ABSTRACTS

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NOMOTHERMIC CARDIOPULMONARY BYPASS: OUR EXPERIENCE—
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Methods: From July 2006 to July 2007, 89 patients underwent normothermic cardiopulmonary bypass (CPB) for the following surgical procedures: CABG n = 37, valve replacement/repairs n = 41 congenital operations n = 9 and aneurysms repairs n = 2. The CPB methodology was standard one with no active cooling with use of hyperkalemic cold blood cardioplegia.

Results: There was no adverse event intraoperatively. Postoperatively patients were extubated after 2 to 8 hours mean being 3 hours. There was no neurological deficit but transient delirium occurred in 2 patients. Pulmonary and renal functions were well preserved in all patients. 73/89 (80%) patients did not require supplemental oxygen after extubation. There was one mortality due to continuous excessive haemorrhage. Transient hyperkalemia occurred in 12 patients and liver enzymes were raised in 2 patients.

Conclusion: Our initial experience with use of normothermic CPB has remained excellent.

THE PERFUSIONIST’S ROLE IN A COLLABORATIVE MULTIDISCIPLINARY APPROACH TO BLOOD TRANSFUSION REDUCTION IN CARDIAC SURGERY—EDY ZELINKA
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Purpose: Transfusion practices in cardiac surgery are a topic of increasing interest. A data-driven, multidisciplinary effort to decrease allergenic red blood cell transfusion was initiated at our institution. Creative perfusion strategies are an essential component of our program that led to an exceptionally low transfusion rate.

Methods: Numerous innovations in treatment protocols were implemented and evaluated to reduce hemodilution that is normally associated with the heart-lung bypass machine. Yearly review of outcomes led to an evolving clinical practice and lowered transfusion rates. Perfusion techniques used on every case are vacuum assisted venous drainage with dry 3/8" tubing, 10 foot arterial-venous loop, retrograde autologous prime, and saline prime removal from the primary and cardioplegia circuit. We use a polymer-coated perfusion circuit. Hemoconcentrator and cell saver use is determined on a case by case basis. Normothermia is maintained except in cases of circulatory arrest or specific surgeon request. Our priming method involves pre-bypass removal of saline from the circuit and replacement with mannitol, sodium bicarbonate, heparin, Amicar, and albumin. Final saline hemodilution ranges between 150–400 milliliters.

Results: 2758 consecutive cardiac surgical procedures (3% OPCAB) were performed from 2003 to 2008. Our incidence of red blood cell transfusion was significantly decreased, from 43% to 13% for all patients and 38% to 9% for CABG only patients. Patient outcomes were not significantly changed.

Conclusions: Cardiac surgery can be performed safely with low utilization of allogeneic red blood cell transfusions. Creative perfusion techniques play a key role in a multidisciplinary approach to blood conservation.
PERCUTANEOUS ASSISTED VENOUS RETURN ISOLATED LIMB PERFUSION (PAVRILP)—GEORGE A JUSTISON

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Purpose: Isolated Limb Perfusion (ILP) is a short term therapy used in conjunction with or without hyperthermia to deliver chemotherapeutic agents to localized areas, thus avoiding the severity of side effects caused by systemic administration. The most common treatment approach is Hyperthermic Isolated Limb Perfusion (HILP) with increased oxygenation of the chemotherapeutic perfusate for treatment of melanoma, soft tissue sarcoma or synovial sarcoma. HILP traditionally involves open surgical dissection and direct cannulation. This approach involves significant morbidity including blood loss, infection, nerve and blood vessel trauma. Isolated Limb Infusion (ILI) has been proposed as a less invasive procedure that has been proposed to reduce these morbidities and isolation complications of ILP. However, the warming and recirculation rates of ILI are not as good as traditional ILP.

Methods: We describe a minimally invasive technique of angiographically placed percutaneous cannulation with vacuum assisted return for HILP. The extracorporeal circuit is comprised of a traditional hardshell oxygenator/reservoir and accommodates all acid base management strategies.

Conclusions: This technique allows superior circulation of chemotherapeutic agents with minimal morbidities and can be performed on an outpatient or limited stay basis.

AN ALTERNATIVE TECHNIQUE TO DECREASE HOMOLOGOUS BLOOD USAGE BY DECREASING CIRCUIT PRIME VOLUMES—ANNA MARIE IULIANELLI

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Purpose: The effects of excessive hemodilution may lead to an increase in homologous blood transfusions. Cardiac surgery is the leading consumer of allogenic blood products thus placing patients at an increase exposure to infections, costs, morbidity, mortality, and lengths of stays. As a result, medical professionals have adopted blood conservation techniques to decrease unwarranted blood transfusions.

Methods: The present study was a comparison of draining the venous line and removing excessive prime volume to a technique of not draining the venous line and removing excessive prime volumes. There were 40 elective CABG patients assessed in each group.

Results: The results showed that there is a significant difference in average post-CPB hemoglobin values between the groups ($p = 0.011$). There is also a significant difference in average change in hemoglobin between the groups ($p = 0.005$) indicating that the group that did not have the venous line drained had a significantly larger decrease in hemoglobin value than the group with the venous line drained.

Conclusions: Draining the venous line can be viewed as a technique that can be incorporated into a blood conserving program, when combined with other protocols, be beneficial to any open heart program in both, decreasing hemodilution and homologous blood usage.

HEMOCONCENTRATING RESIDUAL PUMP BLOOD MAY IMPROVE POST-BYPASS HEMOSTASIS—ROBERT D. LONGENECKER

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Background: Hemoconcentration of residual pump blood following CPB preserves autologous clotting factors and platelets. The standard practice of washing residual pump blood with a cell-saver removes these elements.

Methods: We hypothesized that hemoconcentration of residual pump blood would decrease post-CPB bleeding and blood product utilization. From consecutive patients operated on from 5-1-07 to 4-30-08 two groups were retrospectively compared. In group HC (n = 120) residual pump blood was hemoconcentrated using a Hemobag (Global Blood Resources, LLC); in group CS (n = 277) residual pump blood was processed through the cell saver. Exclusion criteria included aortic replacement, current hemodialysis, acute emergent surgery, and patients who received non-aspirin anti-platelet therapy the same day as surgery. All patients underwent standard cardiopulmonary bypass using a coated hardshell oxygenator, tubing, and centrifugal pump. A cell saver was used intra-operatively in all cases. Patient-specific anticoagulation and hemostasis management were maintained using heparin dose response, heparin levels, kaolin ACTs, and TEG data. Physiologic and transfusion parameters were standardized for all cases based on institutional protocols while on CPB. Post-CPB transfusion was individualized by anesthesiologist and surgeon. CBC and coagulation data were collected at varied intervals through the third post-op day. Total blood loss and RBC, FFP, and platelet transfusions were compared between the two groups.

Results: There was no difference between the groups based on demographics and risk factors. Total blood loss, RBC, FFP, and platelet transfusions were lower in the HC group v the CS group.
Conclusions: Hemoconcentration of residual pump blood may improve post-operative hemostasis by preserving autologous clotting factors and platelets.

ULTRAFILTRATION IS AN EFFECTIVE SUBSTITUTE FOR CELL CENTRIFUGATION IN PERIOPERATIVE BLOOD MANAGEMENT TECHNIQUES—DAVID W HOLT

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Purpose: Blood conservation techniques continue in review and evolution. Cell collection and centrifugation has traditionally been accepted as a standard of practice for processing shed blood. Ultrafiltration has been described for applications during cardiopulmonary bypass as a reasonable method of managing hemodilution without waste of valuable blood proteins such as clotting factors, platelets, and plasma.

Methods: An in-vitro circuit composed of common cardiopulmonary bypass components was tested with bovine blood to implement a modified blood washing technique.

Results: By using ultrafiltration as a substitute to centrifugation, this technique provides a way to decrease patient cost and provide autologous perioperative blood management while decreasing allogeneic transfusion related complications.

Conclusions: This study demonstrated valuable blood components are not simply discarded as waste yet effectively increasing the hematocrit. The cost analysis utilizing perioperative cell salvage by ultrafiltration is a likely worthwhile substitute to cell centrifugation.

PATIENT DIRECTED PERFUSION PRESSURE ON BYPASS, AN ANALOGY FROM ELECTRICAL ENGINEERING? A NEW CONCEPT—MICHAEL POULLIS

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Purpose: To produce a blood pressure target for cardiopulmonary bypass (CPB) that is tailored to the individual patient. Patients perfusion during CPB is nonpulsatile. Converting the pulsatile preoperative blood pressure into an equivalent non-pulsatile pressure that has the same “energy” delivery can be achieved by the use of the technique of calculating the root mean square—an exact analogy utilized in electrical engineering.

Methods: The root mean square (square root of the sum of the squares of the instantaneous blood pressures) of the patients resting preoperative blood pressure was compared with medical mean blood pressure [diastolic pressure + 1/3 (systolic pressure – diastolic pressure)], arithmetic mean and geometric mean of the preoperative blood pressure.

Results: Using the medical mean of the pre operative blood pressure as a guide to pressure to maintain during cardiopulmonary bypass can significantly under estimated the patients’ individual required perfusion pressure, by more than 12 mmHg in some cases.

Conclusions: Tailoring the pressure on bypass so that it correlates with the patients’ preoperative pressure may help to reduce the incidence of organ ischemia, typically renal and mesenteric. This may reduce the morbidity and mortality post-cardiopulmonary bypass. As patients undergoing elective cardiac surgery do not have malperfusion pre-bypass, so if the pressure, flow and hematocrit are all appropriately controlled for, and the patient develops malperfusion, then the debate of pulsatile verses non-pulsatile perfusion needs to be re examined. Clinical correlation is now needed to confirm/refute the validity of this observation.

THE EFFECT OF CUMULATIVE VENOUS AIR ON THE AIR HANDLING OF CARDIOPULMONARY BYPASS CIRCUITS—TED LYNCH

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Purpose: Numerous studies have shown a link between gaseous microemboli (GME) and adverse neurological outcomes after bypass surgery. Previous clinical investigations of air handling in bypass circuits have shown that GME counts exceeding 10,000 are routinely detected after the arterial line filter during bypass surgery. Despite these high counts, the benefits of routine monitoring for GME during CPB surgery have not been fully established, as many believe that once detected there is little that can be done to prevent GME from reaching the patient. Recent observations of CPB air handling using the EDAC Quantifier suggest that the ability to remove air from a circuit degrades over the course of a surgery, and that this ability is related to cumulative air exposure. If this is the case, careful minimization of venous air during routine surgical procedures may help improve the air handling of the circuit during other more complex procedures where it is difficult to minimize venous air without compromising other important perfusion parameters. The purpose of this study is to quantify the extent to which CPB air handling degrades over time.

Methods: In order to test this idea, in vitro tests of air handling in a closed loop circuit were performed. During these tests, counts and embolic load (air volume) post filter were detected for a two minute period following a 5 cc bolus injection of air
into the venous line. The bolus injection was first performed immediately after priming the circuit, followed by bolus injections performed after each in a series of continuous air infusions into the venous reservoir.

**COATED BYPASS CIRCUITRY REDUCES THE RISK OF TRANSFUSION-RELATED LUNG INJURY—WILLIAM DEBOIS**

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**Purpose:** Coated bypass circuitry (CBC) has been shown to reduce transfusion requirements, preserve platelet function and diminish systemic inflammation. Reduced systemic inflammation may have an effect on lung injury. Since components of lung injury include a two step process which is related to both an inflammatory insult and the transfusion of blood products such as seen in transfusion related acute lung injury (TRALI), CBC may reduce this risk by eliminating the inflammatory process.

**Methods:** 100 patients undergoing cardiopulmonary bypass were randomly divided into two groups of 50 patients each (CG = coated group, UG = uncoated group). Patients with chronic obstructive pulmonary disease and those with abnormal coagulation screens were excluded. Moderate hypothermic bypass and alpha-stat blood gas strategies were utilized in both groups. Intensive care staff was blinded as to the grouping. Patients were compared for transfusion requirements, chest tube drainage and ventilatory requirements.

**Results:** Patients were matched both demographically and for NYS preoperative risk. Study patients received significantly fewer units of both red blood cells (2.7 versus 3.9, \( p = 0.02 \)) and fresh frozen plasma (0.9 versus 2.1, \( p = 0.01 \)) throughout the length of stay. Twenty-four hour chest tube drainage trended lower (817 ml versus 949 ml, \( p = 0.07 \)). The time until extubation was significantly longer in the control group (582 versus 396 minutes, \( p = 0.02 \)). Additionally more control group patients (3 versus 1) required extended ventilator support (more than 5 days). There were no deaths in either group.

**Conclusions:** Coated bypass circuits preserve coagulation function which reduces transfusion requirements. Furthermore coated bypass circuits possibly provide a protective systemic effect by attenuating the inflammatory cascade. The combination of inflammatory insult and blood transfusion increases the risk of TRALI. This risk was reduced when coated circuitry was used, as expressed by decreased ventilator requirements and improved the postoperative outcome.

**EVALUATION OF HEMOCONCENTRATOR PERFORMANCE WHEN USED WITH THE HEMOBAG® AND THE RECOVERY LOOP CIRCUIT—ANDREA BERRA**

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**Purpose:** The Hemobag® is a simple blood salvaging device that returns whole blood back to the patient thus increasing patient outcomes and reducing the cost of blood products used. This study evaluated the overall performance of the hemoconcentrator used in conjunction with the Hemobag®.

**Methods:** The in-vitro circuit consisted of a Hemobag®, the normal “Recovery Loop” used with the Hemobag® for post-cardiopulmonary bypass salvage of pump blood, and one of three hemoconcentrators (Cobe 1400 Maxi, Fresenius HF5000, Minntech HRH1400-IUS). Performance (hematocrit, plasma free hemoglobin, ultrafiltration rate) was tested using a starting blood volume of 2000 milliliters (mls) of fresh heparinized bovine blood, two different blood flow rates, (R: manufacturer’s maximum rated flow; R+: 150% of maximum rated flow), and two vacuum settings, (N: no vacuum; Y: application of -80 mmHg vacuum). The starting volume was concentrated until the hemoconcentrator inlet pressure remained above 400 mmHg. Hematocrit and inlet pressure were measured every minute.

**Results:** Running the hemoconcentrator at the manufacturer’s rated flow with no applied vacuum produced the highest average ending hematocrit [48.8% ± 3.3% (range 46–54%) versus 44.1% ± 5.0% (range 34–53%), \( p = 0.017 \)] and the lowest average ending plasma free hemoglobin [75.0 mg% ± 20.7 mg% (range 50–110 mg%) versus 94.2 mg% ± 15.3 mg% (range 70–130 mg%), \( p = 0.078 \)]. Using the rated flow and no applied vacuum also produced a lower ultrafiltration rate [101.7 mls/minute ± 5.6 mls/minute (range 93.6–107.1 mls/minute) versus 179.1 mls/minute ± 26.3 mls/minute (range 124.1–218.3 mls/minute), \( p < 0.001 \)] and took longer to process the blood [13.3 minutes ± 1.0 minute (range 12–15 minutes) versus 7.3 minutes ± 1.5 minutes (range 6–4 minutes), \( p < 0.001 \)].

**PREOPERATIVE HYPONATREMIA AND CARDIOPULMONARY BYPASS: YET ANOTHER RISK FACTOR FOR CEREBRAL DYSFUNCTION?—RICHARD WARWICK**

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**Purpose:** To determine if preoperative hyponatremia is a risk factor for patients undergoing cardiopulmonary bypass (CPB). Hyponatremia is not uncommon in patients prior to CPB, usually secondary to diuretic therapy. However, rapid correction of chronic hyponatremia, ie mixing of the patient’s blood with the CPB prime solution, may have disastrous consequences namely central pontine myelinolysis.
**Methods:** We retrospectively analyzed a prospective validated database of over 15,000 patients undergoing cardiac surgery at a single institution. Using the brain as an index organ, as previously described by Murkin, we specifically looked at length of stay.

**Results:** We identified 89 elective patients with serum sodium less than 135 mmol/L. Average age was 68.43 underwent isolated CABG, 25 underwent isolated valve replacement, 15 patients underwent valve and grafts, 6 underwent other cardiac procedures involving CPB. Overall mortality was 2.2%. Patients had an average length of stay of 14 days, nearly double the average for the remainder of the 13,000 patients undergoing surgery in our institution.

**Conclusions:** Hyponatremia is not a risk factor for death post CPB, but seems to increase length of stay because patients are? Not quite right? This may be due to low grade diffuse subtle neurological injury due to the rapid correction of the chronic hyponatremia. Surgeons, anesthetists and perfusionists should be aware of chronic hyponatremia and its potential rapid correction when commencing CPB. Priming the CPB circuit with small additional calculated volumes of water to adjust the prime sodium to match the patients may be beneficial to prevent adverse neurological injury.

**VARIATION ANALYSIS OF TWO POINT-OF-CARE SYSTEMS USED DURING CARDIOPULMONARY BYPASS: HEMOCRON VS. I-STAT—DEREK ALAN SANDERSON**

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**Purpose:** Activated clotting time (ACT) measurements using Hemochron Response and i-STAT were evaluated by correlation studies prior to a recent change in point-of-care testing. This retrospective study compares the Hemochron Response and the i-STAT methodology of ACT measurement to determine if the change in measurement devices reduced variation in clinical practice.

**Methods:** One hundred cardiac adult surgery cases from August 2007 to May 2008 using either the Hemochron Response or i-STAT ACT were included in the study. Inclusion criteria were: body surface area (BSA) between 1.5–2.5 m², baseline ACT.

**Results:** This study was useful in determining the effectiveness of the hospital-wide change from the Hemochron to the i-STAT ACT. The analyzed data indicates that both systems show special-cause variation.

**Conclusions:** The i-STAT data displays much less special-cause variation and a more linear central tendency in relation to the mean. In addition to the analysis using controls charts, the effect on total heparin administration was demonstrated.

**MECC? MORE THAN HEMODILUTION?—ADRIAN BAUER**

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**Purpose:** The use of minimized extracorporeal circulation (MECC) is an established procedure to perform coronary revascularization. Some studies showed positive effects of MECC compared to conventional cardiopulmonary bypass (CCPB) procedures in terms of transfusion requirements, less inflammation reactions and neurological impairments. Retrospective data analysis done by our workgroup found results in terms of higher MAPs and less norepinephrine consumption. This current study addressed this observation in more detail with particular attention on major organ systems.

**Methods:** This was a prospective, controlled, randomized trial with 40 patients (MECC and CCPB) undergoing coronary bypass grafting. (MECC™ Maquet vs conventional Bypass including roller pump) Primary endpoints were the perioperative course of Calafiore’s cardioplegia. MECC provided a completely empty heart for CABG surgery during cardiac arrest.

**Results:** At four of five time points during ECC the MAP values were significantly higher in the MECC group (after starting the ECC 60 mmHg ±11 vs. 48 mmHg ± 10 p = 0.002). MECC patients received significantly less norepinephrine (MECC 0.56 µg ± 1.6 vs. CCPB 5.2 µg ± 9 p = 0.038). The lactate dehydrogenase increased significantly in the CCPB group. (1 h post ECC 3.6 ± 0.8 vs. 21 ± 0.5 S100) Neuronal specific enolase release was significantly better in MECC patients (S100: 0.56 µg/l ± 0.31 vs. 1.27 ± 0.85 p = 0.02, NSE: 9 µg/l ± 4.6 vs. 19 ± 9 p < 0.001). Significant higher values in the CCPB group were observed for CK-MB and Troponin T (CK-MB 0.38 µmol/l ± 0.1 vs. 0.66 ± .21 p < 0.001; Troponin T MECC 0.08 µmol/l ± 0.05 vs. CCPB 0.22 µmol/l ± 0.15 p < 0.001). The hematocrit decreased by 70% from baseline in the CCPB and by 80% in the MECC group. The perioperative transfusion requirement was lower in the MECC group perioperatively and up to 8 days post-operatively (MECC 8/18 vs. CCPB 14/22 p = 0.56).

**Conclusion:** The results of our study support the theory that MECC procedures provide a higher mean arterial pressure during ECC. In our opinion the use of MECC is less harmful to the major organ systems and very easy to perform.

**EFFECTIVENESS OF CARBON DIOXIDE FLUSHING OF ARTERIAL LINE FILTERS—CARL GISNER**

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**Purpose:** Gaseous microemboli (GME) are connected to neurological impairment and other ischemic complications after surgery. The components of the extracorporeal circuit (ECC) have a large influence on the presence of GME. Butler
distinguished the sources of GME into five categories: suction of blood and air, cavitation, mechanical blows to the circuit, GME release when the blood is warmed, and injection of GME into the circuit. This study investigates the use of carbon dioxide flushing of coated and non-coated arterial line filters to decrease the amount of GME and the time for air to clear the arterial filter.

**Methods:** An adult circuit was implemented with the addition of a silicone oxygenator to allow for vacuum-assisted gas removal and to reduce air pre-ALF. The filters were separated into four groups: flushed coated, flushed non-coated, non-flushed coated and non-flushed non-coated. Carbon dioxide flushing of filters was performed at 6 L/minute for 3 minutes. All ALFs were retrograde primed at 200 ml/minute. An Emboli Detection and Classification Quantifier (EDAC™) was used to gather the embolic data.

**Results:** Total flushed filters had an average total emboli count of 25.375 ± 27.135, and an average time to clear of 133.167 ± 151.512s. Total non-flushed filters had an average total emboli count of 162.875 ± 157.114, and an average time to clear of 348.167 ± 143.705s. Flushed filters had a significantly lower total emboli count with $p \leq 0.0002$ and a significantly lower time to clear with $p \leq 0.00001$ than the non-flushed filters.

**Conclusions:** A significant difference was found in total embolic count and time to clear between flushed and non-flushed filters. This study shows that fewer emboli and a decrease in embolic clearance time correlate with carbon dioxide flushing of the ALF.

**DESIGNING A BYPASS SIMULATOR—STACY LYNN VEACH**

Stacy Lynn Veach

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**Purpose:** With the advances made in the medical field in the last few decades, simulator training has gained popularity. This is certainly true as it relates to the field of perfusion. The perfusionist is required to bring to the operating room the requisite skills, dexterity and a proficiency gained through education and training. There have, however, been very few devices that have been put on the market to address the training needs for this field of medicine. Of the devices that have been on the market, none of them seem to share any widespread use. The simulators that are available come with a high price tag that makes them cost-prohibitive to many programs across the country. The goal of this study was to develop a simulator that could be utilized as a standard training tool for use in teaching perfusion students without the need for extensive expenditure of funds.

**Methods:** The Materials used in the simulator were developed to provide the students with the opportunity to practice perfusion related maneuvers such as initiation, maintenance and termination of cardiopulmonary bypass. The circuit, which is non-sterile and reusable, also allows for the troubleshooting of emergency situations that the perfusionist may face on a daily basis. The simulator was designed to be an inexpensive and reproducible alternative that can be modified according to different institutions equipment and protocols. The method for this simulation required senior students to complete one cycle of initiation and termination on the simulator.

**Results:** The results were based on detailed questionnaires that were filled out by each student. The information was then collected and analyzed.

**Conclusions:** The data showed that the system could be used as a valuable device in the training of perfusion students prior to labs and clinical rotations.

**HEPARIN-INDUCED THROMBOCYTOPENIA: A NEW LINE OF PROTOCOLS—JESSI LYNN GRIFFITH**

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**Purpose:** With Heparin being the most popular anticoagulant, medical professionals must be aware of potential complications, the most severe being heparin-induced thrombocytopenia (HIT). HIT is an immune-mediated allergic reaction to the heparin-PF4 complex. It is characterized by a platelet count of less than 150,000 thrombocytes/mcL, or a 30–50% drop from baseline platelet counts, which can occur within 5–14 days after Heparin exposure. The consequences of HIT are largely preventable with early recognition and proper treatment.

**Methods:** An alternative guideline for a HIT patient follows the use of a thrombin inhibitor, Bivalirudin (Angiomax). Bivalirudin has a shorter half life than other thrombin inhibitors and a reduced need for normal renal function for complete drug elimination. Specific HIT CPB guidelines must include a non-coated pump circuit and the use of Albumin, which aids as a surface coating in the CPB circuit to help avoid cryoprecipitate formation on the non-coated oxygenator. Additionally, stagnation in the reservoir and cardioplegia system should be avoided by maintaining constant recirculation and continuous ACT monitoring. Furthermore, hemoconcentration should be avoided due to the possibility of pulling off Bivalirudin in the effluent.

**Conclusion:** Awareness of HIT and the ability to distinguish it from other causes of platelet count reduction are key ways to avoiding serious consequences. If untreated, 30–50% of these patients with thrombocytopenia progress to thrombosis. Perfusionists must be aware of HIT patient’s and have a set protocol at their institution.
IS A “MINI” PRIME SYSTEM NECESSARY WHEN USING RETROGRADE AUTOLOGOUS PRIMING (RAP)?—WILLIAM DEBOIS

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Introduction: Over the last ten years perfusionists have witnessed tremendous changes in the cardiopulmonary bypass (CPB) circuit which have enabled bloodless cardiac surgery. Many techniques are available to help reduce/conserve blood product usage during surgery requiring cardiopulmonary bypass. Using conventional components low-prime (LP) circuitry and RAP offer modalities which were unavailable a short time ago. Newer “mini” circuits claim to further enhance blood conservation.

Methods: Medical literature was reviewed regarding blood conservation techniques related to CPB prime reduction to evaluate the advantages of low-prime and RAP versus mini circuitry. During mid-1990s techniques for prime reduction were first investigated. The techniques included low-prime circuitry and retrograde autologous priming. These two techniques proved to be simple to perform and significantly reduced blood product usage. Newer mini-circuit perfusion systems became available around the year 2000. These systems offered further reductions in static prime volume.

Results: Several investigators have since shown that lowering the circuit prime volume reduces blood transfusion. Using all conventional componentry, our current low-prime system has a prime of 900 milliliters. The prime volume is further reduced to a negligible level with RAP. Newer mini systems are available, but have been associated with increased risk of air embolism.

Conclusions: There are several disadvantages to reservoir-less mini circuits. Mini circuits are more costly, and most importantly have been shown to increase the risk of air embolism. Low prime circuitry and RAP are synergistic therapies that reduce the patient’s risk of blood transfusion. As we learn more about the harmful effects of unnecessary blood transfusion, perfusionists should use a combination of RAP and a low prime circuit.

PERFUSION STANDARDS OF REPORTING TRIALS (PERFSORT)—MICHAEL POULLIS

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Purpose: The goal of science is the generation of new knowledge through a process that enables its reproducibility. Wide variability exists in the level of specificity provided in journal articles concerning the practice of cardiopulmonary bypass. Without this detail, the science of our profession, and its translation into practice, will be impeded.

Methods: We propose the development a framework for: (1) improving the standard for the reporting of the practice of perfusion in the peer-reviewed literature, and (2) repository for collating data from studies for meta-analyses.

Tier 1. Produce a Perfusion Standards of Reporting Trials (PERFSORT) statement.

Tier 2. Develop a system that records perfusion-related data for all scientific publications concerning the practice of perfusion, irrespective of the peer-reviewed journal

Results: We present a checklist, of variables that are known to influence cardiopulmonary bypass related morbidity and outcome, and a simple electronic submission process for core perfusion related data. Data would be de-identified. A PERFSORT compliance is automatically generated.
Conclusions: This approach has a number of potential advantages:

1. Generation of standards for reporting aspects of perfusion will help improve the quality and relevance of new science concerning the practice of perfusion—PERFSORT.
2. Allow relevant, perfusion related, information to be available to the community of professionals wishing to improve the science of perfusion and its translation into practice.
3. An Internet link from the original scientific article to the original perfusion data should facilitate the synthesis of literature for the generation of practice guidelines.

IN VITRO COMPARISON OF THE NEW IN-LINE MONITOR BMU 40 VS. A CONVENTIONAL LABORATORY ANALYZER—OLIVER GROSSE

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Purpose: Reliable information about different blood parameters is essential maintaining haemodynamics, perfusion and gas exchange during CPB. For this purpose a precise and continuous monitoring is needed. The objective of this in vitro study was to compare a novel continuous in-line blood parameter monitoring system (CIBPMS) vs. a reference laboratory analyzer.

Methods: The study was conducted as an in vitro prospective experimental study during a CPB simulation. The reliability of BMU 40 was tested in monitoring the pO$_2$, SO$_2$, Hct and Hb under physiological and extreme conditions with regards to temperature, oxygenation and blood concentration. Four different tests were performed and conducted with five sensors each. Correlation analyses and Bland-Altman analyses were performed.

Results: A total of 350 measurement points were compared. All monitored values of blood parameters correlated highly with laboratory values (all r values > 0.90). Test 1: Biases of pO$_2$ (act) vary from −3.24 (±6.86) up to 6.0 (±17.89). The biases of pO$_2$ (37°C) ranged from −3.08 (±5.53) up to 68.8 (±67.82). Test 2: The biases (SD) for Hct ranged from −0.35 (±0.79) up to 2.35 (±0.91). The biases (SD) for SO$_2$ vary from −0.45 (±0.86) up to 0.85 (±1.01). Test 3: The biases (SD) of Hct ranged from −0.67 (±1.49) up to −1.00 (±1.84). Test 4: The biases (SD) for SO$_2$ vary from −0.36 (±1.60) up to 0.48 (±0.9).

Conclusions: The BMU 40™ is a reliable device in measuring the pO$_2$, SO$_2$, Hct and Hb under normal physiological and extreme conditions with regards to temperature, oxygenation and blood concentration in simulation of CPB. The algorithm to calculate pO2 (37°) under hypothermic conditions need to be adjusted.*

*In the meantime a new software version of the BMU 40™ has been developed. The algorithm to calculate pO$_2$ (37°) under hypothermic conditions has been improved and the miscalculation eliminated.

COMPARISON OF OPEN AND CLOSED EXTRACORPOREAL CIRCUITS: IMPACT ON AIR HANDLING, INFLAMMATION, HEMODILUTION, MYOCARDIAL PROTECTION—SERDAR GUNAYDIN

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Purpose: We examined intraoperative microembolic signals (GME), inflammatory response, hemolysis, perioperative regional cerebral oxygen saturation (rSO$_2$) and myocardial protection in Euroscore 6+ patients undergoing coronary revascularization (CABG) with open or closed extracorporeal circuits (ECC).

Methods: Over a one-year period, 60 patients were prospectively randomized to one of the two perfusion protocols (N = 30): Group 1: Closed (Vision-GBS-HF™, Gish, CA) ECC with soft-shell venous reservoir (SVR11S-GBS™); Group 2: Conventional open ECC (Control) (Vision-GBS-HF™). Serum lactate, CKMB, free hemoglobin, interleukin-6 (IL-6), C3a, TNF-alpha, D-dimer and CRP levels were measured. Blood samples were collected at T1: Following induction of anesthesia; T2: 15 min after cardiopulmonary bypass (CPB); T3: Before cessation of CPB; T4: 15 min after protamine reversal and T5: Intensive Care Unit. CD11b/CD18 expressions were determined by flow cytometry. rSO2 was monitored by cerebral oximetry (Somanetics) and GME activity at three locations by EDAC (Luna Innovations) simultaneously.

Results: Only statistically significant parameters ($p < 0.05$ vs. control) in groups are demonstrated in the Table. GME detected at T3 (emboli.sec-1) through arterial inflow was 29.2 ± 7 for closed and 20.65 ± 8 for conventional ECC.

Conclusions: Closed ECC provided a comfort and safety level similar to conventional control via satisfactory air handling, attenuated inflammatory response and hemodilution with a better clinical outcome in patients undergoing high risk CABG.

Table 1.

<table>
<thead>
<tr>
<th></th>
<th>CKMB (ng/mL)</th>
<th>IL-6 (pg/mL)</th>
<th>Atrial Fibrillation (%)</th>
<th>CD11b/CD18 (%) at T3</th>
<th>rSO$_2$ (%) at T3</th>
<th>Postop Bleeding (mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closed</td>
<td>8.9 ± 3</td>
<td>T3, T4</td>
<td>30 (9 pts)</td>
<td>16.5 ± 3</td>
<td>71 ± 10</td>
<td>780 ± 70</td>
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<tr>
<td>Control</td>
<td>14.1 ± 5</td>
<td>T3, T4</td>
<td>54 (16 pts)</td>
<td>27.8 ± 7</td>
<td>60.8 ± 11</td>
<td>920 ± 75</td>
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PRESSURE AND OXYGEN DEBT ON BYPASS? POTENTIAL QUALITY MARKERS OF PERFUSION, A CONCEPT—MICHAEL POULLIS

Michael Poullis and Ian Johnson
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Purpose: To develop a marker of quality of perfusion pressure and oxygen delivery during cardiopulmonary bypass (CPB), to complement existing markers of perfusion quality – rewarming rate, maximum temperature on rewarming, lowest haematocrit, and blood glucose.

Methods: Using the electronic acquisition of blood pressure on bypass (YOCAB system) the percentage of time perfusion pressure was below 40 mmHg, average deviance, beta distribution, confidence interval, median, mode, standard deviation, variance, and current and cumulative oxygen debt were calculated.

Results: Numerous different readouts of achievement of maintenance of constant pressure on bypass is now easily achievable with perfusion electronic data management systems. A composite score involving non pressure readouts (eg, oxygen delivery, arterial and venous saturations, and flow rates) may need to be integrated into any perfusion pressure quality marker. The DeMeester score equivalent in oesophageal surgery, with regard to blood pressure or oxygen debt, may potentially aid monitoring perfusion quality during CPB.

Conclusions: Assessment of adequacy of constant perfusion pressure and oxygen delivery may allow the scientific evaluation of pressure and oxygen delivery on bypass for patients to be accurately compared. Currently in studies involving CPB, blood pressure targets are stated with no quantitative assessment of adequacy of achievement of these targets. Electronic data monitoring during cardiopulmonary bypass when correlated with clinical outcome may help to provide a marker of quality of perfusion pressure during CPB, and may indeed allow patient specific perfusion pressure strategies to be developed.

THE EFFICACY OF CO₂ FLUSHING ON DEBUBBLE MANAGEMENT OF ARTERIAL LINE FILTERS—ANGELA M. ASK

Angela M. Ask, Christine Fleissner, and David W. Holt
University of Nebraska Medical Center, Omaha, NE

Purpose: The single most important component in the cardiopulmonary bypass (CPB) circuit protecting the patient from macro and micro gaseous emboli is arguably the arterial line filter (ALF). Gaseous microemboli delivered during cardiopulmonary bypass can cause postoperative neurologic events. Proper CO₂ flushing of the arterial line filter before priming may eliminate the delivery of gaseous microemboli air to the patient.

Methods: For this study, a brief survey was created and implemented to learn the basic techniques CO₂ flushing techniques used in common perfusion practice. From the survey data, a CO₂ flushing technique was created for this prospective randomized study. Fifty ALF were divided evenly into a control (non-flushed) and test (flushed) group to determine the efficiency of debubbling in common perfusion technique.

Results: There was a significant difference (p < 0.0001) found in both the efficiency and efficacy between the control and test group. The practice of CO₂ flushing the ALF prior to priming was found to be a worthwhile effort and even in emergent situations. It is assumed that an improvement in bubble management is likely to be beneficial for the patient.

Conclusions: Additional studies on CO₂ flushing the ALF and other CPB circuit components will help to optimize the protocol necessary for further improvement of perfusion standards of practice.

COMPREHENSIVE ASSESSMENT OF AN OXYGENATOR WITH INTEGRAL ARTERIAL LINE FILTER (ALF) IN THE PEDIATRIC POPULATION—THOMAS JOHN PRESTON

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Purpose: The use of an arterial line filter (ALF) within the pediatric cardiopulmonary bypass (CPB) circuit is not a new concept. It has however always presented the perfusionist with a circuit component that while valuable, increased prime volume. The purpose of this study was to evaluate the change in prime volume and emboli load between a conventional oxygenator with a separate ALF component and a new oxygenator with integral ALF.

Methods: Comparative evaluation of the Terumo Capiox® RX15 (Terumo Cardiovascular, Ann Arbor, MI) utilized in conjunction with the Terumo Capiox® AF125X ALF (Terumo Cardiovascular, Ann Arbor, MI) versus the Terumo Capiox® FX15 oxygenator with integral ALF. The above circuit components, in conjunction with the LUNA EDAC® (emboli detection and classification) Quantifier (LUNA Innovations, Blacksburg, VA) were evaluated at various locations within each patient’s CPB circuit to establish and quantify the presence and volume of gaseous emboli during all phases of cardiopulmonary bypass.

Results: When compared to a more conventional CPB circuit the Capiox® FX15 primes more easily as it does not require the use of a carbon dioxide prime while still providing a 37 micron filter.
**Conclusions:** The use of the new Capiox® FX15 simplifies the arterial limb of the pediatric CPB circuit. Removal of the separate ALF led to the removal of several, now unnecessary, arterial connectors and additional tubing (arterial line filter bypass). The removal of these components led to an overall reduction in prime volume and decreased hemodilutional. The new oxygenator and ALF provided a safe, simplified pediatric CPB circuit.

**THE EFFICACY OF TRANEXAMIC ACID VERSUS APROTININ TO REDUCE BLOOD LOSS IN PEDIATRIC CARDIAC SURGERY—ANDREW J PARKER**

Andrew J. Parker and Joseph J. Sistino  
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**Purpose:** Significant perioperative and postoperative bleeding are of major concern for children undergoing cardiac surgery requiring cardiopulmonary bypass, contributing to both morbidity and mortality. Tranexamic acid and aprotinin are two agents that have been used to decrease blood loss and allogenic blood transfusions during cardiac surgery; however, it remains inconclusive if one is superior in pediatric cardiac surgery. We investigated the effects of both drugs used during cardiac surgery in patients requiring cardiopulmonary bypass.

**Methods:** A retrospective analysis of 200 cardiac surgery patients weighing less than 8 kilograms was conducted. Variables related to the haemostatic function of the patients were statistically analyzed to determine the impartiality of the two treatment groups.

**Results:** The efficacy along with the safety of each drug was analyzed based on data obtained from a chart and database review. Total blood loss and transfused blood products were evaluated in each treatment group along with outcomes including morbidity and mortality.

**MITRAL VALVE RUPTURE AND AVULSED TRICUSPID VALVE IN PEDIATRIC PATIENT FOLLOWING A MOTOR VEHICLE ACCIDENT—ASHLEY B HODGE**

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This is a case report of a rare pediatric case involving the mitral and tricuspid valves due to blunt trauma to the chest. An 8-year-old boy sustained numerous injuries following a motor vehicle accident (MVA). Preoperative echocardiogram revealed avulsion of the postero-medial papillary muscle of the mitral valve and severely prolapsing anterior tricuspid valve leaflet. In addition, he was noted to have a defect in the interventricular septum on the left side with significant hematoma of the septal muscle. Due to worsening pulmonary edema, he was brought in for emergency surgery.

Review of the literature revealed that this type of injury is rarely reported in the pediatric population due to its high mortality rate. Blunt chest trauma in the pediatric population has a mortality rate of 14%, compared to 2.8% mortality rate for general pediatric blunt trauma (1). Of all documented pediatric trauma cases, MVA, falls and auto pedestrian crashes contribute to trauma being the leading cause of death among the pediatric population (2).

**CLINICAL EVALUATION OF THE CAPIOX FX05 (BABY FX) HOLLOW FIBER OXYGENATOR—JOSEPH DEPTULA**

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*Children’s Hospital, Omaha, NE*

**Purpose:** As smaller patients present themselves for Cardiopulmonary Bypass (CPB) for the correction of congenital heart lesions, the trend in the pediatric community has been the reduction of prime utilizing smaller tubing sizes, smaller surface area components, and devices with decreased static priming volumes. Many perfusion product manufacturers have developed new lines of “Neonatal” CPB products, specifically addressing these needs. Although these are lower prime products with smaller connectors excepting smaller tubing, these trends tend to make for a product with flow restrictions and lacking in reserve capacity. A newly developed neonatal oxygenator, the Terumo Capiox FX05 (Baby FX) has recently been introduced to the market. This oxygenator is an improvement upon the Capiox RX05, incorporating a nylon sleeve around the fiber bundle, or an “arterial line filter” (ALF), alleviating the need for a stand alone ALF. Instead of following the trend in industry of further prime reduction, decreasing the surface area of the oxygenator, reducing the maximum flow rate through the device, they have incorporated a filtration technique which reduces the overall CPB circuit prime and surface area contact with extracorporealized blood while maintaining the ratings of their already low prime system. The FX05 oxygenator has a blood flow range of 0.1–1500 cc/min, a 37 micron filter and a static priming volume of 43 cc.

**Methods:** The present study tests this oxygenator for gas transfer, blood path resistance, and blood handling characteristics in a standardized setting during clinical application and compares this data to that published in the manufacturer’s Directions for Use. The study evaluated the oxygenators gas exchange capabilities, pressure drop across the membrane and integrated ALF, and blood flow trauma measured by serum lactate and free hemoglobin in the urine and hemofiltrate.
Conclusions: The Capiox FX05 offers good gas exchange capabilities, a low pressure drop, and low blood flow trauma during normal cardiopulmonary bypass parameters by incorporating an integrated arterial line filter, reducing the overall circuit prime and surface while maintaining a wider range of blood flow compared to similar neonatal oxygenators currently marketed.

EJECTION FRACTION COMPARISON IN PATIENTS UNDER PERCUTANEOUS TRASLUMINAL CORONARY ANGIOPLASTY BEFORE AND AFTER REHABILITATION—AMAL TARJAN
Amal Tarjan, Amal Tarjan, and Behzad Yavari
Shariati Hospital, Isfahan, Isfahan

Purpose: Current guidelines recommending cardiac rehabilitation (CR) after coronary revascularization are largely based on early studies that evaluated only a subset of population and failed to assess the impact of CR on the patient’s perception of their functional status. The main objective of this study was to evaluate the impact of CR in a diverse contemporary population on patient functional outcomes (like EF, BMI, METS).

Method: Sixty-eight patients who were referred by their physicians for CR after PTCA, entered the study. Patients were randomly divided into two groups. Control group consisted of 33 patients aged 57.1/11 ± 11/59. Case group aged 56/71 ± 8/76 included 35 patients underwent CR after PTCA. Echocardiography and exercise test were performed in all patients before and after rehabilitation program. Rehabilitation was performed according to 2007/ACA/AHA/SCAI cardiac rehabilitation guideline. Ejection fraction (EF) was measured in two groups. Data were analyzed using SPSS 14.

Result: The mean EF in case group before CR was 55/29 ± 12/28 and after CR was 57/9 ± 10/62. Thus, EF was significantly increased in case group (p < 0.05) the mean of EF in control group at the first of program was 59/67 ± 9/41 and at the end of program was 59/85 ± 8/91. Thus, EF changes were not meaningful in control group. In our study EF increased in case group rather than control group (p < 0.05).

Conclusions: The results of our study revealed that EF was improved after PTCA using CR based on 2007/ACA/AHA/SCAI cardiac rehabilitation guideline.

A NOVEL TECHNIQUE FOR IMPROVEMENT OF INTRAOPERATIVE BLOOD MANAGEMENT: SUBSTITUTION OF HEMOCONCENTRATION FOR CELL CENTRIFUGATION—ELIZABETH R WORRALL
Elizabeth R Worrall, David W. Holt, and Angela Ask
University of Nebraska Medical Center, Omaha, NE

In the United States, 10–20% of all transfusions are due to cardiovascular surgery despite the research showing that transfusions are independently linked to increased short and long-term morbidity and mortality (Samolyk, Beckmann, & Bissinger, 2005). With a growing shortage of available donated blood products, it would seem logical that the use of autologous blood should be maximized. Arguably, this will help with the shortage of blood as well as decrease the chance of disease transmission and immunosuppression. Presently, intraoperative autotransfusion is generally accomplished with the use of a cell centrifugation. Centrifugation techniques collect blood from the surgical field, processes it, and washes it with normal saline. This finished blood product is packed red blood cells suspended in normal saline and does not contain therapeutic levels of platelets, plasma proteins, or coagulation factors that are critical for the maintenance of hemostasis, fluid balance, and quality homeostasis. A hemoconcentrator removes excess fluids from the blood while retaining all of the platelets, plasma proteins, and coagulation factors. A device that could integrate the benefits of intraoperative collection and processing with a hemoconcentrator to autotransfuse without removing essential elements of blood would benefit the patient in all applications of surgery where currently traditional autotransfusion methods are used.

SELF-PRIMING HEMODYNAMIC RESERVOIR AND INLINE FLOW METER FOR A CARDIOPULMONARY BYPASS SIMULATION—DAVID J. RAASCH
David J. Raasch, Jon W. Austin, and Dr. Richard Tallman
Midwestern University, Glendale, AZ

Purpose: Simulator exercises are used at Midwestern University to augment academic and laboratory training toward consolidating particular skills, increasing situation awareness, and preparing the student for practice within the team environment of an operating room. This study focuses on enhancing cardiopulmonary bypass simulation by developing a self-priming hemodynamic reservoir and installing an inline flow meter.

Methods: A typical cardiopulmonary bypass adult perfusion circuit was constructed using roller pumps and primed with two liters of water. A soft-sided reservoir bag was mounted onto an inclined platform. A one-liter soft-sided bag was placed above the reservoir, providing an overflow reservoir. The priming line extended to the head of the mannequin. The arterial, venous, and vent lines extended through the open chest. The primed perfusion circuit was connected to ports on the filled reservoir bag. The arterial pump output was adjusted to flow rates ranging from one to seven liters per minute, with a complete interruption (to zero flow)
between each test run. Also, an inline flow meter was added to the bypass circuit and an analog to digital converter board was used to pass flow data into the simulation program.

Results: The hemodynamic reservoir bag was self-priming and did not require any attention between pump-runs. Flow data was processed and displayed by the simulation program.

Conclusions: The concept of using an inclined hemodynamic reservoir bag was proven to be self-priming and functioned without problems over a wide range of flows tested. By including a reservoir with the mannequin, plus processing and displaying real-time flow data, a higher fidelity and more realistic simulation experience is created.

MULTIPLE PROCEDURE CASES TRENDING INTO THE FUTURE—CHRISTINA LYNN SHOEMAKER

Christina Lynn Shoemaker
The Ohio State University, Columbus, OH

Purpose: A patient presenting to the operating room for a MAZE, ASD closure, Bentall procedure, mitral valve replacement, and a single vessel CABG in one operation challenges the skills, knowledge, and endurance of the surgical team. These complex procedures intensify the need for effective, accurate, and overall need for best practices.

Methods: The patient is a 56 year old male at 278 pounds and 187 cm (BSA 2.6 m2). He has a history of Idiopathic Hypertrophic Subaortic Stenosis that has been relatively asymptomatic until he was recently admitted into the hospital with symptoms of acute coronary syndrome and atrial fibrillation. Femoral cannulation was used with a 19 French cannula for arterial, while a Dual stage 29/37 French cannula was used for venous. Perfusion equipment included a Biomedicus centrifugal pump with use of vacuum assisted venous drainage at −60 mmHg.

Discussion: Extensive and challenging cases similar to this example are becoming more common. According to a study done by Dirck Rilla, Director of Education and Quality Improvement at Hospital Clinical Services Group, complex procedures in combination with valve procedures are trending steadily upward into the future. The study focuses from the years 2003 to 2008 and has shown an 11% decrease in isolated CABG procedures. Even more remarkably, these complex and valve surgeries have steadily increased by 11%. In conclusion, perfusionists can expect to see patients with higher mortality and morbidity rates, in addition to longer and possibly more difficult pump runs.

THE EFFECTS OF APROTININ ON RENAL FUNCTION OF A WIDE VARIETY OF PATIENTS UNDERGOING CPB—ISAAC RAMESH KUMAR CHINAPPAN

1Isaac Ramesh Kumar Chinnappan and 2Curtis Eldridge
1Rush University, Chicago, IL; John H Stroger Jr. Hospital of Cook County, Chicago, IL; and 2Rainbow Babies and Children’s Hospital, Cleveland, OH

Introduction: Many studies have demonstrated the significance of aprotinin in reducing postoperative bleeding and transfusion requirements in patients undergoing cardiopulmonary bypass (CPB). The routine use of aprotinin has been limited because of concern that aprotinin may induce renal dysfunction. Impairment of renal function and acute postoperative renal failure are common complications of cardiac surgery involving CPB. The objective of this study is to assess the effect of aprotinin on renal function of a wide variety of patients who received aprotinin compared to patients who didn’t receive aprotinin during CPB.

Methods: Retrospective case control research design has been used to assess the effect of aprotinin on the renal function of a wide variety of patients undergoing cardiac surgery with CPB. Blood Urea Nitrogen (preBUN and postBUN), Serum Creatinine (preScr and postScr) and Creatinine Clearance (preCrCl and postCrCl) were measured before and after CPB in both aprotinin and non-aprotinin groups. The pre and post Creatinine Clearance for both groups were calculated by Cockcroft-Gault formula. The study was further extended to assess the effect of aprotinin and CPB on the renal function of males and females; patients with or without hypertension; patients with or without ACE inhibitors in both groups. The renal function was assessed on the basis of the
difference (pre and post) in the mean value of these variables and also its clinical and statistical significance. An alpha level of 0.05 was considered for statistical significance.

**Conclusions:** In the aprotinin group, there was no significant effect of aprotinin on the renal function of a wide variety of patients. In the non-aprotinin group, there was no significant effect of CPB on the renal function of a wide variety of patients. Therefore we conclude that there was no evidence for a statistically significant effect of aprotinin or CPB and renal dysfunction.

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**MEASUREMENT OF OXYGEN IN HUMAN BLOOD FOLLOWING INFUSION OF DILUTE HYDROGEN PEROXIDE—THOMAS STEFFENS**

Thomas Steffens and Matthew O’Brien

*University of Wisconsin Hospital and Clinics, Madison, WI*

**Purpose:** Raising PaO₂ is a critical endeavor in patients with lung disease or injury. Options are limited to increasing inspired oxygen concentrations, increasing gas pressure or extracorporeal membrane oxygenation (ECMO). Hydrogen peroxide (H₂O₂) reacts with catalase in blood yielding water and oxygen. Investigation using various concentrations of hydrogen peroxide infused directly into the circulatory system has been performed; however an accurate assessment of change in PO₂ using inline monitoring has not. The purpose of this study was to ascertain if infused dilutions of H₂O₂ in circulating RBC’s will result in an increase in PO₂ as measured by an in-line monitor and PO₂ analysis and what is the lowest concentration that yields an effective increase in PO₂.

**Methods:** An ECMO circuit and calibrated Terumo CDI 500™ was used to monitor PO₂ following infusion of various concentrations of H₂O₂ into RBCs.

**Statistical analysis:** Correlation coefficient of PO₂ lab result and inline monitor value.

**Trial 1:** With approximately 200 mL of RBC’s circulating at 300 mL/min, circuit PO₂ was equilibrated and CDI calibrated by laboratory analysis. Slow injection of 0.09% H₂O₂ was added to the circuit over 2 minutes.

**Trial 2:** A 20 ml/hr controlled infusion of 0.01, 0.02, and 0.04% of H₂O₂ circulated for over 85 minutes.

**Results:**

**Trial 1:** PO₂ increased from 123 to over 700 mmHg within 3 minutes.

**Trial 2:** With H₂O₂ concentrations of 0.01, 0.02, and 0.04%, PO₂ increased from 96 to 183, 102 to 212 and 104 to 400 mmHg respectively over 86–89 minutes.

PO₂ increases in a linear fashion with a positive correlation coefficient of 1 between the CDI monitor and PO₂ laboratory results.

**Conclusions:** PO₂ increased following infusion of dilute concentrations of H₂O₂. Concentrations as low as 0.01% yielded an increase in PO₂ when infused at 20 ml/hr. An ECMO system with an inline blood gas monitor is a reliable model for future testing of reactive oxygenation.

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**EXTRACORPOREAL MEMBRANE OXYGENATION SUPPORT FOR ACUTE REJECTION THREE YEARS POST CARDIAC RETRANSPANTATION—SARAH MARIE ENDIQUE**

Sarah Marie Endique, Kirti P. Patel, and Terry N. Crane

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**Purpose:** Recipient survival post-cardiac transplantation and retransplantation are dependent on numerous factors including gender, age, comorbidities, and time between transplantation. We report a case of a two-time orthotopic heart transplant recipient, who presented three years post retransplantation with cholecystitis.

**Methods:** During his hospital stay the patient developed acute respiratory failure and pulseless electrical activity (PEA) necessitating cardiopulmonary resuscitation and eventual extracorporeal membrane oxygenation (ECMO) support.

**Results:** After 446 hours of ECMO support, he was weaned to an intra-aortic balloon pump and milrinone infusion. He was discharged home on the 44th day. The course and methodology of his treatment during this hospital stay are discussed.

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**ESTABLISHING HEMOFILTRATION AS A SUBSTITUTE FOR CENTRIFUGATION IN PERIOPERATIVE BLOOD MANAGEMENT TECHNIQUES—JOSEPH LEE**

Joseph Lee, David Holt, and Angela Ask

*University of Nebraska Medical Center Clinical Perfusion Education, Omaha, NE*

**Purpose:** Due to the risks associated with allogenic blood products, there is increased demand for salvaging blood during surgical procedures. Autotransfusion using centrifugation is a common method for collecting blood shed during surgery for reinfusion, but it has disadvantages. The highest priority in blood salvage is preserving red blood cells (RBCs) for oxygen transportation. Centrifugation adequately preserves RBCs, but most of the plasma fraction and other proteins that may be useful in maintaining hemostasis and preventing coagulopathies postoperatively are lost during processing. Hemofiltration has been proposed as a blood salvage method, which may better preserve the plasma fraction and other proteins. In order for hemofiltration to be considered a viable alternative to centrifugation, it must adequately preserve RBCs.
Methods: In this study, samples of bovine blood were diluted with saline and processed through a Cell Saver 5 and a hemofiltration blood salvage device (HBSD) that was developed for this study. The hematocrit of the blood was analyzed before and after processing in order to compare the percentage of RBCs recovered using both methods of cell salvage. An unpaired t-test was used to determine if there was a statistical difference in red blood cell recovery using the two methods with a p-value set at 0.05.

Results: In two trials conducted using the HBSD, 87.4% and 81% of the RBCs were recovered. In two trials conducted using the Cell Saver 5, 77.7% and 78.8% of the red blood cells were recovered. No statistical difference in RBC recovery between the two devices was observed.

Conclusions: Cell processing using a hemofiltration device may adequately preserve RBCs while preserving other blood components, which may aid in hemostasis and preventing delays in hemostasis postoperatively.

ADDITION OF DISTILLED WATER TO PORCINE BLOOD AND ITS AFFECTS ON PLASMA FREE HEMOglobin—LINDSAY BERRIOS

Stephanie Ayoub, Lindsay Berrios, and Jon Austin

Midwestern University, Glendale, AZ

Purpose: During cardiopulmonary bypass (CPB), the occurrence of a water to blood leak may be fatal. Water to blood leaks have been reported in the medical literature. When water mixes with blood, it causes lyses of red blood cells, thus allowing hemoglobin to become free in the plasma (plasma free hemoglobin, PFH). PFH levels above 50–200 mg/dL can dangerously lower the oxygen carrying capacity of the patient’s blood. The aim of this study was to determine the amount of PFH resulting from incremental additions of distilled water to porcine blood.

Method: A pilot study was done using test tubes and porcine blood to determine the desired increments of water to be added to the circuit. A miniature extracorporeal circuit was then constructed. Two trials were conducted by adding distilled water to porcine blood in the test circuit. Aliquots of blood were drawn, then centrifuged and the plasma was obtained. The PFH levels were determined using the Hemocue®.

Results: The results show a strong correlation between PFH and the addition of distilled water (p-value < .001). A model was then developed to compare the results of the study with a hypothetical situation, correlating the experimental values to those of a human cardiac surgical patient.

Conclusions: All manufacturers’ instructions for use recommend testing the blood heat exchanger prior to use. Several methods for testing are described. This study presents a model to determine the amount of leakage needed to cause irreversible blood damage based on individual patients.

AGGREGATED PLATELETS (AP) CAUSE RELEASE OF ENDOTHELIAL CELLS (EC) IN CIRCULATION—DIANA CAROLINA BONILLA

Diana Carolina Bonilla1 and Dr. Sai Sudhakar2

1Ohio State University, Columbus, OH; and 2Division of Cardiothoracic Surgery Ross Heart Hospital, Columbus, OH

Purpose: Aggregated Platelets (AP) contribute to heart ischemia by simple mechanical obstruction of the coronary vasculature. We sought to investigate whether AP could disrupt the endothelium and contribute to the presence of circulating EC and EC derived particles (ECDP).

Methods: Bovine aortic EC were cultured in 6 well dishes to confluence, trypsinized and grown in capillary glass tubes. The tubes were connected to a flow pump with continuously circulating medium, with inlet and outlet valves on either side of tubes. Pump tubing was of two different diameters to allow for different flows. Polystyrene beads that mimic platelet aggregates (90 µ) or AP suspended in medium were injected into inlet and medium was collected at the outlet immediately, at 30 seconds, 1 and 5 minutes, following initiation of circulation. Collected medium was analyzed for presence of microspheres, EC and ECDP. Medium was cultured for 2 days to detect EC colonies. In another set of experiments, EC were pre-labeled with 0.5µ fluorescent beads before culturing in tubes.

Results: Neither intact EC nor ECDP were observed in samples collected following injection of medium alone. Injection of microspheres or AP led to dislodgement of EC and ECDP. Growth of dislodged EC was obvious when circulating medium contained 90 µm beads or AP. Figure 1 demonstrates dislodged fluorescent labeled EC. High flows (85 ml/minute) caused an increased EC detachment compared to low flows (20 ml/min).

Conclusions: Our results demonstrate that AP damage and disrupt the endothelium. Such direct mechanical dislodgement could contribute to the presence of circulating EC and ECDP in acute exacerbation of congestive heart failure. The denuded endothelium could also initiate additional thrombotic events.
IN VITRO EXPOSURE OF BLOOD TO LAPAROTOMY SPONGE AND RESULTANT PLASMA FREE HEMOGLOBIN LEVELS—JENNIFER L WEINKAUF

Jennifer L. Weinkauf, Tya Wilkie, and Jon W. Austin
Midwestern University, Glendale, AZ

Introduction: Blood aspirated from the pericardial sac and reinfused into the patient by the cardiotomy suction system has often been associated with systemic inflammation, coagulopathies, and hemolysis. Others investigators have reported adverse effects of blood aspirated to the cardiotomy suction system when exposed to laparotomy sponges. It was hypothesized that hemolysis would occur when blood was exposed to a laparotomy sponge material.

Methods: Systemically heparinized porcine blood was collected from two pigs into a standard CPD bag, then divided into 10 ml samples and placed into test tubes. Three test tube groups were used: a control group contained only 10 ml of porcine blood, a second group contained 10 ml of porcine blood and a 3 cm square piece of laparotomy material, a third group contained 10 ml of porcine blood and a 3 cm square piece of polyethylene cloth obtained from a biomedical manufacturer. All samples were incubated in a water bath at 37 degree centigrade for thirty minutes. Plasma was analyzed by Hemoscope® plasma/low hemoglobin device, free hemoglobin was measured. Two complete trials were conducted.

Results: While using an analysis of variance (ANOVA) statistical test for the first and second trials, it was found that there was no significance between the concentration of plasma free hemoglobin in the control, laparotomy sponge, and polypropylene samples, with a p-value of 0.49 and 0.86 respectively.

Summary: Blood absorbed by laparotomy sponges are commonly squeezed out and reinfused back to the patient either via the cardiotomy reservoir or the Cell SaverTM.

Conclusions: The purpose of this study was to investigate the level of hemolysis associated with using laparotomy sponges and it was concluded that laparotomy sponges did not cause significant hemolysis.

BLOOD TEMPERATURE MANAGEMENT AND GME CREATION: AN IN-VITRO ANALYSIS—JOSEPH SLEEP

Joseph Sleep and Ingrid Syhre
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Purpose: Gaseous microemboli (GME) have been proven to cause neurological deficits in patients undergoing cardiopulmonary bypass. Creating an optimal perfusion system that minimizes microemboli production and has enhanced abilities to sequester entrained air during the bypass procedure has been an important focus for the perfusion profession. This study looks at the air-handling capabilities of a practical perfusion circuit and correlates blood temperatures with GME loads at certain locations within the circuit.
Methods: Utilizing a standard bypass circuit with emboli detectors and vacuum assisted venous return (VAVR), 30 mL of air was injected into the venous line at eight different temperatures. Emboli were counted distal to the arterial line filter (ALF) by the EDAQ (Emboli Detection and Classification) Quantifier.

Results: The amount of emboli detected distal to the arterial filter progressively increased as the blood temperature dropped.

Conclusion: Air introduced into the venous side of the bypass circuit will result in showers of microemboli being sent to the patient. In addition, as the patient is cooled the air handling capabilities of the circuit will diminish.

BIVALIRUDIN USE IN HEPARIN RESISTANCE PATIENT FOR EXTRACORPOREAL MEMBRANE OXYGENATION: A REVIEW AND CASE STUDY—REBECCA LYNN SELL

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Purpose: Heparin is by far the most commonly used anticoagulant for patients being placed on extracorporeal membrane oxygenation (ECMO). Alternatives to heparin have become available for patients who are resistant. This case report examines a patient sent to us from another institution for management of her hypercoagulability. It was noted from the outside institution that the patient was resistant to heparin.

Methods: The patient originally presented with menorrhagia resulting in severe anemia. The patient developed spontaneous thrombosis of the splenic, hepatic and portal veins. She aspirated developing adult respiratory distress syndrome (ARDS) with which she had progressive respiratory failure, requiring ECMO support with the use of bivalirudin.

Results and Discussion: The course and methodology of her treatment during ECMO and review of alternative anticoagulants are discussed.

BLOOD GLUCOSE MANAGEMENT ON CARDIOPULMONARY BYPASS...EVIDENCE BASED PRACTICE?—MARJORIE HARRINGTON

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Normal, healthy, metabolic blood glucose concentrations are between 65 and 145 mg/dL. During periods of stress, such as surgery, blood glucose (BG) levels increase. Hyperglycemia during cardiac surgery, and in particular during cardiopulmonary bypass (CPB), is also related to altered hormone secretion, altered glucose and insulin production and secretion, and altered metabolic function. Many studies offer knowledge about the importance of treating acute hyperglycemia in medical and post-surgical patients, however, studies demonstrating beneficial intraoperative treatment are still unavailable. A 2007 randomized trial by Gandhi and coworkers compared Intensive Insulin Treatment (IIT) with conventional treatment intra-operatively. The results showed that IIT, a recommended practice in many institutions, does not reduce perioperative death or morbidity, and in fact increased the incidence of death and stroke. In this present time, when evidence based practice is a strongly forthcoming approach to developing consistency in the care of our patients, it is obligatory to assure that accurate and proper evidence is provided. Blood glucose certainly warrants intense monitoring during surgery, but further examination is necessary to establish a goal for maintenance and an algorithm for treatment when required.

A NOVEL TECHNIQUE FOR IMPROVEMENT OF POSTOPERATIVE BLOOD MANAGEMENT: SUBSTITUTION OF HEMOCONCENTRATION FOR CELL CENTRIFUGATION—SHANNON L HINMAN

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Purpose: Cell centrifugation devices are the most often used techniques to reduce homologous blood requirements in the perioperative environment. Interest in blood conservation techniques is growing due to shortage of blood donors, risk of disease transmission and immunosuppression with transfusion of homologous blood. Several strategies used separately or together may help reduce the need for transfusion of homologous blood or blood derivatives. In contrast to traditional techniques, ultrafiltration has an advantage of removing excessive fluids from the blood while preserving plasma proteins, platelets, and coagulation factors wasted by cell centrifugation. These blood components are critical for the maintenance of hemostasis, fluid balance, and quality homeostasis in the surgical patient’s postoperative healing process.

Methods: A device that could integrate the benefits of postoperative blood collection and processing with a hemoconcentrator to autotransfuse without removing essential elements of blood is presented.

Conclusions: This device could benefit patients in all applications of surgery where currently postoperative traditional autotransfusion methods are used.