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BUCKBERG ZERO SUGAR: AN AUDIT OF THE REMOVAL OF DEXTROSE FROM BUCKBERG CARDIOPLEGIA

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Winner of the Medtronic Encouragement award 2020

Abstract

The cardioprotective effects of dextrose cardioplegia make it an appealing choice for cardiopulmonary bypass; however, the inclusion of dextrose may lead to intraoperative hyperglycaemia and postoperative complications (1). This was an audit following a change in clinical practice with 50 patients in each group (dextrose vs no dextrose) assessing continuous cases, excluding insulin dependent diabetics, and patients receiving reperfusion ('hotshot') cardioplegia. Preoperative, intraoperative and postoperative serum glucose levels were assessed along with use of intraoperative insulin. The following postoperative outcomes were recorded: maximum troponin levels <12 hours post-op, ventilation time, ICU and hospital stay, sepsis, stroke, deep sternal wound infection, death and <30-day mortality. There was no statistically significant difference between the two groups for any of the outcome variables measured; hence the removal of 50% dextrose addition to modified Buckberg cardioplegia was safe.

Introduction

Intraoperative hyperglycaemia as defined as a blood glucose >10 mmol/L has been associated with increased morbidity and mortality after cardiac surgery and has been identified as an independent factor worsening the prognosis in patients with acute coronary syndrome and those undergoing coronary artery bypass grafts (CABG) (1, 2). Glucose was included as an additive to Buckberg cardioplegia to increase osmolarity to prevent oedema and provide an energy substrate for the myocardium, and has been shown to have a synergistic effect with oxygen to improve functional recovery (3). However, a study by Ouattara et al. (4) shows that cardiopulmonary bypass (CPB) induces severe hyperglycaemia related to the increased release of stress hormones. CPB also decreases peripheral use of glucose and insulin secretion, which provokes coronary endothelial dysfunction and may further increase the incidence of myocardial ischaemia. The influence of CPB on hyperglycaemia has also been shown by Anderson et al. (5) who compared CABG with CPB to off-pump CABG (OPCAB), showing the average blood glucose post-operatively was more easily controlled and required less insulin for the OPCAB group compared to the CPB group. Overall glycaemic control is impaired with the use of CPB, and patients with elevated glucose levels have worse postoperative glucose control and complications such as increased intra-aortic balloon pump (IABP) use or perioperative myocardial infarction (2).

Mimic et al. (6) compared high glucose concentration blood cardioplegia with crystalloid cardioplegia and concluded that there was no significant difference in clinical outcome and that high glucose content blood cardioplegia did not show any advantage over crystalloid cardioplegia. This may be that the capillary delivery of glucose is rate limiting for myocardial glucose uptake in the beating heart but not during cold cardioplegia, and why the addition of glucose to cardioplegia solution shows no convincing cardioprotective effect (7).

As these studies have shown, there is a wide body of evidence indicating that hyperglycaemia is associated with worse postoperative outcomes and CPB exacerbates the disturbance to glucose homeostasis. Thus, any glucose-containing medications require a review as they may be detrimental to intra-operative glucose levels (8).

A greater frequency of hyperglycaemia during CPB at Auckland City Hospital (ACH) compared to other centres in the Australia and New Zealand Collaborative Perfusion Registry (ANZCPR) was previously demonstrated resulting in a reduction of glucose to the modified Buckberg cardioplegia in 2013 from 47 mL of 50% dextrose (130 mmol/L) to 3 mL of 50% dextrose (1.67 mmol/L). Therefore, I raised the question on whether the complete elimination of dextrose to modified Buckberg cardioplegia could be made safely without detriment to the patient in terms of serum glucose levels, myocardial protection and post-operative outcomes.

Hypothesis

Removal of 3 mL of 50% dextrose from modified Buckberg cardioplegia does not impact myocardial protection and reduces the rate of CPB hyperglycaemia.

Materials & Methods

The study included adult patients undergoing open heart surgery on CPB at ACH. Fifty consecutive patients in 2019 for Group 1, and another fifty consecutive patients in 2020 for Group 2. Group 1 had Modified Buckberg Cardioplegia with 3 mL of 50% dextrose added (CpD), while Group 2 had Modified Buckberg Cardioplegia with no dextrose added (Cp0). The patients were audited with Institutional Board ethics approval. Exclusions for this audit were insulin-dependent diabetics, patients receiving a 'hotshot' reperfusion cardioplegia and patients not receiving Buckberg blood cardioplegia. Patients were allocated their group depending on their date of surgery aligning with the change in clinical practice of removing the 3ml

50% dextrose addition from June 2020 onwards. Cardioplegia was delivered at a 4:1 ratio: 4 parts autologous blood from the CPB circuit and 1 part crystalloid. Cardioplegia was delivered using the CPB circuit with heat exchanger and pressure control in an antegrade, retrograde or ostial fashion depending on surgeon preference. There was an average induction dose of 240 mL crystalloid with maintenance doses of 100 mL crystalloid delivered approximately every 20 minutes.

Preoperative and intraoperative clinical variables were recorded including: CPB time, aortic cross-clamp time, diabetes and diabetes control, patient age and gender, serum glucose levels on standard ABGs (approximately every 30 minutes) and intraoperative use of insulin. Postoperative variables included: serum glucose levels on standard ABGs in the OR and intensive care unit (ICU) for six hours post-op, maximum troponin levels <12 hours post-op, ventilation time, ICU and hospital stay, sepsis, stroke, deep sternal wound infection, death and <30-day mortality.

An analysis of the results assessed: changes in blood glucose from pre-CPB to maximum blood glucose during CPB, post-CPB in the OR and the maximum blood glucose <6 hours in ICU, the frequency of hyperglycaemia and hypoglycaemia, and group difference between the clinical variables listed above.

Results

A total of 100 adult patients were included in the study, with 50 patients per group. The two groups showed no statistically significant difference with respect to: age, gender, procedure type, insulin during CPB or X-Clamp and CPB time (Table 1).

Table 1: Demographic, Preoperative and Intraoperative data and comparison between groups

	CpD (n = 50)	Cp0 (n = 50)	P-Value
Age (years)	60.8 ± 12.3	64.6 ± 10.7	0.11
Gender	39 Male (78%)	41 Male (82%)	0.62
Diabetes	5 (10%)	15 (30%)	0.01
Intraop Insulin	1 (2%)	3 (6%)	0.31
Procedures	13 Complex (26%)	10 Complex (20%)	0.48
X-Clamp Time (min)	78 ± 33.90	74.28 ± 28.99	0.56
CBP Time (min)	119 ± 47.7	116 ± 45.2	0.72

Values are the mean ± SD unless indicated

However, there was a statistically significant difference in the number of patients with diabetes between the two groups: CpD (n = 15) and Cp0 (n = 5) (p = 0.01) (Table 1). There was no statistical significant difference between the two groups for group mean blood glucose: pre-CPB: CpD (mean = 6.08, SD = 1.51), Cp0 (mean = 5.98, SD = 1.45) (p= 0.75), min CPB; CpD (mean = 6.59, SD = 1.31) Cp0 (mean = 6.32, SD = 1.31) (p = 0.29), max CPB; CpD (mean = 8.59, SD = 2.08) Cp0 (mean = 8.35, SD = 1.97) (p = 0.55), post-CPB in OR, CpD (mean = 8.48, SD = 2.06) Cp0 (mean = 8.53, SD = 2.06) (p = 0.90) or max <6 hours in ICU; CpD (mean = 9.72, SD = 1.92) Cp0 (mean = 9.44, SD = 2.26) (p = 0.50) (Figure 1).

There was no statistically significant difference between the two groups, for frequency of hyperglycaemia: pre-CPB: CpD = 6% hyperglycaemia and Cp0 = 4% (p= 0.65), max during CPB; CpD = 30% hyperglycaemia and Cp0 = 22% (p = 0.36), Post CPB in OR, CpD = 22% hyperglycaemia and Cp0 = 20% (p = 0.81) or <6hours in ICU, CpD = 34% and Cp0 = 32% (p = 0.83) (Figure 2). No patients were hypoglycaemic at any time point measured.

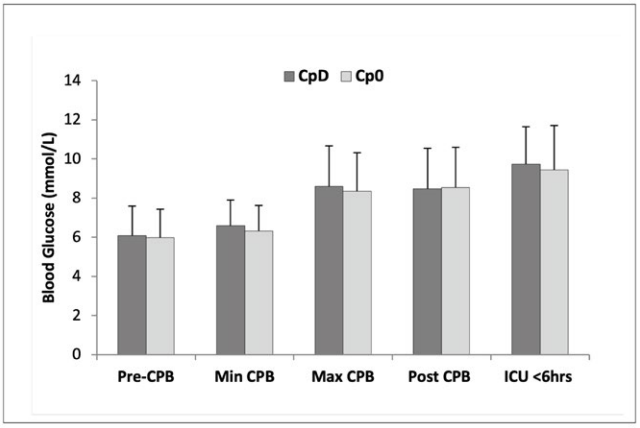

Figure 1: Mean Blood Glucose Levels by Group before, during and after CPB. Data represents mean values and error bars represent standard error

There was no statistical significant difference between the two groups for change in blood glucose from pre-CPB to: Max during CPB: CpD (mean = 2.51, SD = 1.76), Cp0 (mean = 2.37, SD = 1.69) (p = 0.69), post-CPB in OR: CpD (mean = 2.4, SD = 1.61) Cp0 (mean = 2.55, SD = 1.61) (p = 0.65) and <6hours in ICU: CpD (mean = 3.64, SD = 1.81) Cp0 (mean = 3.49, SD = 1.85) (p = 0.65) (Fig 3). The two groups also showed no statistically significant difference in terms of postoperative outcomes (Table 2).

Table 2: Postoperative outcome comparison between groups

	CpD (n = 50)	Cp0 (n = 50)	P-Value
Max Troponin <12 hrs (ng/L)	888 ± 1058	882 ± 1011	0.98
Ventilation Time (hrs)	31.1 ± 108	15.0 ± 16.9	0.31
ICU Stay (hrs)	74.1 ± 169	50.8 ± 46.1	0.35
Hospital Stay (days)	12.3 ± 10.2	14.0 ± 6.36	0.33
Sepsis	1 (2%)	0 (0%)	0.31
DSWI	1 (2%)	0 (0%)	0.31
Stroke	0 (0%)	1 (2%)	0.31
Death	1 (2%)	1 (2%)	1
<30 day Mortality	1 (2%)	1 (2%)	1

Values are the mean ± SD unless indicated

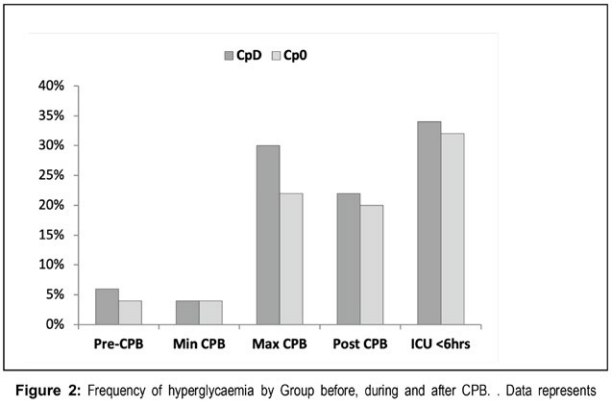

Figure 2: Frequency of hyperglycaemia by Group before, during and after CPB. . Data represents percentage of patients within the group who were hyperglycaemic (>10mmol/L) at that time point

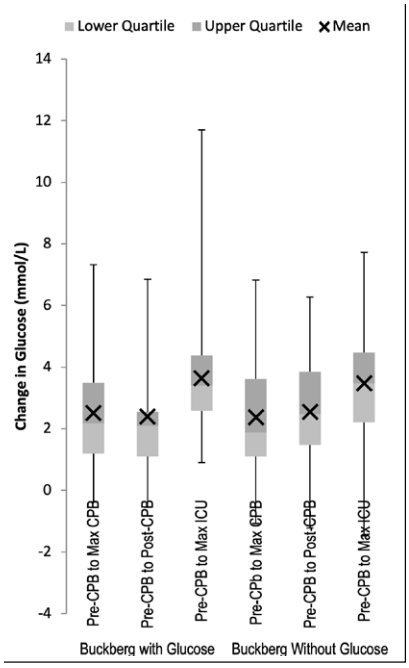

Figure 3: Change in blood glucose from preoperative to intraoperative and postoperative. Mean is represented by the X and error bars represent standard error.

Discussion

The aim of this study was to observe outcomes for patients receiving Buckberg cardioplegia with or without glucose to determine whether the complete removal of 3 ml 50% dextrose addition could be made safely. This study did not find a statistically significant difference in the measured postoperative outcomes between those patients who received dextrose cardioplegia and those who did not, which is consistent with the findings of Lessen et al. (1). However, it was interesting to see that the mean ventilation time in the Cp0 group was half that of the CpD group and the mean ICU stay for the Cp0 group was approximately 24 hours less than the CpD group. Although these results did not meet significance it will be interesting to assess these parameters in the future with a larger sample size to see whether this is a consistent trend with the Cp0 group or was due to random chance and outliers.

The only statistically significant difference between the two groups was the number of patients with diabetes, which was triple in the non-dextrose group (n = 5 vs n = 15). This may have impacted the results of the study as more patients in the Cp0 group had impaired glucose control, potentially resulting in a greater incidence of hyperglycaemia, and this may be the reason there was no significant difference in the frequency of hyperglycaemia between the two groups. Furthermore, once a larger sample size can be assessed it will be interesting to see whether this trend for an increased number of patients with diabetes was random or whether this is indicative of our patient population. The virtual diabetes register by DHB of domicile has shown a rise of approximately 80,000 people in NZ with diabetes from 2010 to 2019 (9). If there is a trend in our patient population for increased rates of diabetes and impaired glucose control, then this reiterates the need to assess these glucose containing medications as suggested by Mongero et al. (8).

Although there was no statistically significant difference between the two groups for frequency of hyperglycaemia, there was a reduction at each time point in the Cp0 group. Of particular note was the frequency of hyperglycaemia during CPB which reduced from 30% to 22%. Once again when a larger sample size can be assessed this will allow for a better evaluation on whether this reduction in hyperglycaemia is a stable change. A larger sample size will also allow for better patient matching ensuring there is no difference between the number of patients with diabetes which will either reveal that this did skew the results or had no impact.

As mentioned sample size and group matching were limitations to this study. The study design of using continuous cases was chosen to attempt to accurately represent the patient population by not excluding comorbidities that we would see on a day to day basis. This also allowed us to reach our target sample size quickly so we could evaluate the results and ensure that our hypothesis was correct and safe.

From the results of this audit the complete elimination of 50% Dextrose from modified Buckberg cardioplegia has become standard practice at ACH which provides the opportunity to continue to assess the safety of this change with a greater sample size. It has also resulted in a reduction in waste as we have been able to change from 500 mL PVC bags of glucose to 10 mL glass vials, and as there are now no additions to our maintenance cardioplegia solution, this has eliminated the use of injection spikes (Accessory Spike GPN 101593). Both of these changes result in a reduction in waste and use of plastic which is beneficial for the environment.

Conclusion:

The complete removal of 50% dextrose addition to modified Buckberg cardioplegia resulted in no statistical significant difference to any outcome variable, and therefore was safely removed. Following this audit elimination of dextrose to modified Buckberg cardioplegia has been implemented as standard practice at Auckland City Hospital. As this change is now standard practice it provides the opportunity to further investigate this question with a larger matched sample size, which was a limitation to the study.

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12TH – 15TH AUGUST 2021

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The Heritage, Queenstown, New Zealand.

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AROUND THE PUMP ROOM
IN THE HEART OF THE WAIKATO, NEW ZEALAND

Britney Westbrook CCP, FANZCP

The perfusion department at the Waikato District Health Board (DHB) has endured many changes over the past few years. One significant milestone was having myself qualify in November 2020 as the first ANZCP graduate in over 13 years. In honour of this, below is recognition of our unit and the exciting works in the pipeline.

The Waikato region in New Zealand is surrounded by farmlands, rivers and lakes. The longest river in New Zealand is the Waikato River which runs straight through the heart of Hamilton, where our hospital is situated. We are spoilt with views of the river and lunch spots with picturesque views which overlook yachties on neighbouring Lake Rotoroa.

Our unit has two joint Chief Perfusionists, Emma Peplow and Jack Bhana. There is a uniqueness around having two Chiefs in a unit of five perfusionists. They have separate responsibilities and delegations which reduce the individual workload, sharing managerial, clinical work and training roles. Jordan Morris from Ohio in the United States has recently joined us. She was the ECMO co-ordinator in her previous role and has brought many skills we are benefiting from. Mike Levett is our newest recruit coming from Sydney, we are really looking forward to the addition of another perfusionist from outside New Zealand.

The fifth member of the team is Courtney Adams, our latest trainee who joined us last October. The success of our previous training program has made the transition for Courtney smooth and seamless into our unit. She has achieved great exam results thus far and is finding her feet clinically alongside the training from all her colleagues.

The Waikato Cardiac department is on the move, there are plans to increase the size of the unit with theatre staff numbers and procedures. Over the following years we are hoping to increase our open-heart procedures to well over 700 per year, making an additional 2–3 spaces per week for extra elective cases. With this in mind, the formation of an ICU that is cardiac only will facilitate this expansion and more, which is also on the cards for the future.

But it doesn't stop there, we are also involved in circulating the chemotherapy drugs around the abdomen in HIPEC procedures. These are rapidly increasing in numbers as we are the only unit in New Zealand that offer this procedure. The positive outcomes with these patients have led Waikato DHB to now offer HITOC procedures to patients with thoracic cancer. In light of this, we have just completed the first HITOC in New Zealand with great success.

Our perfusion team enjoys keeping up to date and being involved in research, our units latest research is the upcoming 'Humidified CO2' study. This study has originated from our cardiac department and aims to determine whether the addition of humidified warm, cold or zero CO2 reduces the number of bubbles in the heart when the cross clamp comes off. We are hoping to get draft numbers from this research over the next couple of years.

Our department is an enjoyable workplace with a growing close-knit team. The balanced 'Kiwi' lifestyle we treasure encourages our passion for the job. We are proud of where our unit has come and where it is heading with our future team of six.

The past year has been difficult for everyone due to the COVID-19 pandemic and we hope to see many of you in person as the world begins to open up again.

From our unit to yours, thank you for continuing to provide lifesaving care to patients every day.

L-R: Courtney Adams, Jordan Morris, Jack Bhana, Britney Westbrook and Emma Peplow

Selected Abstracts from the 37th Annual Scientific Meeting of Australian and New Zealand College of Perfusionists

APPLICATION OF A SCAVENGING SYSTEM FOR THE MEMBRANE OXYGENATOR AND THE VENOUS RESERVOIR: AN EXPERIMENTAL STUDY

A. J. Vilayil, J. Pauli (Clinical Trainee), J. Suthumporn (Clinical Trainee), J. McMillan CCP (USA), CCP (AUS), Perfusion Services, Victoria

Background: There have been multiple studies suggesting that a scavenging system should be applied on the oxygenator gas outlet and the venous hard-shell reservoir using two different vacuum sources separately. However, no clear guidelines have been recommended for this technique.

Aim: Therefore, this study is an attempt to reduce the potential ill-effects of scavenging gases and volatile anaesthetics escaping into the operating room without compromising the integrity of the consumables, equipment and any augmentation to the venous return.

Methods: This study was conducted in a laboratory setting to provide maximum control of all parameters to be measured. The circuitry was designed to scavenge the oxygenator gas outlet safely and to demonstrate the practicality and simplicity of the system utilized, as well as to demonstrate the safety of scavenging the venous reservoir while eliminating the gases and condensate. All of the components used are freely available to all perfusionists in the operating room.

Findings: It was demonstrated in the experiment that the custom-made metal connector attached to the scavenging port of the membrane oxygenator outlet did not allow volume or gaseous solution to cross the membrane and exit through the scavenging port. The integrity of the membrane oxygenator remained intact when high vacuum pressure (-700 mmHg) was applied. CO2 accumulation was captured by a soda lime canister and weight change was observed. In addition to venting of CO2, the pCO2 in the prime was tested, and both methods indicated that a vacuum pressure greater than -10 mmHg is required to effectively eliminate high levels of CO2.

A NEW ROLE FOR THE PERFUSIONIST IN TREATING PATIENTS WITH ARTIFICIAL STONE ASSOCIATED SILICOSIS

Dan Chambers, Simon Apte, Ian Smith, Mark Kroll, Gary Walker, Charles McDonald, Ivan Rapchuk. The Prince Charles Hospital, Chermside, Queensland

Background: Artificial stone contains very high levels of silica bound by resin; much higher than found in natural stone products. Due to its high silica content, artificial stone is a source of hazardous dust exposure for workers that are employed in the manufacturing, finishing, and installation. Inhalation of 'respirable crystalline silica' (RCS) can lead to silicosis (a progressive, irreversible and probably incurable fibrotic lung disease). The only life-saving therapeutic option in end-stage silicosis is transplant. Several small case series from China suggest a benefit to small volume, segmental lung lavage to remove RCS. This present study is investigating the safety and effectiveness of whole lung lavage (WLL) to remove RCS.

Methods: Twelve patients with artificial stone associated silicosis were enrolled to undergo bilateral WLL. After standard anaesthetic induction, patients were intubated with a dual lumen tube to allow for single lung ventilation concurrent with single WLL. Patients were rolled on their side (lung to be lavaged was uppermost). A lung lavage circuit, consisting a Terumo FX25 connected to a heater-cooler unit and primed with sodium bicarbonate buffered saline that was connected to the dual lumen tube. A lavage volume estimate of 10 ml/Kg was initially used and lung compliance pressures were measured. Total lung lavage volumes of 25–30 L over a three hour period were targeted for each single lung lavage and controlled by a perfusionist.

Results: To date, six patients have received bilateral WLL. The study has been paused to review safety and effectiveness before completing the study target of 12 patients. WLL has been well tolerated and there has been a significant clearance of RCS as determined by comparing conventional BAL samples pre- and post-whole lung lavage.

Conclusion: Bilateral WLL to treat artificial stone associated silicosis is a safe procedure that removes significant RCS from the alveolar space. Improvements in lung function and lung volumes have been demonstrated. Further studies in several Australian hospitals are due to begin.

PULSATILITY: KNOW THE LIMITATIONS (PART 1)

J. Pauli (Clinical Trainee), J. Suthumporn (Clinical Trainee),
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Perfusion Services, Victoria

Background: Organ dysfunction following cardiopulmonary bypass (CPB) has been shown to be associated with the presence of gaseous microemboli (GME) intraoperatively. A few in-vitro models available concluded that pulsatile perfusion (PP) creates an environment for supplementary GME delivery. The objectives of the study were to determine if perfusate viscosity, temperature, gas flow, pulse rate and blood flow will have an effect on GME count and volume during pulsatile mode of perfusion in a controlled laboratory setting.

Aim: First, to design a circuit whereby, temperature, gas flow, pulse rate and blood flow could be governed and measured while simultaneously quantifying GME count and volume. Second, to create a system of conducting the experiment efficiently.

Method: The circuit components included a COBE roller pump, a COBE computerized perfusion controller, a Stöckert Heater-Cooler System 3T, a LivaNova Inspire 8F hollow-fibre membrane oxygenator with hard shell venous reservoir, integrated heat exchanger and arterial filter, 3/8" internal diameter (ID) tubing, ½" ID tubing, 3/8" x 1/2" connector, and an Affinity hard shell reservoir. Pressure transducers connected to a GE patient monitor were used to record pressure waveforms at both the pre-membrane and post-membrane sites. Spectrum M3 monitor with bubble sensors were used to detect GME at the pre-membrane and post-membrane sites. Temperature probes were used to monitor temperature at both the pre-oxygenator and post-oxygenator sites. An oxygen tank with flow meter was used to deliver gas to the membrane oxygenator. A Hoffman clamp was placed in the venous line to regulate venous reservoir level. Tests were conducted at three different pulse rates (40, 60, 80 beats per minute), under three flow rates (2, 4, 6 litres per minute), with or without gas flow (0 or 3 litres per minute), at three temperatures (20°C, 30°C, 37°C) using two fluids with different viscosities (Normal saline solution and whole milk), to yield a total of 324 experiments.

Findings: Pulsatile perfusion using normal saline solution as perfusate yielded 162 data points. Due to the coagulation of whole milk at 30°C, pulsatile perfusion at 37°C had not been performed. Pulsatile perfusion using whole milk as perfusate yielded 105 data points. The whole experiment generated a total of 267 data points.

Conclusion: The circuit and experimental design are both simple and reproducible. It enabled measurement of GME count and volume as well as the control of temperature, gas flow, pulse rate and blood flow precisely. A solution containing saline and glycerol, which can give a viscosity similar to that of blood, could be substituted for whole milk to avoid coagulation at 30°C and above.

PULSATILITY: KNOW THE LIMITATIONS (PART 2)

J. Suthumporn (Clinical Trainee), J. Pauli (Clinical Trainee),
J. McMillan CCP (USA), CCP (AUS)
Perfusion Services, Victoria

Background: Organ dysfunction following cardiopulmonary bypass (CPB) has been shown to be associated with the presence of gaseous microemboli (GME) intraoperatively. A few in-vitro models available concluded that pulsatile perfusion (PP) creates an environment for supplementary GME delivery.

Aim: The objective was to research and determined appropriate statistical testing to analysis the relationship between each of the variables and GME count and volume.

Method: IBM SPSS Statistics program (New York, USA) was used to statistically analyse the data. The Shapiro-Wilk test of normality was used to firstly determine the type of distribution. The data was determined to be not normally distributed and a non-parametric correlation test, Spearman's rank-order correlation coefficient test was determined to be best suited as the data met the test criteria.

Findings: The results show a statistically significant strong positive correlation between temperature and GME count and volume. It also showed a weak positive correlation that was statistically significant for pulse rate and GME count and volume. Viscosity was found to have a weak and moderate negative correlation to count and volume respectively, which are both statistically significant. Both gas flow and blood flow regarding GME count and volume had very weak negative correlations which are not statistically significant.

Conclusion: Both temperature and pulse rate had a positive correlation on embolic load, with higher counts and volumes observed as both factors are increased.

"IF YOU DO NOT MEASURE IT, YOU CANNOT IMPROVE IT"

J. Suthumporn (Clinical Trainee), J. Pauli (Clinical Trainee),
J. McMillan CCP (USA), CCP (AUS)
Perfusion Services, Victoria

Background: Technologies developed to measure blood flow in coronary artery bypass grafts such as the Doppler flowmeter have been around since 1988. Measurements of blood flow intraoperatively permit early detection of technical errors and therefore their correction without subjecting patients to further invasive investigative procedures.

Aim: To retrospectively study the use of transit time flow measurement (TTFM) within one cardiac unit through understanding the technology of the device used and its benefits and limitations.

Methods: A cohort of 151 patients from September 2019 to June 2020 were reviewed which included a total of 399 grafts.

Findings: Measurements showed a mean pulsatility index (PI) of 2.4 ± 1.5, mean graft flow (MGF) of 45 ± 30 ml/min and diastolic filling percentage (DF%) of 66% ± 9%. It was observed that 81% of the collected PI values were below 3, 95% of the acoustic coupling index (ACI) data were above 30% and 94% of DF% were above 50% of all data collected.

Conclusion: TTFM is a promising quality control adjunct to the surgeon's judgement, with the potential to aid decision making when considering to re-anastomose a graft. Furthermore, its utilization may result in a reduction or avoidance of reinvestigation of coronary artery grafts at the catheterization laboratory.

LESSONS LEARNED USING ECMO TO MANAGE SEVERELY ILL COVID-19 PATIENTS: RESULTS FROM OUR FIRST 210 PATIENTS

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Background: ECMO has been used as a tool to manage severe respiratory collapse in patients suffering from coronavirus disease (COVID-19). While the role of ECMO in managing adult patients with ARDS is well accepted its utility as a modality for COVID-19 remains to be seen. The goal of this report is to analyze registry data on the use of ECMO across American hospitals.

Methods: Beginning in March 2020, an adjunct database for COVID-19 patients managed on ECMO was created as a supplement to a national registry of medical procedures (SpecialtyCare Operative Procedural rEgistry, SCOPE). Data was obtained from hospitals across America where perfusion and ECMO services were provided. The data metrics included demographic profiles of patients, medication and treatment regimens applied before and while on ECMO, and outcomes of these interventions. Patients were further separated into two groups dependent on survivability.

Results: There were 210 COVID-19 ECMO patients from 29 distinct hospitals from March 17, 2020 to October 20, 2020. The median yearly age of patients was 51.5, 71.4% were male, and 92.9% were placed on veno-venous ECMO. 44.2% of patients were Latino, 17.1% African American, and 23.3% Caucasian. While 27 patients are still on ECMO, 183 are off support with 94 (51.4%) unable to be weaned or succumbing while hospitalized. Of the 89 survivors 70% have been discharged from the hospital. Median time on ECMO was 12.1 days (IQR=7.3-16.0 days) for survivors and 14.7 days (IQR=7.3-27.7 days) for non-survivors. Survivors were generally younger (47 v. 53 years) more likely to be Caucasian (29.2% v. 17.6%), have lower composite pre-ECMO comorbidity (26.1% v 29.2%) and had higher usage of commercial ECMO systems and lower use of dual lumen cannulae. While the use of adjunctive therapies changed over the seven month period, the use of intravenous steroids, anti-interleukin-6 receptor blockers, convalescent plasma, Remdesivir, hydroxychloroquine, and prostaglandins were similar across groups.

Conclusion: The use of ECMO resulted in approximately a 50% survival rate of select critically ill patients with COVID-19. Substantial variation exists in pharmacotherapeutic management of these challenging patients, but ECMO offers a reasonable rescue strategy.

HIGHER FLOW ON CARDIOPULMONARY BYPASS IN PEDIATRICS IS ASSOCIATED WITH A LOWER INCIDENCE OF ACUTE KIDNEY INJURY

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Objective: Adequate perfusion is of paramount concern during cardiopulmonary bypass (CPB) and different methodologies are employed to optimize oxygen delivery. Temperature, hematocrit, and cardiac index are all modulated during CPB to ensure appropriate support. This study examines two different perfusion strategies and their impact on various outcome measures including acute kidney injury (AKI), urine output on CPB, ICU length of stay, time to extubation, and mortality.

Methods: Predicated upon surgeon preference, the study institution employs two different perfusion strategies (PS) during congenital cardiac surgery requiring CPB. One method utilizes a targeted 2.4 L/min/m2 CI and nadir hematocrit of 28% (PS-1), the other a 3.0 L/min/m2 CI with a nadir hematocrit of 25% (PS-2). This study retrospectively examines CPB cases during which the two perfusion strategies were applied to determine potential differences in packed red blood cell administration, urine output during cardiopulmonary bypass, AKI post CPB as defined by the KDIGO criteria and operative survival as defined by the Society of Thoracic Surgeons.

Results: Significant differences were found in urine output while on CPB ($p < 0.01$) and all combined stages of postoperative AKI ($p = 0.01$) with the PS-2 group faring better in both measures. No significant difference was found between the two groups for packed red blood cell administration, mortality, time to extubation, or ICU length of stay.

Conclusion: Avoiding a nadir hematocrit less than 25% has been well established but maintaining anything greater than that may not be necessary to achieve adequate oxygen delivery on CPB. Our results indicate higher cardiac index and oxygen delivery on CPB is associated with a lower rate of AKI and this may be achieved with increased flow rather than increasing the hematocrit thus avoiding unnecessary transfusion.

CARDIOPULMONARY BYPASS MANAGEMENT AND ACUTE KIDNEY INJURY IN 118 JEHOVAH'S WITNESS PATIENTS: A NATURAL EXPERIMENT

Tim Willcox, Richard Newland, Rob Baker

Previously presented at the PDU Winter meeting 2019 and published 2020 Perfusion

Introduction: Blood product transfusion is associated with significant adverse outcomes in surgical patients with low predicted morbidity and mortality. There has been recent attention given to modifying factors of cardiopulmonary bypass (CPB) to reduce the incidence of acute kidney injury (AKI). A relatively small cohort of patients presenting for cardiac surgery refuse blood products primarily on religious grounds. Accurate detail of the modifiable factors of CPB relating to AKI is previously unreported in this patient population.

Methods: 118 adult Jehovah's Witness patients refusing transfusion were propensity matched to 118 adult patients accepting transfusion from the 30.942 patients in the Australian and New Zealand Collaborative Perfusion Registry. The primary endpoint was AKI. Intraoperative and bypass management characteristics were also compared between early (2007-2012) and late (2013-2018) cohorts along with the acceptance or refusal of transfusion.

Results: In patients accepting transfusion, 49% received a blood product. In patients refusing transfusion, AKI was lower (8% vs 22%; P = 0.003). Cell salvage use was higher (70% vs 22%; P < 0.001; as was use of hemofiltration (8% vs 4%; P = 0.03) and tranexamic acid in the early period (87% vs 62%, P = 0.004) but not late (100% vs 97%; P = 0.15). There was no difference in modifiable CPB factors (mean arterial pressure, minimum oxygen delivery (DO2i), retrograde autologous prime, circuit prime volume) between the two groups, however prime volume decreased and DO2i increased over time for both. Patients refusing transfusion had lower postoperative blood loss (P = 0.02) and shorter postoperative length of stay (P = <0.001) with no difference in morbidity (P =0.46) or mortality (P = 0.68).

Conclusion: Refusal of transfusion in patients undergoing CPB was associated with reduced AKI, hospital stay and postoperative blood loss, whilst not impacting mortality. Management of CPB for patients refusing blood products arguably constitutes a standard of care for low risk cardiac surgery.

A STUDY TO INVESTIGATE BUFFERING CONSISTENCY OF PERFADEX SOLUTION IN LUNG PROCUREMENT FOR TRANSPLANTATION

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Background: The Alfred Hospwwital has a large lung transplant program. Donor lungs are procured and flushed with buffered Perfadex to reduce reperfusion injury and primary graft dysfunction, Perfadex is a solution created by XVIVO.

Objectives: THAM is added to Perfadex at the donor hospital several minutes before flushing the donor lungs. THAM acts as a proton acceptor and corrects acidosis by binding with hydrogen ions. This quality study will describe any variability in the pH of the flushing solution after it has been buffered.

Methods: A sample of buffered Perfadex was taken at the donor hospital by the procuring anaesthetist after THAM was added and mixed. The sample was stored in ice and pH tested at the Alfred with twenty-four hours. A proof of concept was performed to establish the efficacy of the protocol and consistency of testing before starting.

Results: Eight donors are included in the study, and each lung donation was flush with three 2800 ml bags of Perfadex. SPSS version 25 was used to generate descriptive statistics. A paired t-test was used to compare the three samples of Perfadex for each donation, and no significance was noted.

	n	Mean ± SD	Range
Sample A	8	7.46 ± 0.36	(7.85- 6.79)
Sample B	8	7.59 ± 0.28	(8.01- 7.28)
Sample C	8	7.55 ± 0.21	(7.90- 7.25)

A paired-samples t-test showed no significant differences in pH levels between Samples A and B ($p>0.05$), Samples A and C ($p> 0.05$) and Samples B and C ($p>0.05$).

Conclusion: This study demonstrated some variability in the pH of Perfadex that is used for flushing the donor lungs as a result of the addition of THAM. When the results were analysed this was not demonstrated to be statistically significant.

THE EFFECT OF CONVENTIONAL ULTRAFILTRATION ON RENAL OUTCOMES IN PATIENTS RECEIVING DEL NIDO CARDIOPLEGIA SOLUTION DURING CARDIAC SURGERY: A RETROSPECTIVE STUDY

Britney Westbrook CCP, Waikato District Health Board

Objectives: Conventional ultrafiltration (CUF) in the intra-operative setting assists in reducing post-operative volume overload and haemodilution during cardiopulmonary bypass (CPB). In our institution the hot topic remains around determining whether the addition of the ultrafiltration device to the circuit, combined with one liter of del Nido cardioplegia is beneficial? The correlation between ultrafiltration and post-operative renal outcomes is controversial. This study aims to examine the effect of intra-operative ultrafiltration vs. non-ultrafiltration on post-operative renal outcomes, specifically acute kidney injury (AKI).

Methodology: Retrospective data was collected from a single institution, over a two-year period (2019–2020). Patients who underwent coronary artery bypass grafting (CABG) or single valve replacements with del Nido cardioplegia were the focus. Scrutinising the data generated a population set, which was able to be matched according to variables appropriate for each of the two groups, one with CUF (n=58) and the other without CUF (n=103), with a total of 161 patients.

Results: The plasma haemoglobin (Hb) in both groups comparably depleted from baseline to post-operative on average measurement (CUF 3.23g/L and without CUF 5.67g/L , p=0.73) without reaching any statistical significance. The average Hb from baseline to post-operative Hb with CUF showed only a slight 6% reduction, however was not statistically significant when compared the 16% reduction without CUF. The two groups had no statistical difference in average elevation of serum creatinine, from baseline to peak 48 hour post-operative (CUF 15.4 µmol/L and without CUF 17.9 µmol/L, p=0.68). The three stages of AKI were varied throughout both groups and defined according to the AKIN classification. Stage one was illustrated more often without CUF (17% and 10%) with no statistical significance and both stages two and three, were very similar in their findings p=0.81 (stage two with CUF 2.1% and without CUF 2.7%, stage three with CUF 0.2% and without CUF 1.15%).

Conclusion: The addition of CUF during CPB did not correlate to a reduction in renal dysfunction post-operatively. CUF did reduce the Hb depletion post-operatively and serum creatinine, but neither of which reached statistical significance. This suggests additional data analysis of the variables and increased cohort size, would reduce the limitations and may result in more conclusive outcomes. Further investigation surrounding oxygen delivery index (DO2i), will be required to provide further insight and claim any correlative outcomes.

PERFUSION QUIZ – MULTIPLE CHOICE 2

Sreenivasulu Galaeti CCP FANZCP

1. Blood cardioplegia was re-introduced and popularised by:
   a. Gibbon
   b. Lillehei
   c. Debakey
   d. Buckberg
   e. Melrose

2. Under normal physiological conditions, which organ has the lowest oxygen consumption per unit weight.
   a. Brain
   b. Kidney
   c. Lungs
   d. Liver

3. Which of the following hormones, released during CPB, is NOT a vasoconstrictor?
   a. Anti-diuretic hormone
   b. Epinephrine
   c. ACTH
   d. Norepinephrine

4. The approximate pressure in the umbilical arteries is _____and in the umbilical vein is _____.
   a. 80 mmHg and 30 mmHg
   b. 50 mmHg and 20 mmHg
   c. 30 mmHg and 15 mmHg
   d. 20 mmHg and 10 mmHg

5. Pick the most correct alternative:
   a. Heparin acts to reduce the effectiveness of the Antithrombin III reaction.
   b. Heparin function depends upon an adequate level of Antithrombin III.
   c. Heparin enhances the conversion of prothrombin to thrombin.
   d. For the safety anticoagulated patient on CPB, the ACT should be prolonged to values between 200–300 seconds.
   e. None of the above are correct.

6. The chemical driving force for a substance crossing a cell membrane:
   a. Depends only on the concentration gradient, regardless of whether or not the substance is an ion.
   b. Depends only on the concentration gradient if the substance is uncharged, but also depends on the electrical force if the substance is an ion.
   c. Is the total driving force on the substance, even if it is an ion.
   d. Is the force that pushes molecules across the membrane, but only if the substance is actively transported.
   e. Always favours movement of a molecule into the cell.

7. The absolute refractory period of a neuron:
   a. Occurs only during the repolarization phase.
   b. Occurs only during the depolarization phase.
   c. Is due to the high negative polarity of the neuron.
   d. Occurs during depolarization and the first phase of repolarization.

8. What is the next step when calcium ions enter the axon terminal of a neuromuscular junction?
   a. Myosin will bind to actin and form cross bridges.
   b. Vesicles of acetylcholine will be drawn to the membrane.
   c. Calcium ions will be released from the sarcoplasmic reticulum.
   d. An action potential will spread down T-tubules.
   e. Acetylcholine will bind to receptors and open ion channels.

9. What is the minimum amount of urine the body needs to produce a day to be able to excrete metabolic waste products?
   a. 700 mL
   b. 200 mL
   c. 400 mL
   d. None of the above

10. If you receive 1 liter of 9% saline solution, what effect will this have on your red blood cells?
    a. Crenation
    b. Lysis
    c. No effect
    d. Increased oxygen-carrying capacity
    e. They will move faster

11. The Coanda effect demonstrates that:
    a. The lateral pressure exerted by a flow of gas or liquid varies inversely with velocity of that gas or liquid.
    b. The amount of gas entrained from an opening distal to a tube constriction and proximal to the tube end is proportional to the flow of gas moving through the tube.
    c. A stream of gas exiting a constricted tube end may adhere to distal surface planes given the proper angles.

12. The effect of haemoglobin saturation on carbon dioxide dissociation is termed as the:
    a. Bohr effect
    b. Haldane effect
    c. Henderso-Hasselbalch equation
    d. Bronsted-Lowry theory

13. The function of von Willibrand factor is:
    a. Binds platelets to each other.
    b. Binds platelets to the phospholipid surface.
    c. Carries factor VII.
    d. Binds platelets to the subendothelium.

14. According to AAMI, reference flow is the flow in which oxygen delivery equals _____ ml/min/L of blood flow under AAMI standard conditions (35% Hct, 37°C, Hb=12 mg/dL, FiO2=100%).
    a. 40
    b. 50
    c. 60
    d. 70

15. In heparin induced thrombocytopenia (HIT) patients, usually _____ type of immunoglobulins are involved.
    a. IgG
    b. IgD
    c. IgE
    d. IgM

16. Regarding TEG (thromboelastography) all of the statements are correct except _____.
    a. R-Valve indicates clotting time from start of test to initial fibrin formation.
    b. Alpha angle is increased in hypercoagulable states and decreased in thrombocytopenia.
    c. MA represents strength of the clot.
    d. LY-30 AND LY-60 are decreased in state of fibrinolysis.

17. P50 is the PO2 in which the haemoglobin is 50% saturated with oxygen, normal P50 valve _____.
    a. 26.6 mmHg
    b. 40.0 mmHg
    c. 50.5 mmHg
    d. 75.0 mmHg

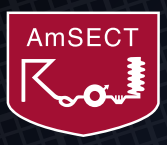
18. Which cardiac pacing mode is considered as a more physiologic pacing mode?
    a. AAI
    b. DVI
    c. VVI
    d. DDD

19. If CPB flow is 4L/min, PaO2 = 250 mmHg, PvO2 = 40mmHg, Hb = 10 g/dL, SaO2 = 99%, SvO2= 70% minute oxygen consumption (VO2) is approximately _____ mL/min.
    a) 151
    b) 200
    c) 250
    d) 300

20. Blood pH dropping below ____ or rising above ____ may results in cell death.
    a) 6.8 and 7.8
    b) 6.0 and 8.0
    c) 5.0 and 8.0
    d) 5.6 and 5.5

Quiz #2 – References

AAMI reference flow is the flow in which oxygen delivery equals 40 ml/min/L of blood flow under AAMI standard conditions (35% Hct, 37°C, Hb=12 mg/dL, FiO2=100%] Myers GJ. Understanding off-label use and reference blood flows in modern membrane oxygenators. The journal of extra-corporeal technology. 2014 Sep;46(3):192.



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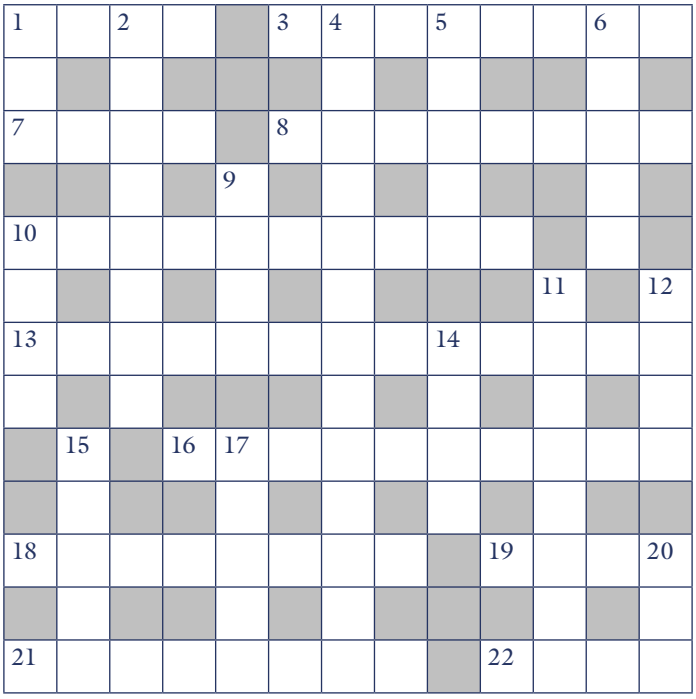
PERFUSION QUIZ
POTGER'S PSEUDO –
PERFUSION PUZZLE NO. II

(Originally published in the inaugural 'The ASCVP Gazette'. Vol 1; No. 1; May 1998.)



ACROSS

1 Conduit for extracorporeal circulation in foetus
3 Science of flow
7 Major conduit returning blood to heart
8 Language function defects potentially seen after impaired perfusion of the brain
10 Receptor potentiated by sympathomimetic drugs
13 Pertaining to profound hypersensitivity response of body to an exogenous antigen
16 Tunica adventitia of the heart
18 Subjective indications of a disease
19 Ramifications of HIV infection
21 Pertaining to conduit for air and expired gases in neck
22 8 bits

DOWN

1 Central venous catheter
2 Action of protamine on heparin effect
4 A sugar abnormality implicated in exacerbating cerebral pathology on CPB
5 Reclusive large herbivore living in the forests of the Congo
6 Translocation of tissue
9 25.4 mm
10 Microbial culture media
11 Degree to which a substance is poisonous
12 Name of patient having first documented rib resection
14 Temperature monitored in nasopharynx
15 Region of variation in velocity between free stream of viscous fluid and stationary surface: 'boundary _ _ _ _ _'
17 Prosthetic article used to repair VSD
20 File a claim for damages

CALENDAR OF EVENTS
2021

Anticipate changes to conferences and meetings; expect rescheduling as virtual meetings or cancellations [Editor]

MAY

1–4, May 2021
AmSECT 59th International Conference - A Virtual Experience
www.amsect.org

AUGUST

12–15, August 2021
Perfusion Downunder
Queenstown, New Zealand
"We are inviting the same faculty for PDU [2020] in August 2021 and we have secured the Heritage Queenstown for the 12th to 15th August 2021. We are very grateful to the Queenstown venue's generosity in transferring booking costs through to 2021 in these difficult times."
www.perfusiondownunder.com/

NOVEMBER

10–13, November 2021
3SCTS (including ANZCP Annual Scientific Meeting)
Cairns, Queensland
This will be a combined scientific meeting of three societies – ANZCP, ANZSCTS & ANZCA CTVP SIG. In 2021 our Symposium will also be held in conjunction with the International Society for Minimally Invasive Cardiothoracic Surgery 2021 (ISMICS) Workshop.
https://anzcp.org/

Quiz #2 – Answers

1. d	5. b	9. b	13. d	17. a
2. c	6. a	10. a	14. a	18. d
3. c	7. d	11. c	15. a	19. a
4. b	8. b	12. b	16. d	20. a

POTGER's Pseudo – Perfusion Puzzle No. II Solution

C	O	R	D		R	H	E	O	L	O	G	Y
V		E				Y		K			R	
C	A	V	A		A	P	H	A	S	I	A	S
		E		I		E		P			F	
A	D	R	E	N	E	R	G	I	C		T	
G		S		C		G				T		A
A	N	A	P	H	Y	L	A	C	T	O	I	D
R		L				Y		O		X		A
	L		E	P	I	C	A	R	D	I	U	M
	A			A		E		E		C		
S	Y	M	P	T	O	M	S		A	I	D	S
	E			C		I				T		U
T	R	A	C	H	E	A	L		B	Y	T	E

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