Guest Editorial

D’où Venons-nous/Que Somes Nous/Où Allons Nous?
Accidents Are Inevitable

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If I were to say to you, “I’m your perfusionist and I’ll be running the heart-lung machine for your operation tomorrow. After you go to sleep, the surgeon is going to put a couple of tubes into your heart about the diameter of a garden hose. Blood arriving at your heart, instead of going to your lungs, will do a detour down that tube to the heart-lung machine. I’ll pump that blood through an artificial lung and some filters back to the aorta—the artery downstream from your heart. I’ll be taking over the function of your heart and lungs with the machine while we stop your heart and turn off your lungs for an hour or two so the surgeon can sort out those blocked coronaries and fix up that valve. In essence I’ll be your heart and lungs while you’re sleep.” What would be your likely thought process? Perhaps avoidance of a disaster would figure high on the list.

Cardiopulmonary bypass (CPB) is an exacting discipline (1). It is a planned life support intervention using an artificial circuit controlled by the perfusionist to replicate the function of the heart during a prolonged period of induced cardiac and respiratory arrest. This is not free of immediate significant risk to the patient.

FROM WHENCE HAVE WE COME, WHAT ARE WE, WHERE ARE WE GOING?

The famous 1897 postimpressionist painting by Paul Gauguin entitled D’où Venons-nous Que Somes Nous Où Allons Nous represents the transition of life from birth to the beyond, a concept applicable to the consideration of perfusion as a profession in respect of attitudes and the management of safety.

Technologically the first question can be illustrated in our local experience by comparing the original Melrose heart-lung machine (HLM) used for the first CPB in New Zealand to our current state Sorin SS HLM setup with a membrane oxygenator and all the associated microprocessor-controlled safety features of current HLMs. The future is speculative, but miniaturization of extracorporeal circuits is the most likely direction, bringing even greater challenges from a safety perspective with ever-decreasing reserves.

The mechanisms of safety and the reductions in iatrogenic injury from perfusion incidents have been primarily technology-driven. Perfusion is part of a system, but in terms of a culture of safety, it remains a relatively under-developed part. It is variably remote from the other parts of the system as a result of a hierarchal history and the profession’s specialization. In considering from whence we have come locally, it is appropriate to look at the contribution of one of the pioneers of perfusion in our region, Mr. Sid Yarrow.

D’OU VENONS-NOUS—FROM WHENCE HAVE WE COME?

Sidney Yarrow, who died in May of last year at age 88 years, was involved in the first CPB performed in New Zealand. He was integral in the development of the perfusion apparatus and the perfusion protocol to establish a safe model of CPB at its inception. In terms of today’s perfusionists, Sid’s background is interesting. Born in London in 1923, he grew up in the East end. It was a Jewish household, his mum’s family from Romania and his father’s from Poland. They had escaped Poland because of...
persecution of Jews and after arriving in England changed their name from Yarrowski to Yarrow. The family was poor and Sid grew up with seven brothers joining the Air Force during World War II as an electronics engineer. Sid emigrated to New Zealand in 1953. With his experience in radar, he worked briefly for the Navy before he was recruited to Green Lane Hospital in 1954, to what was then the national cardiac surgical unit, by cardiologist James Lowe to work in the catheter investigations laboratory.

In 1957, after the advent of CPB in the United States, Sid worked with Brian Barratt-Boyes (later to become Sir Brian), David Cole, and others in the comparative isolation of a small nation in the Antipodes perfecting a model of heart–lung bypass. In a remarkable saga of innovation and dedication, Sid developed the apparatus for CPB, including building his own DeWall bubble oxygenator that was used in a series of animal experiments as the run-up to the first bypass. When the Melrose HLM arrived with no instructions for use, no working diagrams, and missing essential parts, Sid was charged with getting it functional. He worked with others designing parts from scratch for the HLM, some of which remained in use for many years, notably the venous reservoir (2). Of necessity he designed and built New Zealand’s first pacemaker (3). The culmination of all of this work was the success of the first CPB in 1958, notwithstanding the absence of all of the safety features accepted as routine today (4).

Perfusion at Green Lane Hospital, in the first decades, was conducted using a rigid protocol and performed under close medical supervision. This was in an environment of rapid development of cardiac surgery and CPB that was relatively unencumbered by the formal ethics constraints of today. Current basic technological safeguards such as level detectors, bubble, or temperature alarms were not available and servoregulation of the HLM not thought of. Although the lack technology was mitigated by a culture of very close attention to detail and CPB routinely conducted by the perfusionist and an assistant, perfusion accidents were inevitable and some resulted in serious injury and death (5).

**QUE SOMES NOUS—WHAT ARE WE (NOW)?**

Much of CPB research has been surgically focused and although the physiology of perfusion is becoming better understood, the impact of perfusion practice on outcome has lacked (and still lacks) any strong evidence to support how perfusion is conducted (6). This has only relatively recently become the focus of attention with the establishment of perfusion databases such as the Perfusion Downunder Collaborative Database (PDUC), the International Consortium for Evidence Based Perfusion (ICEBP), and the Northern New England Cardiovascular Disease Study Group turning our attention to a more evidence-based approach to practice (7,8). In respect of understanding and managing safety, the perfusion profession is further behind.

Managing and understanding accidents and human behavior is elegantly explained by James Reason’s concept of the Swiss cheese model of defences to demonstrate varying penetration of layers of defences by an accident trajectory that may constitute avoidance, near miss (partial penetration), or an accident (complete penetration) (9). He further explains three levels of human performance, skill-based, rule-based, and knowledge-based actions that are controlled either by automatic (dealing with routine actions like driving to work everyday—very fast) or conscious (problem-solving from first principles—very slow) psychological controls, which can fit a model of error type (skill-based slip lapses or knowledge-based mistakes) (10). The relevance for perfusion is that perfusion and the cardiac operating room fall into what Charles Perrow describes as a tightly coupled, highly complex system (similar to nuclear power plants or aviation) where accidents are inevitable regardless of the skill of the operator (11). There is a natural expectation that scrutiny of the safety record of perfusion over the evolution of the profession and the associated development of the technology would be associated significant improvement.

Although the PDUC and the ICEBP have established overdue and essential mechanisms for prospective collaborative data collection and outcome analysis, our understanding of how safe we are relies largely on periodic retrospective surveys of perfusion practice and incidents (12–17).

Comparison of these surveys suffers from variations in study design such as whether the questions were answered on behalf or by individual perfusionists (14,16), varying survey periods, the mechanism and timeliness of reply, and most importantly that they are retrospective and as such rely on recall rather than reference to a prospective database of incidents. However, review of a timeline of such surveys of perfusion incidents poses rather than answers the question of “Que Somes Nous—what are we (now)?” Palanzo observed in 2000 that perfusion is safer than it was 25 years ago given serious adverse outcomes resulting from CPB-related incidents had dropped from 1:1000 to 1:1453 (18). That was at that time encouraging. However, if we take a chronological snapshot of perfusion accident surveys from 1982, the inclusion of the more recent surveys challenges the perception that there is a progressive widespread reduction in serious adverse events (SAEs) defined as serious injury or death resulting from perfusion accidents. A comparison of perfusion-related SAEs in five perfusion incident survey periods to 2007 shows a plateau rather than a decline in this associated morbidity and mortality (13–17). The lower incidence
of SAEs in the Charriere survey of perfusion incident and accidents in France in 2005 appears at odds with other surveys and in contrast with the more recent Dutch perfusion incident survey with perfusion incidence for SAEs of 1:1562 (16,17). Comparison of surveys is further complicated by the inclusion or exclusion of postprotamine-related SAEs and although some report both, interpretation is not clear-cut. In comparing SAEs, Groenberg states their incidence (1:1236) would compare more favorably with the surveys of the surveys of Jenkins, Mejak, and Charriere had they used the same questions (1:1567 vs. 1:1300, 1:2937 vs. 1:1453, and 1:2611 vs. 1:3220, respectively) (19). In essence, as Groenberg concludes, we are left with serious injury and death resulting from perfusion incidents over the 12 years to 2007 that is well matched.

The nature of incidents over these surveys reveals coagulation within the circuit still prominent and continued air entrainment in one to two cases per 1000, the latter not associated with the use of low-level alarms, which are variably used depending on whether a soft or hard shell reservoir is used.

Incident reporting in perfusion literature is largely confined to the type of retrospective surveys discussed previously and prospective incident reporting is rare. Not surprisingly in a prospective computer-based perfusion incident registry, Svenmarker found the incident rate to be far greater (4.5–7.6%) than that reported in the retrospective Australasian Perfusion Incident survey (2.9%) of the previous year (14,20). In a later analysis of their prospective incident registry, the former authors report a continued reduction in incident rate in their own center (21). More recently, an incident rate of 2.6% was reported in a prospective program for reporting nonroutine perfusion events at Boston Children’s Hospital between 2005 and 2009 (22).

OÙ ALLONS-NOUS—WHERE ARE WE GOING?

Wider-based perfusion-based incident reporting systems are not in use with the exception of the Australia and New Zealand College of Perfusionists (ANZCP) Perfusion Incident Reporting System (PIRS) (http://anzcp.org/ pirs/pirs_entry.htm). This system briefly described in a guest editorial has until recently been restricted to members of the ANZCP (23). It has periodically reported to the ANZCP Gazette and its web site featured reports and alert notifications to college members. This web-based system now has unrestricted access and is positioned to receive perfusion incident reports internationally.

The framework of the PIRS encompasses incident detail, preventive actions as well as human factors and has the potential to provide a current picture of potential risk through both near miss and accident analysis. Summaries of incidents, accident/near miss trend data, and preventable actions summaries provide a learning opportunity that may improve incident prevention. Of interest, the three categories of incident consistently most frequently reported are circuit disruption, air entrainment, and drug/medication error. Reporting of near miss events as opposed to accidents and SAEs is of possibly greater benefit to improving safety in that by their frequency and nature may herald and hopefully prevent more serious events (24). Providing an international access web-based perfusion incident reporting system will necessitate resourcing capable of processing reports and providing feedback to the perfusion community in a timely manner. There are now clear signals for such profession-based reporting systems from governing bodies’ guidelines, from the professions through endeavors such as the FOCUS initiative, and from health authorities (24,25).

The National Patient Safety Agency of the British National Health Service (NHS) has established a comprehensive national reporting system for all patients receiving NHS care and reporting incidents of harm or death that will be mandatory for all NHS Trusts extending to private healthcare providers by 2012. The prospect of engaging the perfusion community to report incidents is challenging. Although incident-reporting is widely recommended in guidelines, and purported to be in widespread use in practice surveys, it is not mandatory (26). The experience of PIRS is that in Australia and New Zealand, incidents are uncommonly reported to a readily available registry. Interrogation of the PDUC database, which asks of each procedure “did an incident occur” and “was this reported to PIRS,” supports this notion. In what might be construed as a group biased in favor of reporting, of 5652 procedures, the reported occurrence of perfusion incidents by PDUC contributing centers was 1.2%. This is lower than any published survey and represents either excellent practice or underreporting. The majority of reported incidents, 66%, were near miss vs. 33% accidents. Of the eight participating centers, the incident rate varied from 0% (two centers) to 3.35%. Furthermore, only 49% of these incidents were reported to the PIRS.

Reasons for this low reporting are speculative but reflect the limitations voluntary reporting and also, more importantly, the culture of safety in perfusion. There is increasing recognition of the value of incident reporting in health care and changing the culture of safety to one of engagement across disciplines (27). It is plausible that in perfusion, there is a safety complacency associated with more sophisticated technology such as servoregulation of the HLM. Production pressure can stress staffing levels and specialization has resulted in greater autonomy of perfusionists that may negatively influence the human factors of the operating room. It can be argued that perfusion training programs have not placed appropriate...
weight to a culture of safety that includes human factors and the demonstrated value of simulation (1,28). Like in many countries, there is no statutory governance of perfusionists in Australia and New Zealand despite the college lobbying both governments to register the profession. Thus, there is no mechanism for mandatory reporting of incidents and professional regulations recommend reporting only major incidents.

An important part of identifying weakness in a system is an effective process to learning from mistakes. In a recent review article, “High Stakes and High Risk: A Focused Qualitative Review of Hazards During Cardiac Surgery,” the authors’ first area of recommended investment is transparency—to “seek to develop a local culture of safety in which speaking up is the norm. Ask frontline providers about problems and create a blameless reporting system to capture errors and close loops so near misses do not compound on each other. Communicate lessons learned and safety updates via routine dispatches throughout the organization” (29).

Engagement of a robust and secure perfusion incident reporting system is an essential and realistic objective.

REFERENCES