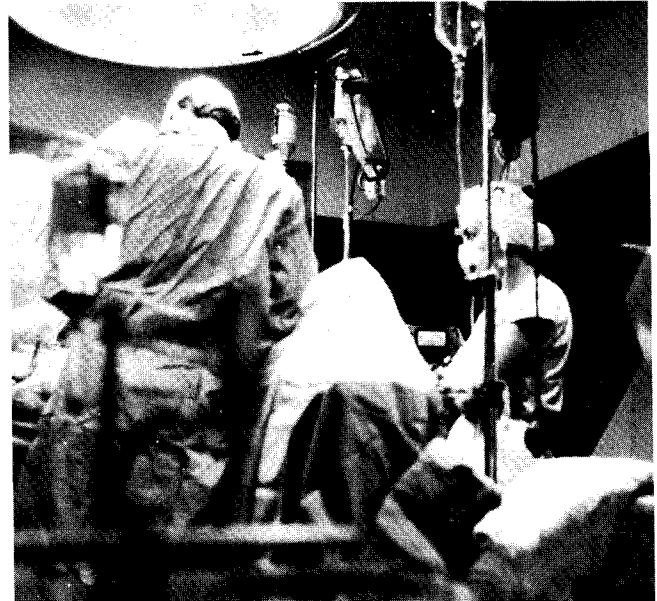


“ . . . that every patient I pumped was a great challenge to my professional competence.”

you perhaps have a very unsatisfactory perfusion. Perhaps one day I will have the time to list all the small details, but for now these will do as I am only trying to make a point. One observation I would like to make, which is not a justification for loose techniques and inattention, is that I never failed to be amazed at the resilience of the human body to insult. Another observation is, that, in general the quality of perfusion in an emergency situation tends to be much higher than for a routine scheduled case. (There I go again with that word routine). I remember the first heart transplant recipient I perfused. If memory serves me right it was only a 40 minute perfusion but the extra care I took, just because of the novelty of my involvement, in retrospect was interesting. I remember we did blood gasses every ten minutes and the fourth analysis on bypass was identical to the first analysis. I even remember the figures, PO_2 120, PCO_2 40, PH 7.4, HCO_3 24. It was a text book perfusion, if there is such a thing. However, it served as a reminder, as did all emergency bypasses, that I should never ever waiver from my attention to detail. That every patient I pumped was a great challenge to my professional competence. Each perfusion, or probably I should be honest and say the greater majority of them, was an exercise in the highest order of quality. The

same surgeon whom I worked for and mentioned previously also hit me with another piece of advice that I have never forgotten. He said you should consider each patient that you put on bypass as your own mother and strive for the excellence in quality you would want her to receive.

In todays rapidly changing world of cardiopulmonary bypass with greater work loads I want to emphasize to you the dangers of complacency in attitudes to bypass. Very early in my career I discovered the necessity of taking myself away from clinical cardiopulmonary bypass for at least one day each week. I involved myself



to other disciplines and tried to acquire as much knowledge as possible. My theory being that it was probably better to know a little about a lot than a lot about a little. This weekly sojourn away from my pumps and oxygenators and all the trimmings of bypass became increasingly important to me as the years went by. It certainly kept me from getting complacent about my attitudes to bypass. My philosophy that perfusion had to be a personal challenge to my professional competence kept me working at a high level for 8 years. I suppose during that time I pumped about 1500 patients and I like to look back and be secure in the knowledge that everyone of those patients had the best possible bypass that medical science and myself could offer at the time. I can honestly say that I adhered to my high principles of constant attention to small details even though I had to lay my principles on the line rather frequently. You all know what it's like at 7 A.M. Monday morning after a weekend at the beach! To me my work as a pump

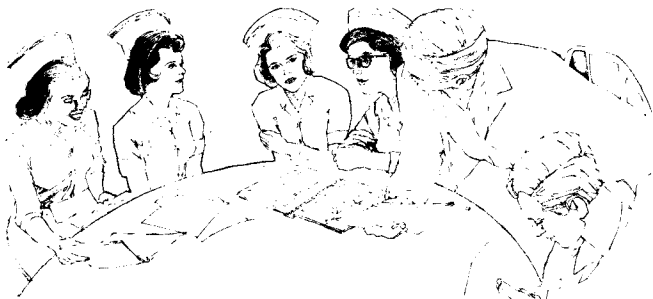
Reflections:

“The quality of perfusion will always lie heavy in the hands of the human factor.”

tech. was almost vocational. I had a profound sense of commitment and involvement that was fortunately reciprocated by my employers and understood by my wife and family.

I shall now try and sum up what I have been trying to say. I think what I am trying to point out is that perfusion is more of an art and less of a science and that in this age of technological advancement in all disciplines it is possible for technicians to start developing an unerring faith in science. I don't think that perfusion can or will ever become automated to the point where equipment makes the decisions. The quality of perfusion will always lie heavy in the hands of the human factor. Sophisticated equipment and gadgetry is only an aid to man and if used in its proper context can be extremely beneficial. It is very easy to slip into a state of blind faith where equipment is concerned. In terms of the quality of perfusion nothing will ever replace the human brain, eyes and hands and the vast knowledge that can be stored in the human brain as a result of past experiences. Maybe the time has come to re-evaluate your role as a member of the surgical team. Put things back into perspective. Pay more attention to the numerous small details that collectively add up to quality. Try and get the highest and best possible performance from the equipment that you have available before assuming that something newer and most expensive must automatically give you an improvement in quality.

To repeat I still maintain that perfusion is more of an art and less of a science. It always was, it is to-day, and hopefully it always will be.



Commission tells how to improve heart surgery in hospitals

NEW YORK — Strict guidelines for improving the quality of heart surgery in the nation's hospitals were issued last month by the Inter-Society Commission for Heart Disease Resources. In a report published in *Circulation*, a monthly journal of the American Heart Association, ICHD said that new technics for coronary artery surgery, such as the aorto-coronary vein bypass operation, are stimulating hospitals to expand their surgical programs, and that "we may see a proliferation of poorly conceived, poorly planned units with costly duplication and facilities of sub-optimal care.;;

Some major recommendations made by the commission: only when a need for them has been clearly documented in the community.

- Hospitals planning new surgical programs should submit proposals to an authorized local or regional planning group for review and evaluation.

- To qualify as a cardiac center the smallest practical unit should perform four to six operations with extracorporeal circulation (heart-lung machine) weekly.

- At least two surgeons with appropriate training for coronary artery surgery should be available at all times to provide coverage if one is unavailable during an emergency.

- The minimum recommended load for a coronary diagnostic laboratory is 10 procedures a week and not less than five procedures a week for each angiographer.

Chairman of ICHD's committee on coronary artery surgery which prepared the report is Dr. Derward Lepley Jr., of Marquette University.

Extra-Corporeal Technologist

We are presently seeking an individual to join our four man cardio-vascular technician team. The successful candidate will have had experience in cardio-pulmonary bypass and catherization techniques.

We are a large clinic with a 120-physician staff, located in the center of Wisconsin, where hunting and fishing are prevalent. Excellent fringe benefit program and negotiable salary. For more information contact:

L. R. Stauske
Personnel Manager
Marshfield Clinic
Marshfield, Wis. 54449