Invited Editorial
Go With the Flow (probe)!

I am often amazed by how technology that allows safe cardiopulmonary bypass (CPB) continues to evolve and advance. Improvements in today’s equipment and supplies have provided greater patient safety and fewer complications than in years past. Given the advancement of the technical aspect of cardiovascular perfusion, I believe that our profession has largely overlooked a major shortcoming in equipment used for CPB.

There are essentially four main objectives that perfusionists address during CPB: 1) adequate blood flow; 2) oxygenation/ventilation of blood; 3) temperature control of blood; and 4) anticoagulation of blood to allow such exposure to foreign surfaces. As clinicians, we expect that testing of parameters such as blood gas levels and anticoagulation of the blood during CPB is both accurate and precise. The Centers for Medicare & Medicaid Services regulates all laboratory testing (except research) performed on humans in the United States through the Clinical Laboratory Improvement Amendments of 1988 (1), and any site performing such testing must be licensed. Furthermore, the accuracy of laboratory testing equipment is routinely validated to ensure the accuracy of results. Even when inline monitors such as the CDI-500 (Terumo Cardiovascular Systems, Ann Arbor, MI) are used, results are typically validated against values generated by standard laboratory machines (2). Also, equipment such as gas blenders and heater/coolers undergo rigorous testing and clearance by the U.S. Food & Drug Administration. Perfusionists expect and insist that each piece of equipment functions properly to allow precise control and monitoring of parameters such as oxygenation, anticoagulation, and temperature during CPB.

Although each of the variables mentioned are closely controlled, regulated, and monitored, there is often a lack of precise monitoring of patient arterial blood flow. When using a centrifugal blood pump (CP), manufacturers incorporate a flow sensor that may be appropriately used on the arterial line for monitoring of patient arterial blood flow. However, when using a roller pump (RP), no such device is typically made available by the same manufacturers, and perfusionists often must rely on arterial pump speed as an indirect measure of flow to the patient. Hospitals may purchase standalone devices such as the HT110 Bypass Flowmeter (Transonic Systems Inc., Ithaca, NY), but these devices can be cumbersome and expensive and do not conveniently interact with heart–lung machines or electronic charting software. In an age when integration represents the future, addition of such equipment should be unnecessary.

Lee-Sensiba (3) reported in 1998 that an arterial purge line can “steal” as much as 40% of the intended pump flow away from patients at low flows. More recently, Wang et al. (4) showed that a significant amount of flow is diverted away from the patient when the arterial purge line is open and that shunting of blood flow could result in hypoperfusion. The authors concluded that a flow probe should be used distal to circuit shunts to monitor arterial flow. Additional larger shunts such as a hemoconcentrator or recirculation line are also incorporated into CPB circuits and theoretically steal even a higher percentage of patient flow. It is important to mention that even with no intracircuit tubing shunts open, pump speed does not necessarily reflect pump flow when the arterial pump is not 100% occlusive.

Although this editorial does not aim to debate the benefits of RPs versus CPs, there is plenty of evidence to suggest that RPs can be safely used for CPB. Saczkowski and colleagues (5) did a meta-analysis of 18 randomized controlled trials representing 1868 patients comparing RPs and CPs. Their study found no difference between RPs and CPs in postoperative blood loss, red blood cell transfusion, intensive care unit or hospital length of stay, or mortality. There were also no reported pump-related malfunctions or mishaps. It has also been shown that RPs may cause less hemolysis than CPs when the occlusion is set appropriately (6). Furthermore, multiple studies have shown that RPs are less hemolytic when set less occlusively than that which is recommended by manufacturers and typically used by perfusionists (7,8). However, use of a less occlusive RP may not be safe without the incorporation of a flow sensor on the arterial line as a result of the loss of forward flow. Although there are methods that may allow the perfusionist to estimate arterial blood flow (8,9), the patient’s arterial flow is not a parameter that should be estimated but instead measured using a flow sensor. Also, any estimations done “on the fly” during CPB do not incorporate the impact of changes in blood temperature and viscosity. They are also generally not reflected in the perfusion record, particularly when using an autocapture electronic record.

Based on the outstanding work of researchers such as DeSomer (10) and Ranucci (11) and their colleagues, we have learned the importance of monitoring values such as
The choice of RPs versus CPs is still largely based on preference, and there is not an industry standard. There are clearly advantages and disadvantages to each type of pump. Although many perfusionists consider CPs safer than RPs, it is time that users of RPs improve the safety and precision of CPB by incorporating the use of an arterial flow sensor if they have not already done so. The arterial blood flow delivered to the patient is a crucial factor in determining the success of CPB. As perfusionists, we have a responsibility to measure and document patient arterial blood flow as accurately and precisely as possible.

Cory M. Alwardt, PhD, CCP
Mayo Clinic Hospital
Phoenix, Arizona

REFERENCES


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