The Charles C. Reed Memorial Lecture

50 Years Of Perfusion In New Zealand: Vignettes From The Green Lane Experience

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Introduction

MR. MARK KURUSZ (Austin, Texas): This year's Charles C. Reed Memorial Lecturer comes from Auckland, New Zealand, Timothy Willcox. He traveled even farther than our first speaker who Bill Keen alluded to, Don Pastoriza-Pinol, who came from Sidney, Australia, in 1991.

I would like to tell you a few things about Tim before he addresses the group.

He has been a practicing perfusionist since 1972 and Chief Perfusionist at the Green Lane and Auckland City Hospital. In 2004 until the present he has also been on the faculty at the University of Auckland Medical and Health Sciences in the Department of Anesthesiology. He is a member of the Australasian Board of Cardiovascular Perfusion that certifies perfusionists in that part of the world, and he was also Past President of the Australasian Society of Cardiovascular Perfusionists.

For the last several years he has run an annual program on perfusion down under, as they would say, and he is the recipient of many awards for his work.

I think most of us probably know Tim from the medical literature, and he was the one who really alerted us very early that venous line air is not innocuous, that venous line bubbles can traverse the extracorporeal circuit and end up in the patient's systemic circulation.

Most recently he has worked on a database project to prospectively gather information on perfusion practice and perfusion incidents in Australia.

I would like you to please welcome Mr. Tim Willcox, this year's Charles C. Reed Memorial Lecturer.

MR. TIM WILLCOX: It was a surprise and a delight to get a phone call from Aaron Hill asking if I would give the 19th Charles C Reed memorial lecture at the American Academy of Perfusion meeting in Dallas in February of 2009. Traditionally this lecture has been given by perfusionists invited from outside the United States to draw from their experiences and talk about perfusion practice and its development in their country. The first Lecture by Don Pastoriza Pinol from Melbourne in 1981 was the forerunner of presentations from every continent of the globe over the following 18 years, a remarkable tribute to Charlie Reed's contribution to the profession. If we plot the home countries of these lectures on a world map the true impact of the global representation of this memorial lecture is revealed. New Zealand is one of the most distant perfusion communities from the United States, however close relationships have been forged since the first clinical cardiopulmonary bypass in New Zealand, five years after John Gibbon's breakthrough in 1953. While New Zealand (the Maori name is Aotearoa – meaning the land of the long white cloud) has a land area some 3% of the United States with a population of 4.3 million, we are blessed with outstanding landscapes, fauna and flora, a rich and vibrant cultural heritage of the indigenous Maori people and a love of sports and the outdoors instilled by the likes of Sir Edmond Hillary and perhaps epitomized in the successes of the All Black rugby football team.

Because of our proximity to our nearest neighbor Australia, 2150 Km across "the ditch", otherwise known as the Tasman Sea, we are sometimes viewed from the northern hemisphere as part of the same country. While we share very close associations including that of the perfusion community, there are important cultural differences that result in a friendly sibling rivalry and uniquely different sense of humor.

New Zealand perfusionists are linked to our Australian colleagues under the umbrella of the Australia and New Zealand College of Perfusionists (ANZCP). Established in 1982 as the Australasian Society of Cardiovascular Perfusionists (ASCVP), the Australasian Board of Cardiovascular Perfusion was set up in 1989 to provide a structured certification and credentialing program consisting of a 2 year modular postgraduate course together with employment as a trainee perfusionist to fulfill the clinical training. This course transitioned to a postgraduate diploma of perfusion in 2002 and in the same year formal recertification was established by the Board. In 2006 the diploma was replaced by the Master of Science - Cardiovascular Perfusion run by the Swinburne University of Technology in conjunction with the Board as an entirely on line program (*http://courses.swinburne.edu.au /Courses/ViewCourse.aspx?mi=100&id=2636*

2). In 2007 the ASCVP was restructured to become the Australia and New Zealand College of Perfusionists (ANZCP).

Cardiac surgery and cardiopulmonary bypass (CPB) are conducted in five centers throughout New Zealand; Auckland, Hamilton and Wellington in the North Island and Christchurch and Dunedin in the South Island. While there is a state funded public health system that provides healthcare, including cardiac surgery, at no direct cost to the patient, there are optional private providers of cardiac surgery in each of these centers although on a smaller scale.

Of the 3500 CPB procedures performed annually in New Zealand, the majority are undertaken in Auckland at the Green Lane Cardiothoracic Unit situated at Auckland City and Starship Children's Hospital. This quaternary centre is the national referral centre for pediatric cardiac, transplantation and ECMO and my place of work for some 36 years. The Green Lane Cardiothoracic unit was established in the early 1950's by Sir Douglas Robb, a chest and cardiothoracic surgeon. Green Lane Hospital was situated on the slopes of the extinct volcanic cone "Maungakiekie" also known as One Tree Hill (the subject of a song by U2) because of the lone tree that was situated on the summit unit it was removed after being damaged by Maori protestors in 2000.

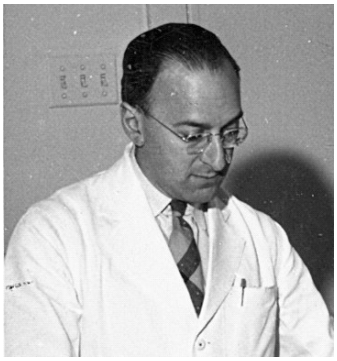

Figure 1. Mr. Sidney Yarrow (1956)

In the lead up to CPB in New Zealand, Mr. Sidney Yarrow was appointed in 1956 as a technician by the cardiologist Dr. J.B. Lowe essentially because of his expertise in electronics. (See Figure 1) Sid had experience in radar with the RAF prior to emigrating to New Zealand from the UK and was working at that time for the NZ navy. He was employed at Green Lane to establish and manage monitoring systems in the catheter investigation laboratory but was soon to play a pivotal role in establishing CPB in New Zealand as the pioneer of perfusion. Sid Yarrow is arguably New Zealand's Charlie Reed – such has been his influence on the profession. By this time Gibbon had achieved the first ever clinical success using a heart lung machine for cardiac surgery however this initial success was short lived. Dr. C. Walton Lillehei was in 1954 having greater success with cross circulation and at the time Sid Yarrow's appointment, Sir Douglas Robb persuaded the hospital board to purchase a sigmamotor finger pump planning to embark on cross circulation procedures with a young cardiothoracic surgeon at Green Lane, Dr Rowan Nicks (later to perform Australia's first heart surgery using CPB and alive and well in Australia in his 90s). However technology was advancing rapidly in the USA and CPB was facilitated by developments such as the De Wall bubble oxygenator. New Zealand's remoteness had always necessitated resourcefulness and Sid Yarrow was a master of the Kiwi "do-it-yourself" attitude. He built his own De Wall Bubbler and together with the newly appointed Sir Brian Barratt-Boyes who was to become a giant in the world of cardiac surgery and Professor David Cole, (cardiac and vascular surgeon) spent many hours in the animal lab perfecting models of CPB. In describing the oxygenator in a New Zealand Medical Journal article [1] in 1989 Sid recalls "the relatively bubble free blood settled in the tubing from which it was returned to the patient via the arterial pump." As it transpired, the "relatively bubble free blood" was only returned to sheep as Sid's De Wall Bubbler was not used clinically. In his memoirs of those early experimental efforts, David Cole recalls how the occasional haunch of sheep found its way home and his Labrador significantly increased her girth. I later heard that such delicacies were not only destined for pet food and as a result of the ether anesthetic fixing in fatty tissue of these animals there was a minor explosion in an oven.

Figure 2. The Melrose machine arrives

Sir Brian, who had worked with Denis Melrose at Hammersmith Hospital, arranged for the import at a cost of £3000 of one of six Melrose heart lung machines that had been built by New Electronic Products, Cavendish Road London. Sid Yarrow was charged with making it clinically operational. The Melrose machine had a number of deficiencies and Sid recalls it arriving with no manuals or operating instructions. (See Figure 2)

Sid together with Alfred Melville from what was to become the New Zealand Department of Industrial and Scientific Research, set about designing and making many ingenious accessories and modifications including a depulstor (See Figure 3) interposed between the reciprocating pumps and the rotating disc oxygenator to attenuate the violent pulsations, a very efficient cylindrical venous reservoir that could be lowered and raised on a mast to permit effective gravity drainage with a stainless steel antifoam coated gauze mesh section for cardiotomy inflow (See Figure 4) and a metal gauze arterial line filter.

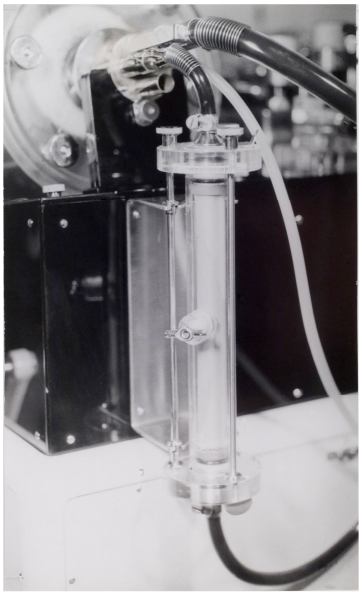

Figure 3. Depulsator designed and built for the Melrose Machine by SY and Alfred Melville.

There was no temperature control in the Melrose machine. Sid had a stainless steel tank built that was fitted with an electric jug element through which a crystalloid prime was circulated to heat the components of the extracorporeal circuit (See Figure 5). The prime fluid was then discarded into a bucket and the heating tank bypassed. The circuit was reprimed with fresh heparinized blood, the warmed circuit precluding excessive temperature loss through the short bypass run. Sid recalls being on the donor panel and quite often priming the pump with his own blood harvested the morning of the operation. In those days the donor's name as well as the recipient's was on the bottle. On one occasion the anesthetist Dr. Jack Watt held up a bottle of blood with Sid's name as the donor and said to Sir Brian, "What you think of this?" to which BB (as he was known) replied, "you'd better leave that to the end Jack – use the good stuff first".

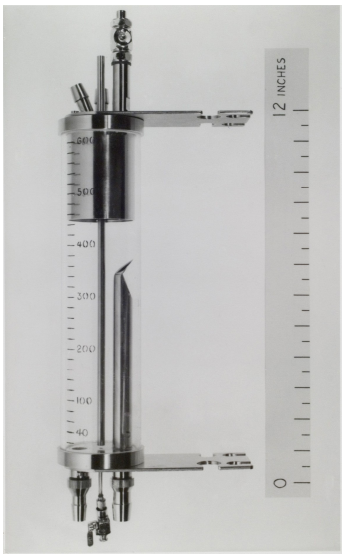

Figure 4. The venous reservoir (600 ml). Venous blood entered at the bottom and cardiotomy blood through the antifoam coated stainless steel mesh at the top.

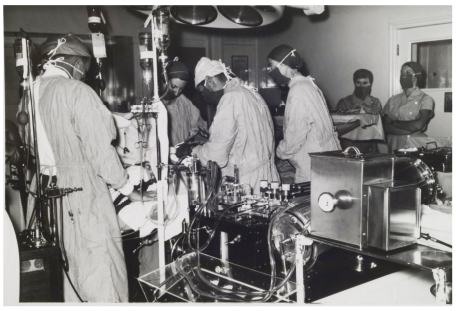

Figure 5. Melrose HLM with heating tank

Amongst the many challenges many laid down by Sir Brian (then Mr. Barratt-Boyes) to Sid Yarrow was when he summoned Sid to his office and said, "We'll need a pacemaker before we can do a VSD so you'd better go and make one". Recounting his experiences to the Green Lane perfusionists at Auckland City Hospital recently, Sid recalls that at the time he was working very long hours modifying the newly arrived Melrose Heart Lung Machine. However he set about using his electronic

expertise acquired in the British air force where he had worked extensively on Radar, and largely in his own time at home built the first pacemaker to be used in New Zealand.

And so after six consecutive successful animal CPB procedures the first human heart operation using CPB was successfully performed in New Zealand on the 3rd of September 1958 on a 9 year old girl with VSD. (See Figure 6) She remains alive and well today.

Figure 6. The first bypass operation in New Zealand Sept 3 1958. VSD on 9 year a old girl (alive and well at the time of publication)

The limitations of the Melrose heart lung machine meant that its clinical use was comparatively short and it was superseded by Pemco heart lung machines made in Ohio and Kay Cross disk oxygenators which we used through to 1973. The adult Kay Cross oxygenator was huge by comparison to current devices with 144 stainless steel disks rotating at 100rmp in a glass cylinder that was manually coated with Dow Corning antifoam A. Smaller sizes by length were used down to the 9 inch disk oxygenators for pediatrics. They were a challenge to operate as I vividly recall, devoid of any safety devices such as low level alarms. Manual cleaning and reassembly was onerous and time consuming. Disposable bubble oxygenators revolutionized set up times although our initial experience with the Bentley Temptrol was plagued with excessive hemolysis, caused as we discovered by inadequate gas flow through the sparger and the dispersion holes being deformed by dried blood. The transition to membrane oxygenators was made in the early 80s and thence to modular heart lung machines with micro processing which heralded a new era of safety and precision in CPB.

Fifty years on by comparison we use a wide range of CPB circuits and equipment a fraction of the size of those early devices enabling the very safe application of CPB for considerable periods of time. As the national referral centre for ECMO we have recently designed a system to effectively contain the ECMO circuit on a stretcher bridge (See Figure 7) that can be used in very confined spaces including ambulance, fixed wing and helicopter and we have successfully transported patients on ECMO support from centers up to 1500 Km away.

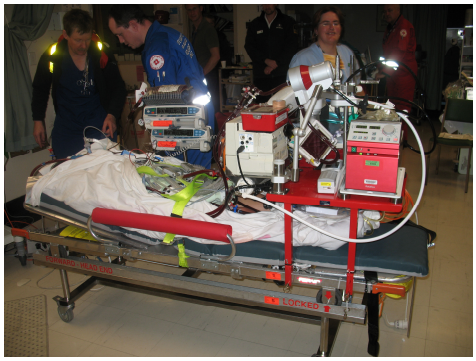

Figure 7. ECMO transport

Green Lane has a strong history of contribution to research in the field of cardiac surgery and, despite economic and political constraints and relocation to a new site this has continued, with regular publications in the peer reviewed literature from the perfusion department. Over the past decade there has been a strong interest in emboli and brain protection. This was galvanized by work by Dr Simon Mitchell on neuroprotection by Lidocaine during cardiac operations [2]. It was the casual observation during this study of increased numbers of emboli counts in the right common carotid artery during stable CPB that lead to a series of in-vitro experiments that confirmed our hypothesis that air entrained into the venous line resulted in arterial line emboli[3,4]. Further work demonstrated the exacerbation of this phenomenon by the application of vacuum assisted venous drainage[5,6]. This work was corroborated by others[7,8] and lead to an enjoyable and mutually fruitful relationship with Dr. David Stump, Dr. Tim Jones and Dwight Deal from Wake Forest University and was furthered through the Key West Outcomes Meetings run by Dr. Stump, Dr. John Murkin and more recently Clive Landis. We are currently revisiting emboli behavior of current CPB circuits using more sophisticated emboli detection developed by Dr Stump and now commercially available (EDAC - Luna Innovations Inc VA).

A relatively recent development in the pursuit of knowledge in the field of perfusion that originated in New Zealand is the formation of Perfusion Downunder known as PDU. The mission of PDU is "To promote

original prospective research into the effects of perfusion management on patient outcomes and so validate perfusion practices and interventions throughout Australia and New Zealand"… achieved through the creation of a meeting of excellence and scientific rigor that engages a faculty of excellence with objectives that meet those of the meeting… to grow perfusionist generated research initiatives with an overriding aim to foster networking both scientifically and personally within the perfusion profession. Perfusion Downunder (http://www.perfusiondownunder.com) is not dissimilar in its aims to the American Academy of Perfusion. The PDU Winter Meeting now alternates annually between Queenstown in the South Island of New Zealand and Hayman Island on the Great Barrier Reef in Australia. A development of PDU is the Perfusion Downunder Collaboration chaired by Assoc. Prof. Rob Baker from the Flinders Medical Center in Adelaide Australia. This is a collaboration of a group of individuals who, through the creation of a collaborative network of perfusion and interested researchers, share the commitment to cooperation and collaboration in the pursuit of excellence in perfusion. The PDUC has established a multicentre database using a dataset that is designed to link perioperative demographic clinical and electronic perfusion data to outcome data. The aim is to enable benchmarking and prospective clinical studies using accurate real-time perfusion data.[9]

Another development aimed at improving the practice of perfusion is the Perfusion Incident Reporting System (PIRS). This is an international web based online perfusion reporting system run out of New Zealand through the ANZCP. It is currently limited to the New Zealand and Australian perfusion community through the ANZCP but there are plans to expand the system. PIRS allows a perfusionist to file a perfusion accident or near miss on-line by answering 39 questions, the majority as check boxes, including a description of the incident, how it was managed and what preventive action was taken. The information is validated by the PIRS editor then de-identified and placed in a database. If a cluster of incidents occur or one relating to devices that may pose a threat to other users, a "PIRS Alert" detailing the problem is posted on the College Website. Review of the database allows identification of trends in incident type and subtype; e.g. accident or near miss; equipment or management; circuit, drug / medication, air in circuit etc. as well as trends in reporting and human factors.

Over the past 50 years perfusion in New Zealand has developed into a sophisticated profession. These vignettes of perfusion in New Zealand and its development honor the memory of Charles Reed and his influence on the field of cardiopulmonary bypass in so many places across the globe including Aotearoa - the land of the long white cloud. An the old Maori saying goes: *He aha te mea nui? He tangata. He tangata. He tangata.* What is the most important thing? It is people, it is people, it is people.

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