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Impact of Myocardial Protection by Single-Dose Cardioplegic Techniques on Microvascular Integrity (Endothelial Glycocalyx) in Combined Aortic Valve Surgery

Background: The endothelial glycocalyx (EG) is fundamentally involved in numerous physiologic and pathophysiologic actions in the circulatory system. The present study aimed to compare plasma levels of syndecan-1, a biomarker of EG integrity, in patients undergoing primary aortic valve replacement with CABG with either del Nido or HTK vs. crystalloid cardioplegia verified by cell culture.

Methods: This prospective study included patients undergoing combined aortic valve replacement who received different cardioplegic solutions between January 2015 and November 2018: Group 1: St. Thomas (control) (n = 98); Group 2: Del Nido (n = 92); and Group 3: HTK (n = 106). Serum syndecan-1 levels were measured by ELISA via an arterial line before (T1) and via a coronary sinus sample at the end of the cardiopulmonary bypass (CPB) (T2) with a solid-phase monoclonal BB4 antibody (higher levels implicate worse protection). A right atrial specimen is collected at the end of CPB and processed. Cells were incubated with LPS in culture medium until 24 hours. EG shedding (syndecan-1, SC-12765) until 24 hours was documented in microscopy.

Results: There was not a significant difference among the groups with respect to demographic data, type of surgery, and BMI. Early perioperative data demonstrated that all three types or cardioplegic techniques provided effective clinical outcome with similar effects on blood biochemical parameters. Serum syndecan-1 concentration is summarized in Table. Microscopic imaging confirmed quantitative results of syndecan-1 dying with significantly better confluenes in Group 3 vs. control (10,350 ± 3,000 in HTK; 13,240 ± 3,200 in del Nido; and 17,250 ± 3,200 RFU in control, p = .036).

Conclusion: Given its importance, protection of the EG is undoubtedly a promising future target in cardiac operations. Our data underline the comparative impact of single-dose protection techniques verified by cellular function. A possible association between elevated syndecan-1 levels and postoperative complications needs to be clarified in larger studies.

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Case Report: The Use of del Nido Cardioplegia during Bypass on a Pediatric Sickle Cell Patient

Introduction: Sickle cell anemia and beta thalassemia are rare red blood cell disorders that affect the heme portion of the hemoglobin molecule. When triggered, a variety of chronic and acute complications can arise that lead to detrimental outcomes for this patient population. During cardiopulmonary bypass, patients are often exposed to conditions such as hypothermia, hypoxia, hyperfusion, and acidosis, all of which can trigger sickling events.

Methods: This case report describes a 4-year-old child with known sickle cell and beta thalassemia, mitral regurgitation, and dilated cardiomyopathy, presenting to the OR for mitral valve repair. The case report describes the preoperative and intraoperative management of a patient with known sickle cell disease and the successful use of del Nido cardioplegia for myocardial protection.

Results: One day before surgery, a partial exchange transfusion occurred, reducing the hemoglobin S from 60 to 13.7%. Cardiopulmonary bypass and cross-clamp times were 98 and 63 minutes, respectively. The patient did not experience any sickling events during her hospital stay and had an uneventful postoperative course. The patient was discharged on POD 3.

Conclusion: Patients with sickle cell disease often require heightened management and monitoring to ensure sickling events are prevented. The use of cold 1:4 del Nido diverted to wall suction did not cause any negative sickling events to this patient. More research is needed to provide support for the use of cold del Nido cardioplegia delivery to this patient population. Keywords: sickle cell disease, cardiopulmonary bypass, del Nido cardioplegia, congenital heart disease.

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Comparison of Blood Conservation Techniques following Cardiac Surgery

Background: Blood transfusions are often necessary after cardiac surgery to correct coagulopathies, blood loss, or hemodilution. Complications arising from blood transfusions increase morbidity and mortality. Various blood conservation techniques are available to attenuate transfusion requirements following heart surgery. There is a lack of evidence comparing these techniques regarding
postoperative clinical/biochemical outcomes. The purpose of this research was the comparison of three different blood conservation
techniques aimed at providing a higher hemoglobin concentration, decreased blood transfusion, and enhanced biochemical/clinical
postoperative outcomes.

Methods: This was a prospective cohort study enrolling 99 patients separated into three groups based on the blood conservation
technique. Group I consisted of 35 patients undergoing online-modified ultrafiltration, Group II 30 consisted of patients undergoing
offline-modified ultrafiltration, and group III consisted of 34 patients undergoing cell washing. Specific parameters were measured
in ICU at the following time intervals: arrival, 8 hours, and 18 hours. The primary and secondary outcome variables were the level of
serum hemoglobin at 18 hours, volume of blood transfused, and ICU fluid balance.

Results: The serum levels of hemoglobin were significantly different at all three time intervals. At all intervals, the serum
hemoglobin levels of Group I were significantly higher than those of Group II. The serum hemoglobin levels of Group III were
significantly higher than those of Group II at 8 hours and 18 hours. Group II had a significantly lower transfusion volume and fluid
balance than Group I and a significantly lower weight than Groups I and III. Although the patients receiving online MUF and cell
washing had higher hemoglobin levels at 18 hours, they received more blood product transfusions and fluid over the ICU period than
those patients receiving offline MUF.

Conclusion: Pros and cons exist in each method; however data suggest that offline MUF appears to provide enhanced
biochemical/clinical outcomes during the postoperative period.

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Does Standardizing Extracorporeal Circuit Designs for Cardiopulmonary Bypass Affect Outcomes: Results from a National Perfusion Registry

Background: Standardization of clinical practice is an effective means of reducing unwanted variation and improving safety. There
are numerous extracorporeal circuit (ECC) designs in clinical practice, which both complicates the conduct of cardiopulmonary bypass
(CPB) and increases costs, especially in situations where clinicians may conduct perfusion at more than one center. The present study
was undertaken to determine the effect of standardizing ECC by incorporating new-generation devices as part of a pack enhancement
project (PEP).

Methods: The standardization of ECC in cardiac centers within a national perfusion provider was undertaken to incorporate new-
generation oxygenators and coated circuitry to both reduce variation and improve safety among clinicians. The PEP was carried out in
adult centers performing cardiac surgery across the United States. Data were analyzed for 6 months before the change and compared
with an equal time thereafter. The outcome measures were ECC circuit volumes, hematocrit (Hct) drift, and transfusion or
intraoperative red blood cells (RBC). Group differences in pre-change and post-change metrics were assessed with Welch’s ANOVA.

Results: The transition time frame took just under 12 months and included soliciting input from end users, pack redesign, and
education and implementation. Before the PEP, 91 hospitals used 47 different ECC configurations which were reduced by 61.8% to 18
packs. There were subtle but significant changes after implementing the PEP when comparing 5,702 post-change to 5,746 historical
controls. The net prime volume increased slightly, whereas RBC transfusions declined from .42 U (1.23) per procedure to .37U (1.19),
p < .05. A concurrent analysis of 50,367 patients not in the PEP conducted over the same time period showed no change in RBC
transfusions.

Conclusion: Although small changes in the net prime volume and transfusion rates were seen with the standardization of ECC,
familiarity of the circuit design afforded clinicians continuity with the practice technique.

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Epic Utilization (Past, Present, and Future)

Abstract: With the 2018 version of Epic, users now have the option to adopt the new perfusion module. The module creates an
intraoperative electronic record that is shared with anesthesia and is designed to improve intraoperative communication. The University
of Wisconsin perfusion department has used Epic for nearly 10 years and will be transitioning to the new perfusion module in the
coming year. This presentation discusses UW perfusion’s current and past utilization of Epic and the changes on the horizon.

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European Consensus Report on the Conduct of Cardiopulmonary Bypass in Adults: An Interdisciplinary Effort

Background: The implementation of evidence-based guidelines in clinical practice has great potential to improve the quality of care provided to patients on cardiopulmonary bypass. In the United States, AmSECT has by its ICEBP subcommittee provided interdisciplinary guidelines on different subjects to guide perfusionists in daily practice. In view of these efforts, the European perfusion community also joined forces with surgeons and anesthesiologists to commence work on a consensus report on the conduct of cardiopulmonary bypass in adults.

Methods: The EACTS methodology on developing clinical guidelines (1) was used as a guiding document. A task force from all three disciplines—EACTS, EACTA, and EBCP—was set up. Topics were chosen and PICOT questions were developed from these topics after which literature searches were undertaken. The available literature studies were evaluated and recommendations were proposed, ranked into classes (I, IIa, IIb, and III), and provided with a level of evidence (A, B, and C).

Results: The aforementioned effort, together with face-to-face meetings, e-mail, and telephone discussions, has led to a multitude of recommendations on different topics. The publication of the recommendations is underway and will be available in three different journals.

Conclusion: Although there is insufficient evidence on most topics regarding the conduct of CBP in adults, we believe that this document is a first step in providing evidence-based guidance to perfusionists and clinicians in Europe involved in the care for cardiovascular patients. In the future, more interdisciplinary and international collaboration will hopefully ensue to provide more guidelines with higher levels of evidence.


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Identifying Occupational Hazards in Clinical Perfusion Practice: A Mixed Methods Study

Introduction: Occupational hazards are defined as workplace risks related to a certain vocation. The Occupational Safety and Health Administration cites hospitals as one of the most hazardous places to work. The purpose of the study was to define the scope of occupational hazards specific to perfusion practice. This includes both physical and mental risks and impairments.

Methods: After obtaining IRB approval, a qualitative structured questionnaire was initially sent to five perfusionists of various demographic backgrounds to aid in the development of the final occupational hazard survey. Next, a voluntary 23-question survey link was sent to perfusionists to provide feedback on perfusion-related occupational hazards in the profession. Some of the measured parameters include demographics, practice size and area, caseload, prior perfusion-related injuries, and level of stress using a Likert scale. In addition, the survey incorporated open-ended questions to provide participants with opportunities to share their thoughts, suggestions, and experiences.

Results: Of the 254 respondents, 129 (51.4%) felt they had to work while feeling physically impaired from an injury or pregnancy. Forty (16.1%) had experienced extreme psychological fatigue at least once a year. Forty-eight (19.0%) said that they had experienced burnout at least once in a year. Ninety-eight (38.9%) had personally experienced emotional stress, whereas 99 (39.3%) had witnessed emotional stress in a fellow perfusionist in the past year.

Conclusion: Although this is a small sample size and may be biased to those who may have experienced these occupational hazards, it is very important to identify the hazards and develop strategies to improve the workplace environment for perfusionists.

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Impact of Pre-bypass Autologous Blood Collection on Blood Transfusion Rates

Introduction: Pre-bypass acute autologous donation (PAAD) is a method of blood conservation that reduces exposure of blood to the cardiopulmonary bypass circuit and may prevent the contact activation of platelets and clotting factors. The purpose of this study was to evaluate the impact of PAAD on product transfusion rates in cardiac surgical patients.

Methods: This is a retrospective study of patients undergoing cardiac surgery between 2015 and 2017 for either a coronary artery bypass (CABG), valve replacement, or combined valve/CABG procedure. PAAD was performed by removing blood from the venous line of the bypass circuit immediately before the institution of cardiopulmonary bypass. The amount of PAAD volume was determined during the surgical time-out. This was based on patient size, baseline hemoglobin, and type of case. Poisson logistic regression was used to determine whether PAAD was a significant predictor for blood product transfusion.
Results: After obtaining institutional review board approval, we reviewed records on \( n = 154,65.3\% \) who received PAAD and \( n = 82,34.7\% \) with no blood withdrawal before CPB. The median PAAD volume in the PAAD group was 750 mL.

Results: Patients undergoing PAAD had a 14.3% RBC transfusion rate \( (27 \pm 91\text{ units}) \) and without PAAD; the RBC transfusion rate was 62.2% \( (1.56 \pm 1.79\text{ units}) \). The significant \( (p < .05) \) odds ratios for red blood cell (RBC) transfusion were baseline hemoglobin \( .617 \ (5.30–7.19) \), PAAD \( 997 (979–999) \), CPB time 1.009 minute \( (1.003–1.015\text{ minute}) \), age 1.034 years \( (1.013–1.055\text{ years}) \), and BSA OR \( .326 \ (1.124–8.57) \).

Conclusions: PAAD could not be used in all patients. However, using the odds ratio in the Poisson logistic regression model, a one-unit reduction in RBC transfusion is predicted for each 500 mL of PAAD. PAAD was also associated with a significant reduction in FFP and platelet transfusion.

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Institutionalizing Characteristics of High-Reliability Organizations through a Perfusion Information Management System

Abstract: Perfusionists work in a highly complex environment with no room for error. When errors do occur, they must be identified and corrected without delay. Organizations which work in such environments and perform with few accidents have been described as high-reliability organizations (HRO). A focus on system and process rather than individual skill has been identified as an important characteristic of HROs. Comprehensive care services (CCS) staff face a variety of challenges as they perform their duties across more than one hundred hospitals in 18 states. One of these challenges is the level of process variation which typically exists between individual surgical teams within a single center. This variation is only magnified as we consider the differences across institutions. Promoting the standardization of clinical workflows and the adoption of best practices are central goals of the Health Information Technology for Economic and Clinical Health (HITECH) Act of 2009. Early experience of incorporating clinical workflows into institutional electronic medical records (EMRs) has largely been reported as a disappointing experience for many clinicians, but little has been reported on the adoption of perfusion-specific EMRs. CCS has further customized and developed new features within a commercially available perfusion information management system (PIMS). Our goal was to codify and standardize workflows, forms, and practices across the organization. We have used the tools of this PIMS, such as barcode supply entry and clinical decision support engines, to improve patient safety and drive staff behaviors. We report on the opportunities which exist to “hard-wire” the American Society of Extracorporeal Technology (AmSECT) standards and guidelines for perfusion practice and improve surgical team communication.

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Microfluidic Point-of-Care Ecarin-Based Clotting and Chromogenic Assays for Monitoring Direct Thrombin Inhibitors

Background: Direct thrombin inhibitors (DTIs), such as bivalirudin and dabigatran, have maintained steady inpatient and outpatient use as substitutes for heparin and warfarin, respectively, because of their high bioavailability and relatively safe “on-therapy” range. Present clinical methods lack the capacity to directly quantify plasma DTI concentrations across wide ranges. At present, the gold standard is the ecarin clotting time (ECT), where ecarin maximizes thrombin activity and clotting time is evaluated to assess DTIs’ anticoagulation capability.

Methods: This work focused on the development of a microfluidic paper analytic device (μPAD) that can quantify the extent of anticoagulation and DTI concentration within a patient’s whole blood sample. Capillary action propels a small blood sample to flow through the nitrocellulose paper channels. Digital images of whole blood migration are then captured by our self-coded Raspberry Pi and/or the Samsung Galaxy S8 smartphone camera.

Results: Both the flow length and the blue absorbance from the plasma front on the μPAD were measured, allowing simultaneous, dual assays: ecarin clotting test (ECT) and ecarin chromogenic assay (ECA). Statistically significant \( (p < .05) \) changes in flow and absorbance were observed within our translational research study.

Conclusion: Currently there are no quantitative, commercially available point-of-care (POC) tests for the ECT and ECA within the United States. Both the ECT and ECA assays could be instrumental to differentiate between supratherapeutic and subtherapeutic incidents during bridging anticoagulant therapy and limit the unwarranted use of reversal agents.

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Protamine Test Dose: Impact on ACTs and Circuit Integrity

**Background:** Protamine is the gold standard for heparin reversal following cardiopulmonary bypass (CPB). A protamine test dose (PTD) is administered to examine a patient’s hemodynamic response before full heparin reversal. Historically, at our institution, no standardization is implemented to cease CPB pump sucker usage during PTD, using pump suckers until full protamine dose administration. This returns shed blood to the patient during the PTD and enables urgent CPB recommencement if necessary. However, this practice has been unpredictably associated with CPB circuit clots, rendering the circuit unusable. Therefore, this study investigates a PTD, patient ACT responses, and circuit integrity. We hypothesize the PTD will result in ACT destabilization; continued pump sucker usage will result in an increased risk of disrupting CPB circuit integrity.

**Methods:** Data were prospectively collected on 120 CPB patients undergoing various cardiac procedures from July to October 2018. ACTs were documented before CPB termination, post PTD, and post protamine full dose. Statistical analysis was completed using a paired t test.

**Results:** The average PTD was 36 + 21 mg or 11 + 7% of the full protamine dose of 367 + 153 mg. This “test” dose ranged from 1 to 67% of full dose depending on the anesthetist. Post PTD ACTs were widely variable. On average, there was a 40 + 25% drop from last ACT on CPB (650 + 155 seconds) to the ACT post PTD (376 + 153 seconds) p < .05. In fact, 81 + 5% of patients’ ACTs fell below our institutional ACT standard of 480 seconds for CPB initiation.

**Conclusion:** In conclusion, regardless of the PTD, CPB circuit integrity is at risk when pump suckers are used during PTD administration. There is a high variability in anesthesiologist practice regarding PTD administration. There is no reliable way to predict how a patient’s ACT will respond to a PTD. Therefore, we recommend the pump suckers be discontinued before any protamine administration.

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Reducing the Impact of Perfusion Medical Waste on the Environment

**Background:** The U.S. healthcare system generates more than four billion pounds of waste each year, and therefore, waste disposal has become a serious environmental problem facing health-care institutions. The operating room is the second largest source of hospital waste, and no current practices or standards exist in terms of perfusion waste recycling or reuse. A typical perfusion circuit produces approximately 15 pounds of incinerated infectious waste. Contaminated perfusion circuits consisting primarily of polyvinyl chloride (PVC) and polycarbonate are difficult to sterilize, recycle, or reuse.

**Methods:** A literature review of internet-based and peer-reviewed publications was conducted to identify all resources that describe sterilizing, dechlorinating, and recycling of medical grade disposable products.

**Results:** There are several chemical methods available to reharvest PVC after it has been properly decontaminated and melted down. Dechlorination by near-critical methanol (NCM) shows promise in the recovery of additives such as plasticizers, stabilizers, and lubricants. In the cable industry, e.g., the reinjection of PVC has both ecological and economic advantages. Dechlorinated PVC also creates a less toxic by-product when incinerated. Although this process is not recycling, it lessens the impact of poisonous chlorine gas release into the atmosphere. Sterilizing, dechlorinating, and recycling the perfusion circuit may be a promising avenue for reducing the ecological impact of perfusion waste. Other uses of decontaminated PVC are lightweight concrete, fuel, wood composites, and floor matting.

**Conclusion:** Although an economically sensitive mode of reusing, reducing, and recycling a circuit does not currently exist, this presentation will explore the perfusion waste dilemma and present potential solutions in hopes of promoting future recycling and reuse opportunities.

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Review of Outcomes and Blood Utilization for Ventricular Assist Devices in Congenital Heart Surgery Patients

**Introduction:** Ventricular assist devices (VADs) are an important treatment option for patients with heart failure. The purpose of this retrospective review was to determine outcomes following device implantation.

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Methods: Twenty-three patients received device implantation between April 2008 and December 2017. Patients were divided into two groups based on the type of VADs. Outcomes included survival, neurological events, significant bleeding, device thrombosis and replacement, bridge to transplantation, blood transfusion, transplantation, recovery, and survival.

Results: The median age at the time of device implantation was 7 years (2 months–35 years) with a median BSA of .82 m² (range 3.1–2.1 m²). Patient diagnoses included cardiomyopathy (18 patients, 78%), anomalous left coronary artery from the pulmonary artery (ALCAPA) (two patients, 8.7%), hypoplastic left heart syndrome patients (one patient, 4.3%), and single ventricle with hypoplastic right ventricle (one patient, 4.3%). Eleven patients (48%) received a pulsatile ventricular assist device, and 12 patients (52%) received a continuous flow ventricular assist device. Overall survival of patients was 70%. More patients in the study experienced thrombotic pump complications (n = 10, 43%) compared with hemorrhagic pump complications (n = 2, 9%). The range of pump change outs for the pulsatile flow group was one to five pumps (median = 3) compared with a range of one to three pumps (median = 1.5) for the continuous flow group.

Conclusion: Survival data in this single-center study support the use of ventricular assist in this population.

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Team Simulation of Extracorporeal Cardiopulmonary Resuscitation (E-CPR) in the Field

Abstract: With an annual incidence of more than 350,000 and 39.5% occurring in public places, out-of-hospital cardiac arrest (OHCA) is a prominent public health problem. Integrating layperson CPR and public-access defibrillation programs into community emergency response has shown potential for improving OHCA outcomes. However, even with early layperson intervention and advanced life support (ALS) EMS response in a witnessed OHCA event, the underlying pathology may not be amenable. Some evidence suggests that early initiation of venoarterial (VA) ECMO in select patients with refractory pulseless cardiac rhythms may improve survival. In our health system, in coordination with emergency medicine, critical care medicine, cardiothoracic surgery, and EMS, we have implemented an ECMO-CPR (ECPR) alert to prepare an ECMO team for treatment of an OHCA patient meeting the inclusion criteria. To expand this program’s reach, we developed a training program to create a field ECMO team using our prehospital physician members, paramedic and first responder partners, perfusionists, and nurses. In the field team, the EMS physician was responsible for cannulating the patient. One paramedic group was trained to assist the physician and preparing the patient and equipment in sterile fashion. Another paramedic and first responder group continued high-performance resuscitation and established mechanical CPR. We conducted a simulation of the program at a pediatric academic ECMO conference with a high-fidelity gel model for the cannulation. The simulation modeled a student athlete suffering a witnessed cardiac arrest with sequential resuscitation by laypeople, first responders, paramedics, and, finally, the field ECMO team all in 28 minutes. An integrated field ECMO team can be a feasible approach to initiating advanced care in select refractory OHCA patients and can be refined using a training and simulation model.

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The Effect of Standardizing Autologous Prime Techniques in Patients Undergoing Cardiac Surgery with Cardiopulmonary Bypass

Background: Autologous priming of the extracorporeal circuit has been used as a technique to reduce iatrogenic anemia in patients undergoing cardiac surgery with cardiopulmonary bypass (CPB). The purpose of this study was to review the results of standardizing autologous priming (AP) techniques to reduce variation among clinicians and their effect on clinical outcomes.

Methods: Standardized goal-directed protocols for AP were established by the cardiac team and applied to all adult cardiac surgical patients where CPB was used. Following IRB approval, data were analyzed for two sequential groups of patients: nonstandardized AP (NST-AP) and standardized AP (ST-AP). The exclusion criteria included pre-CPB hemodynamic instability and preoperative hematocrit values less than 30%. The primary endpoint was hematocrit change (Hct) with secondary outcome measures of allogeneic blood product transfusions. Data are presented as mean and standard deviation.

Results: Of the 192 patients evaluated, 82 were in the NST-AP group and 110 in the ST-AP group. There were no preoperative demographic differences across groups. The total AP volume was lower in the NST-AP group than ST-AP patients (486.8 ± 259.6 mL vs. 1,048 ± 218.7 mL, p < .001). Although pre-CPB Hct were identical between groups, the first on-CPB (25.7 ± 4.5% vs. 27.9 ± 4.2%, p < .01), high CPB (27.7 ± 3.5% vs. 29.1 ± 3.6%, p < .01), last CPB (26.0 ± 3.9% vs. 27.3 ± 3.3%, p < .02), and first postoperative (32.5 ± 4.0% vs. 34.3 ± 3.9%, p < .003) were all significantly higher in ST-AP patients. The perioperative transfusion rate was higher in NST-AP patients (63.6%) vs. ST-AP (44.6%), p < .01. There were no differences in intraoperative red blood cell (RBC) transfusion, but postoperatively more patients in the NST-AP group received RBC than ST-AP (51.7% vs. 29.1%, p < .01).
Conclusion: The application of a goal-directed AP protocol was effective in reducing variation among clinicians, which resulted in higher hematocrits and lower transfusion rates.

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The Evolution of Patient Blood Management Programs in Cardiac Surgery: What Is

Background: The implementation of a multidisciplinary patient blood management (PBM) program may contribute to a reduction in transfusion requirements, a decrease in health costs, and an improvement in patient outcomes. We compared two different time intervals under different strategies of blood management in a tertiary cardiac unit.

Methods: This retrospective cohort study included high-risk patients (EuroSCORE II > 5) undergoing cardiac surgery with cardiopulmonary bypass under different PBM strategies during the period from January 2012 until December 2018 (Table). Patients were matched for age, gender, BMI, and STS score: Group 1 (control): (2012–2015) (n = 688) and Group 2: (2015–2018) (n = 732).

Results: The percentage of patients who received transfusion was 25.6% in Group 2 and 74.8% in control (p < .0001). Postoperative hemorrhage (Group 2: 420 ± 50 and 875 ± 50 mL in control; p = .014), respiratory support duration (9.3 ± 2/14.7 ± 2 hour; p = .041), and ICU stay (1.2 ± 1 vs. 2.8 ± 1.1 days, p = .035) were significantly better in the Group 2 vs. control. No differences in mortality and major complications were noted. Stepwise multiple logistic regression analysis demonstrated minimally invasive surgery (OR:4.1), minimally invasive extracorporeal circuitry (OR:3.8), utilization of salvaged blood (OR:2.8), and pharmacologic interventions (iron, fibrinogen) (OR:2.1) as leading independent predictors of the reduction in transfusion. Cost analysis demonstrated 15.7% decrease in Group 2 with respect to Group 1 (p = .022).

Conclusions: Based on available evidence, PBM protocols are likely to be most productive for high-risk cardiac patients. The extent is in significant progress, introducing minimally invasive techniques and circulation as well as pharmacologic support. Studies with higher patient population are still warranted.

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The Golden Ration 1.6 of Fibonacci, an Innovative Design and Management of the Extracorporeal Circulation

Abstract: The cardiopulmonary bypass (C.P.B.) can expose patients to a cerebrovascular and systemic risk while undergoing heart surgery, either because of an embolic activity coming from the extracorporeal circulation (E.C.C.) itself or because of a failure to remove or inadequate removal from the chambers of the heart by the device. Not only does this depend from the typology of the material and the security system but also from the management type and technique. This article shows how to optimize the management methodology of the extracorporeal circulation devices to achieve a better fluid dynamic quality, connected to a better postoperative outcome. A circuit that would summarize the best expression of the fluid dynamics, following the Golden Spiral 1.6 of Fibonacci standard was used to prove the superiority of the Fibonacci E.C.C. in terms of fluid dynamics and reduction in producing and transport of G.M.E., reduction of the hemolytic aspects during the C.P.B., and an improved metabolic management as compared with the conventional E.C.C., based on the reduction of the effect of P.O.C.D.

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The Use of High-Fidelity Simulation Is Pivitol to Creating a Simple and Effective ECMO Training Program

Abstract: With the availability of durable ECMO circuit components in the late- to mid-2000s, the ability to provide long-term support for adults with acute pulmonary and or cardiac failure without multiple circuit changes led to exponential growth in the use of ECMO in the United States. The argument for effective personnel responsible for bedside management has been debated for many years. Nevertheless,
the use of ECMO specialist’s over perfusionists has been an effective, safe, economical model. However, providing efficient and consistent training that prepares specialists to safely manage ECMO patients is complex and expensive when outsourced. Developing your own ECMO specialist training program does not have to be complicated. In fact, overly complicated training programs can be ineffective because of the overload of information expected to be comprehended in a short amount of time. At the University of Kansas Health System, we aimed to create a training program that provided algorithms for specialties to effectively manage and triage ECMO patients. The use of high-fidelity simulation was pivotal to the success of our program. The focus was put on 10 sentinel events that we thought were essential to providing safe and quality care. Through a combination of didactic course work and high-fidelity simulation, ECMO specialists were able to effectively triage these 10 events with confidence and competency. The use simulation has been an extremely effect model for training in our institution, especially when our key concepts can be seen and managed in a real-time safe environment.

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Poster Presentation

A Case of Purpura Fulminans Caused by Hemophilus influenzae aegyptius Complicated by Acute Respiratory distress Syndrome

Background: Purpura fulminans (PF) describes an acute syndrome of rapidly progressive hemorrhagic necrosis of the skin due to dermal vascular thrombosis associated with vascular collapse and disseminated intravascular coagulation (DIC). It may occur in individuals with dysfunction of the protein C anticoagulant system, with acute severe infection, or idiopathically without any coagulation dysfunction or infection. Antecedent infections are most commonly group A-streptococcus, staphylococcus, pneumococcus, vibrio, and meningococcus. However, Hemophilus influenzae is also a potential cause of the disease.

Methods/Results: A 19-year-old male presented to an outside hospital on Saturday (January 27, 2018) with malaise and associated diarrhea. The patient was sent home with Tylenol/Motrin. The following day, he returned to the hospital with worsening viral symptoms and was diagnosed with influenza. At the outside facility, he was intubated, was noted to have renal failure, and required pressor support with marginal hypoxia and hypercapnia. On transfer to Montefiore Medical Center (MMC) on January 30, 2018, the patient required escalating pressor support, levo .15mcg/Kg/min, and phenylephrine 300mcg/min. Furthermore, on arrival to MMC, the patient was noted to have cold bilateral upper and lower extremities with skin mottling. The patient progressed to present with both respiratory and metabolic acidosis: lactic acid 9.4 mmol/L (.6 – 2.2), anion gap 29 mEq/L (7–16), and he was hypercapnic; pCO2 venous 56.8 mmHg (35.0–45.0) and hypoxic; and pO2 venous 56.6 mmHg (80.0–100.0). It was noted that the patient was in respiratory failure with shock and was decompensating while on maximal medical therapy. The patient and family were informed by the attending physician that veno-venous extracorporeal membrane oxygenation (VV-ECMO) would be the next line of support.

Conclusions: On ECMO support day 7, the diagnosis of purpura fulminans was determined as a complication of the patient’s severe sepsis because of the acute inflammatory response with systemic activation of the coagulation and complement pathways and endothelial dysfunction resulting in disseminated intravascular coagulopathy (DIC). Furthermore, diagnosis of PF was also confirmed by laboratory findings associated with DIC, such as prolonged plasma clotting times, thrombocytopenia, decreased plasma fibrinogen concentration, and increased fibrin degradation products.

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A Single-Centre Evaluation of Two Adult ECMO Oxygenators

Background: This is a retrospective study on prospectively collected data to evaluate the performance of EOS (LivaNova) and EUROSETS (Eurosets) ECMO oxygenators and their influence on blood product consumption during ECMO.

Methods: The evaluation period spanned from February 2017 to May 2018. There were 10 patients in each group, and all were supported on venoarterial ECMO. Oxygen (O2) transfer, carbon dioxide (CO2) transfer, and pressure drop across oxygenators were calculated for each patient in both groups up to day 7 of ECMO. Data on platelet counts, packed red blood cells (PRBC), and platelet transfused were recorded in non-postcardiotomy patients (six in EUROSET and seven in EOS) up to day 7 of support. All data were calculated for each patient in both groups up to day 7 of ECMO. Data on platelet counts, packed red blood cells (PRBC), and platelet transfused were recorded in non-postcardiotomy patients (six in EUROSET and seven in EOS) up to day 7 of support. All data were analyzed by SPSS Statistics V22.0.

Results: Blood flows were similar, 3.76 ± .71 L/min (EURO) and 3.55 ± .67 L/min (EOS) (p = .199). O2 and CO2 transfer was higher in the EURO group, 148.35 ± 47.04 mL/min vs. 130.68 ± 51.28 mL/min (p = .060) and 147.54 ± 71.65 mL/min vs. 123.92 ± 58.16 mL/min (p = .073), respectively. Pressure drop was significantly lower in the EURO group, 17.25 ± 5.23 mmHg/LPM vs. 34.50 ± 9.84 mmHg/LPM (p < .001). Platelet counts and PRBC transfusion were comparable, 102.69 ± 69.17 × 109/L (EURO) vs. 92.66 ± 46.86 × 109/L (EOS) (p = .955) and
1.11 ± 1.37 units/day (EURO) vs. 1.31 ± 1.99 units/day (EOS) \((p = .795)\), respectively. Platelet transfusion was also similar, .49 ± .69 unit/day (EURO) vs. .60 ± .66 unit/day (EOS) \((p = .372)\). There was no incidence of oxygenator failure reported for both groups during support.

**Conclusion:** In this study, sample sizes for both groups maybe too small to obtain any significance in the parameters studied. Both oxygenators were on par in their performance with the absence of significant adverse effects on blood product requirements.

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**Benefits of Cell Washing of Donor Pack Cells before Transfusion for Extracorporeal Circulation**

**Objective:** The goal of this thesis was to analyze the effects of allogenic blood transfusion and to examine whether washed or unwashed perioperative transfusion yields more benefits. This thesis examined the length of stay, mortality, and adverse reactions of patients who received washed or unwashed packed red cells. The hypothesis of this thesis was washing of allogenic packed red cells before perioperative transfusion yields more benefits and postoperative outcomes to the patient vs. transfusing with unwashed packed cells during cardiopulmonary bypass.

**Methods:** A prospective study design of 60 patients in total (Group 1 and Group 2, \(n = 30\) each) was performed to assess preoperative, immediate postoperative, 6 hours post-CPB, and 12 hours post-CPB hematocrit, hemoglobin, red blood cell volume, potassium, sodium, and glucose levels and analyzed them to compare the differences between both groups, which yields more benefits in terms of length of stay, mortality, and adverse reactions. The age of packed red cells during transfusion was noted to understand the impact and importance of new vs. old packed cell units. Published scholarly literature and data were gathered and analyzed to present the effects of transfusing with washed and unwashed packed red cells in adult patients undergoing cardiopulmonary bypass procedures. The measures of mean, standard deviation, and \(p\)-value were calculated based on paired \(t\) test using GraphPad Software and Excel. All in all, a meta-analysis was performed to better understand the postoperative outcomes of both groups.

**Results:** Under review.

**Conclusion:** The data collectively suggest that washing allogenic packed red cells before perioperative transfusion is more beneficial to the patient undergoing cardiopulmonary bypass. The positive results of washing packed cells continue to outweigh the negative effects of transfusion with unwashed packed cells; therefore, it should be a standard of practice for all pack cell transfusion during extracorporeal circulation for adult cases.

Heena Rana  

**Onset Venous Saturation as a Predictor for Oxygenation Control during CPB**

**Abstract:** Some device testing standards do not address the day to day clinical condition. Such is the case of the AAMI/ISO testing standard for blood gas exchangers (oxygenators). Devices are tested at a venous inlet saturation of 70 ± 5%. However, these conditions are not often seen in the clinical scenario. Venous saturations are usually lower and present a wide range of variables. Two main areas of focus would be on the performance capability of the device under low venous inlet conditions and the controllability/consistency of the performance. The purpose of this study was to address the latter. The clinical reality is that usually after one or two blood gases, oxygenation and gas exchange are fine-tuned and under control. Depending on the institutional protocol, it may be one hour into cardiopulmonary bypass (CPB) time. The goal of this study was to hypothesize that onset venous blood gas can be used for precise control of oxygenation (gas exchanges) on CPB. In venous samples taken just before CPB, onset \(\text{FiO}_2\), blood gases, and \(\text{O}_2\) transfer will be analyzed to develop a better controlled oxygenation technique for CPB. Data and results of the analysis will be presented. After the initial study, device performance, \(\text{CO}_2\) control, and patient outcomes should follow.

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**Optimizing Heparin–Protamine Management with the Sienco Sonoclot**

**Background:** The Sienco Sonoclot is a hemostasis management tool which uses an ultrasensitive viscoelastic coagulation detection system to monitor in-vitro hemostasis. The Sonoclot’s results are demonstrated in the Sonoclot signature. The Sonoclot
signature can be divided into three phases that can be mapped to three phases of hemostasis development. These phases are coagulation, fibrin formation, and the clot retraction. The ACT result quantifies the performance of the coagulation phase. The clot rate result quantifies the rate of fibrin formation within the blood. The platelet function result quantifies the clot retraction phase. The need for a more precise, individualized heparin–protamine management strategy is the basis for this study.

Methods: Whole human blood was drawn into citrated tubes with a total sample size of 15. Each tube was divided into five smaller aliquots of which baseline, heparin only, and three heparin: protamine ratio vials were analyzed for their coagulabilities. The Sienco Sonoclot was used for all testing which involved obtaining an activated clotting time (ACT) for each aliquot.

Results: ACT values increased with the addition of heparin from baseline samples. The heparin: protamine ratio aliquots varied by sample with the 1:1 ratio returning to within baseline limits most of the time. Higher ratios served to prove protamine’s anticoagulant abilities when administered in the absence of heparin. General linear mixed model (GLMM) and pairwise comparisons demonstrated a significant difference between baseline and heparin-only ACT values (p < .0001). There was no statistical significance between baseline and the 1:1 heparin: protamine ratio ACT values (p=.81).

Conclusion: The heparin: protamine ratio of 1:1 brought the ACT value within baseline limits when compared with the 1:1.5 and 1:3 ratios. Excess protamine serves as an anticoagulant, whereas a titrated, smaller dose serves to neutralize heparinized, anticoagulated blood.

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Comparison of Hemosep and CATS in Washing Stored Packed Red Blood Cells

Abstract: The redistributitive process of stored packed red blood cells (PRBCs) may potentially occur between 0 and 42 days. At 42 days of storage, PRBCs expire. However, long before their expiration date, PRBCs acquire storage lesions, which may be incompatible with the blood of the recipient. Changes seen include a decrease in pH, 2,3 DPG, and an increase in extracellular potassium. To remove or alleviate storage lesions from PRBCs, units may be washed. Use of the Fresenius Kabi Continuous Autotransfusion System (CATS) cell salvage device is one option for cell washing. This study compares the CATS device with the Advancis Surgical Hemosep product in washing stored PRBCs. Porcine blood samples (n = 26) were acquired, RBCs were isolated by centrifugation, and samples were stored for 21 days. After storage, samples were divided into three groups: control, CATS, and Hemosep. Data were collected using a centrifuge and an EPOC blood gas analyzer. All three groups were compared. A statistically significant difference was seen between and in favor of the Hemosep vs. CATS in all categories except pCO2 and hematocrit. There was no significant difference in pCO2 between groups. After data collection, a small follow-up study was completed to analyze the residual volume found in each Hemosep bag after the washing process to determine effective RBC mass. The follow-up study determined an average of 193 mL of residual volume remained in each Hemosep bag after processing. Adjustment of the initial results for the Hemosep group’s hematocrits was made. These data suggest that the Hemosep may be considered an alternative option for washing stored PRBCs and is superior in many aspects of the washing process. Washing of PRBCs is also suggested to be an effective method before transfusion and should be considered by clinicians where possible.

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Protective Effect of Endothelin Receptor Antagonist on Cardiopulmonary Bypass–Associated Lung Ischemia Reperfusion Injury in Beagles

Objective: This study was aimed to determine the protective effect of endothelin receptor antagonist (ERA) on cardiopulmonary bypass (CPB)–associated lung ischemia reperfusion injury (LIRI).

Methods: Twenty-four beagles were randomly assigned to three groups (n = 8): Sham group (thoracotomy followed by 4 hours observation), CPB group (2 hours CPB followed by 2 hours observation), and ERA group (sitaxentan infusion for 1 hour before 2 hours CPB, followed by 2 hours of observation). Hemodynamics, arterial blood gas, lung damage scores, wet/dry (W/D) ratio, levels of inflammatory factors (tumor necrosis factor [TNF]-α and interleukin [IL]-6), oxidative stress factors (malondialdehyde [MDA] and superoxide dismutase [SOD]), and several proteins (caspase-3, hypoxia-inducible factor [HIF]-1α, phosphorylated Akt [p-Akt], and phosphorylated endothelial nitric oxide synthase [p-eNOS]) were determined.

Results: Lung damage scores in the ERA group were significantly lower than that in CPB group but higher than that in Sham group (p < .05). The W/D ratio in the ERA group was significantly lower than that in the CPB group, and the lowest W/D ratio was...
observed in the Sham group ($p < .05$). The expression levels of caspase-3 and HIF-1α in the ERA group were lower than that in CPB group but higher than that in the Sham group; levels of p-eNOS and p-Akt in the ERA group were higher than those in both CPB and Sham groups ($p < .05$). TNF-α and IL-6 in the ERA group were lower than that in the CPB group but higher than that in the Sham group ($p < .05$).

**Conclusions:** CPB may predispose LIRI. ERA infusion could decrease CPB-associated inflammation, apoptosis, and LIRI in beagles via regulation of the HIF-1α/p-Akt/p-eNOS pathway. **Keywords:** lung, ischemia reperfusion, cardiopulmonary bypass, endothelin, antagonist.

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**Successful Use of ECMO for a Tracheal Slide Procedure: A Case Report**

**Abstract:** Airway and surgical management for pediatric patients with tracheal stenosis is complicated and exceptionally difficult if there is an obstruction present. The case being presented involves a pediatric patient with tracheal stenosis and complete tracheal rings who was unable to be adequately ventilated despite several valiant attempts. After a cardiac arrest, the decision was made to initiate VA ECMO. This was initiated to manage oxygenation and cardiac dynamic stability while waiting until the patient was stable enough to undergo a successful tracheal slide repair. VA ECMO is a critical adjunct for preserving the viability of the lungs and heart support. After five days of ECMO with satisfactory blood gases and anticoagulation, the patient was brought to the OR and placed on cardiopulmonary bypass to undergo a tracheal slide repair to correct the tracheal stenosis and rings. Careful measures were taken to ensure that no air was entrained into the ECMO circuit or to the patient during this transition. After the trachea was repaired, the patient was weaned off of cardiopulmonary bypass. Clinical indicators, including blood gases and x-ray, were performed to assess the lungs and determine the state of the patient during the transition. After the trachea was repaired, the patient was referred for cardiopulmonary bypass support. Clinical indicators, including blood gases and blood pressure, were performed to assess the lungs and determine the state of the patient on ventilation without ECMO. The patient was determined to be stable with a successful repair. ECMO was able to provide a reliable source of gases exchange in place of a challenging airway management situation. In addition, cardiopulmonary bypass offered the advantage of improved visibility during the procedure without the risk of air entrainment into a closed system. The use of this technique should lead to better outcomes for tracheal slide repair in the future.

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**The Effect of Goal-Directed DO2i Monitoring on Oxygen Delivery**

**Background:** This study was performed to determine whether goal-directed, real-time indexed oxygen delivery monitoring influenced oxygen delivery while on cardiopulmonary bypass. Inadequate oxygen delivery has been shown to correlate with a higher incidence of acute kidney injury after bypass. This assessed whether standard perfusion practice resulted in adequate oxygen delivery or whether real-time oxygen delivery monitoring with a goal DO2i delivery provided better results.

**Method:** Oxygen delivery indexed for patient size, nadir indexed oxygen delivery, total cardiopulmonary bypass time, pre-bypass hemoglobin, and nadir hemoglobin were recorded for 200 patients between two high-volume cardiac surgery centers. Indexed oxygen delivery was calculated every 15 minutes while on cardiopulmonary bypass, and the area under the curve was used to assess whether a goal oxygen delivery of 280 mL O2/min/m² was met for the duration of the surgery. These results were then compared between the two hospitals.

**Results:** This study showed that there was a significant difference between the two institutions across all measured parameters. The institution monitoring real-time oxygen delivery for patients in the institution not monitoring DO2i.

**Conclusion:** Goal-directed DO2i monitoring can result in a higher oxygen delivery to patients while on cardiopulmonary bypass.

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The Role of Exosomes in Cardioprotection

**Background:** Exosomes are microvesicles released from one cell for communication and modulation of recipients. These nanoscopic lipophilic vesicles are secreted by most cells under tissue culture conditions, contain proteins that are normally present within the cytosol or endosomal compartments, and can play a role in the modulation of recipient cells during disease states. Specifically, exosomes have been identified as cardioprotective following myocardial infarction. Among the benefits of the exosomes released during myocardial infarction include inhibiting apoptosis, and promoting cell proliferation or angiogenesis, which is important for recovery following myocardial infarction. Various microRNAs and heat shock proteins have been found within exosomes. The purpose of this work was to propose a novel approach to treating ischemic reperfusion injury in cardiopulmonary bypass patients.

**Methods of isolation:** A novel method of isolation used when working with human samples published by the University of Colorado and Notre Dame University would be used in a proposed study concerning various exosome content between patients undergoing cardiopulmonary bypass, where ischemic reperfusion injury is of much interest. This method uses ultracentrifugation and gel chromatography to isolate pure exosomes.

**Therapeutic options:** Exosomes are currently being analyzed as a potential therapeutic delivered by the way of mesenchymal stem cells, which have the ability to differentiate into myocytes.

**Conclusion:** Although exosomes are not a currently developed treatment for ischemic heart disease, they show great promise as a future therapeutic modality. Their ability to modify recipient cells in a state, such as ischemic reperfusion injury following cardiopulmonary bypass, is of great interest in future research.

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Sterilely Primed ECMO Circuits Can Be Used at 30 Days and Beyond: A 9-Year Review

**Background:** Pre-primed circuits (tubing, pump, and oxygenator) facilitate ECMO readiness in emergencies. Emergently prepared ECMO circuits are at risk for errors in sterility vs. pre-primed circuits have been under scrutiny for their ability to be maintained with the sterility. We have adopted a standard approach to building, priming, and culturing the ECMO circuits that mitigate this risk.

**Methods:** Once circuits were built and primed, they were either used for a patient, or readied for the next patient. A sterility culture was obtained at 30 days. In addition, any circuit that was tampered with or suspected of contamination was not used on any patient and was cultured before being discarded. If any growth was detected, the team was notified immediately by the laboratory. Standard work for building and priming was developed including donning hat, mask, and sterile gloves. The ECMO circuits were developed as custom packs, minimizing the need for cutting or manipulation of the disposable circuitry. Although the circuit is available, it was left undisturbed.

**Results:** Between April 2010 and December 2018, 70 cultures were obtained from 59 ECMO circuits that were ≥30 days old (See Figure). There were 55 circuits that were untampered before use and all had no growth at day 30 or greater. The four circuits, in which the sterility was in question after being primed, were cultured before being disposed of, and all grew microorganisms (3 Gram-positive and 1 Gram-negative).

**Conclusion:** Sterilely primed and maintained ECMO circuits are safe for use for at least 30 days. If an ECMO circuit is tampered with, or conditions in which one thinks the sterility has been compromised, it should be discarded as it is not safe for patient use.

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Oxygen Saturation’s Effect on Infrared Emissivity in Porcine Blood

**Background:** Infrared thermal technology provides a noninvasive approach to monitoring temperature by instantly converting light wavelengths (700 nm–1 mm) emitted from an object into a temperature readout. One potential application applies infrared thermal technology to cardiac surgery with respect to monitoring a patient’s regional and systemic temperatures. Because of the dynamic nature of oxygen saturations and the correlating effect on blood’s emissivity, it is thought that a standard infrared thermometer cannot achieve accurate readings at various oxygen saturations. This effect stems from the constant oxidation/reduction (redox) reactions undergone by hemoglobin in the red blood cell as oxygen is bound to and released from it. As oxygen exchange occurs, iron rapidly changes from the ferrous to the ferric state, thus changing in emissivity ultimately resulting in inaccurate infrared thermal readings.
Method: To complete the experiment, porcine blood was circulated through two circuits using oxygenators for purposes of oxy/deoxygenation. Using a mercury thermometer as a control to compare three infrared thermometer readings, temperatures were recorded at incremental oxygen saturations and temperatures.

Results: Significant differences were found when comparing infrared thermometers set to emissivity .1, .89, and .95 across all temperatures and oxygen saturations. The thermometer with an emissivity of .1 was significantly less accurate. The thermometer with an emissivity of .89 was less accurate in all measurements except one. The thermometer with an emissivity of .95 was most accurate.

Conclusion: The study concludes that oxygen saturation does not interfere with infrared thermal readings when using a thermometer with an emissivity of .95 in the infrared thermometers’ algorithm. This may be due to hemoglobin’s insignificant emissivity change because of the redox of hemoglobin or the property by which the thermometer only measures the surface temperature of the red blood cells.

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