

## Outcome Abstracts

### ENCEPHALOPATHY AFTER CORONARY ARTERY BYPASS GRAFTING: A SERIOUS POSTOPERATIVE OUTCOME

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**INTRODUCTION:** Much attention has been paid to stroke associated with CABG. Less attention has been paid to patients with evidence of diffuse brain dysfunction presenting as delirium, confusion, coma, and seizures in the immediate postoperative period.

**METHODS:** A prospective evaluation of 2771 patients operated upon between January 1997 and December 2000. Preoperative risk factors were obtained before surgery, and postoperative outcomes were determined on each postoperative day before discharge. Encephalopathy included those patients with delirium, coma, or seizures and was treated as a separate and mutually exclusive outcome from stroke. Logistic regression analyses were performed to determine risk factors for these outcomes.

**RESULTS:** For patients without encephalopathy, length of hospital stay (LOS) was 6.9 days and mortality 2.0%. The incidence of encephalopathy was 6.9% with a LOS of 15.2 days and mortality of 7.5%. The model for encephalopathy includes five preoperative factors: past CVA (OR 2.1,  $p < 0.01$ ), hypertension (OR 1.5,  $p = 0.05$ ), presence of a carotid bruit (OR 1.6,  $p = 0.04$ ), diabetes mellitus (OR 1.5,  $p = 0.02$ ), and age ( $> 65$ -75 years, OR 1.5,  $p = 0.04$ ;  $> 75$  years: OR 2.8,  $p < 0.01$ ). Time on cardiopulmonary bypass was also strongly predictive of postoperative encephalopathy ( $p < 0.01$ ).

**CONCLUSIONS:** Encephalopathy is a serious postoperative consequence of CABG with a LOS similar to that of stroke and a mortality rate five times that of patients without stroke or encephalopathy.

### CHANGES IN REGIONAL CEREBRAL METABOLISM WITH 18FDG-PET BEFORE AND AFTER CABG

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**INTRODUCTION:** The cause of cerebral damage following CABG has not been determined. Since  $SjO_2$  falls during rapid rewarming and there is rebound hyperaemia after CPB @  $28^\circ\text{C}$ , mismatch of perfusion and metabolism might cause regional cerebral ischaemia. This has never been studied as PET scanning is difficult at the time of CABG.

**METHODS:** 12 patients undergoing elective CABG with bypass @  $32^\circ\text{C}$  received 18FDG-PET imaging before and immediately after CABG, in 2 sequential groups: A] pre-op imaging awake, B] pre-op image anaesthetised with arterial sampling of FDG for absolute quantification. Post-op injection of FDG was 5' after end of CPB with imaging @ + 45' when uptake was complete.

**RESULTS:** Gp A] Post-op FDG showed 40% reduction in metabolism, with significant regional variation maximal in the cingulate gyrus. Gp B] Pre-op FDG was markedly reduced compared to Gp A, but post-op FDG images showed no significant global or regional difference compared to pre-op. Transcranial Doppler MCA velocity fell 30% after induction of anaesthesia: velocity averaged over 45' post-CPB (the time of FDG uptake) was similar to pre-op after an initial rise.

**CONCLUSIONS:** Gp A images showed regional variation in metabolism between pre- and post-op images: however Gp B showed no regional variation in metabolism, suggesting that anaesthesia itself was the cause. It is not possible to measure PET flow intra-operatively, but to produce cerebral ischaemia with normal metabolic demand would require marked fall in regional flow after bypass when other studies have shown flow is increased. The change in current practice from bypass @  $28^\circ\text{C}$  to  $32^\circ\text{C}$  may have helped to minimise temperature gradients during rewarming and avoid ischaemia.

### NEURODEVELOPMENTAL OUTCOME AFTER CONGENITAL HEART SURGERY: RESULTS FROM AN INSTITUTIONAL REGISTRY

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**INTRODUCTION:** The neurodevelopment of five-year-old children following repair of palliation of CHD was examined.

**METHODS:** A battery of neuropsychological tests was administered to 243 children between 1998 and 2001. The Committee on Clinical Investigation approved this study, and informed consent was obtained from the parents of participating patients.

**RESULTS:** In the sample, mean Full-Scale (FSIQ), Verbal (VIQ), and Performance (PIQ) IQ scores were in the normal range ( $96.8 \pm 15.9$ ,  $97.8 \pm 14.6$ , and  $96.3 \pm 17.1$ , respectively). Single ventricle patients ( $n=34$ ) scored lower than patients with two ventricles ( $n=209$ ) on FSIQ ( $p=0.008$ ), PIQ ( $p=0.004$ ), visual memory ( $0=0.02$ ), and a test of visual-motor skills (Drawing,  $p=0.02$ ; Matching,  $p=0.02$ ; Pegboard,  $p=0.01$ ; Composite score,  $p=0.003$ ). Patients subjected to hypothermic circulatory arrest (HCA) were not different from the non-HCA group ( $p=0.45$ ). Within the HCA group, longer duration of HCA was associated with lower FSIQ ( $p=0.0001$ ). Lower FSIQ scores were also predicted by a lower socioeconomic status (SES) ( $p=0.0001$ ), younger age at first heart surgery ( $p=0.02$ ) and the diagnosis of velocardiofacial syndrome (VCFS) ( $p=0.0001$ ).

**CONCLUSION:** Children with CHD perform within the average range. Lower SES, Single ventricle palliation, VCFS, younger age at surgery, and longer periods of HCA are associated with lower IQ scores.

### ASPARTATE AND GLUTAMATE: PUTATIVE MARKERS OF SUBCLINICAL BRAIN INJURY FOLLOWING CAROTID ENDARTERECTOMY

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**INTRODUCTION:** Twenty-five percent of patients having carotid endarterectomy (CEA) show significant cognitive dysfunction based on neuropsychometric (NPM) test performance compared to patients having spine surgery (1). To validate these clinical findings with an independent measure of brain injury, we measured serum concentrations of glutamate and aspartate in patients having CEA at 2 time points.

**METHODS:** 24 patients were enrolled in this IRB-approved study. Patients were given a battery of 5 standard NPM tests before, and 1 day post-surgery. Changes in NPM test scores were converted to z-scores and injury defined as a decrease in performance  $> 2$  S.D. compared to a surgical control population. CEA patients had blood drawn preoperatively and 12 hours postoperatively. These samples were stored on ice, separated with an analytical centrifuge and frozen at  $-80^\circ\text{C}$ . Bloods were analyzed for aspartate and glutamate by HPLC with an electrochemical analytic cell. All surgery was performed under general anesthesia with routine and EEG monitoring.

**RESULTS:** Symptomatic patients demonstrated significant elevations in serum aspartate amongst injured patients, but not in those uninjured. Neither amino acid, however, showed significant elevations in the injured group vs. the uninjured group as a whole.

**CONCLUSIONS:** These preliminary results suggest that aspartate may prove to be a biochemical marker of subclinical brain injury. Stroke, 29 (6), 1110-5, 1998.

### RESPIRATORY INSUFFICIENCY FOLLOWING CPB IS ASSOCIATED WITH RE-INFUSION OF MEDIALSTINAL BLOOD

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**BACKGROUND:** Pulmonary and cognitive dysfunction are well-documented complications after cardiopulmonary bypass (CPB).<sup>1,2</sup> Shed blood returned during CPB by cardiotomy suction (CS) has been identified as a source of brain lipid microemboli (LME) during CPB, which has been linked with neurologic deficits following cardiac surgery.<sup>3</sup> We hypothesized that LME returned via CS may also contribute to respiratory insufficiency.

**METHODS:** After institutional ACUC approval, 15 dogs were instrumented for CPB. Normocapnia was maintained by mechanical ventilation. CPB was stabilized at normothermia (37°C) for 10 minutes then core temperature was reduced to hypothermia (28°C) for 30 minutes. Dogs were then randomized into 2 groups: gaseous microemboli; GME (blood withdrawn from venous reservoir, and then aspirated from open pan, n=6) or LME (medialstinal blood aspirated from chest, n=9). The aspirated blood (500 ml) was sequestered in the CR until rewarming to normothermia prior to end of CPB. Arterial blood gas values were measured at: Pre-CPB, End CPB, and Post CPB (30 min - 6hr). Two-way ANOVA was used for statistical analysis.

**RESULTS:** There was no significant difference in mean arterial pressure, temperature, or PaO<sub>2</sub> between groups. The LME group had a significant reduction in O<sub>2</sub> % saturation post CPB compared to the GME group, which continued for 2 hours (p<0.050\*). At 6 hours post CPB, the LME group O<sub>2</sub> % saturation remained lower than pre-CPB p=0.073).

Arterial O<sub>2</sub> % saturation (mean ± sd)

	Pre CPB	End CPB	30 min	2 hour	6 hour
GME	97.9 ± 3.3	99.7 ± 0.2	95.4 ± 3.5	94.2 ± 5.9	99.4 ± 0.5
LME	97.3 ± 3.2	99.6 ± 0.4	86.6 ± 6.5*	81.9 ± 12.1*	91.7 ± 10.1

**CONCLUSIONS:** Medialstinal blood may have a higher level of activated platelets, leukocytes, complement factors, etc., which could be further elevated by the stresses applied by aspiration. Re-infusion of aspirated shed blood during cardiac surgery may contribute to acute pulmonary dysfunction following CPB.

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### COGNITIVE CHANGE FIVE YEARS AFTER CORONARY ARTERY BYPASS SURGERY

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**INTRODUCTION:** Although cognitive decline following coronary artery bypass graft surgery has been widely reported in patients up to 6 months post surgery relatively little research has been conducted into the changes, which may occur in the longer term. Previous studies have shown that the extent of immediate postoperative decline is still detectable 5 years after surgery. In this study we investigated the neuropsychological changes 5 years after surgery in a single group to investigate pre, intra and postoperative factors contributing to 5 year cognitive changes.

**METHODS:** 107 participants were assessed on a battery of 10 neuropsychological tests pre-operatively, at 6 days, 8 weeks and 5 years after surgery. The overall neuropsychological (NP) change score declined at 6 days showed some recovery at 8 weeks and declined again at 5 years. In multivariate analysis the number of microemboli recorded during surgery, post-operative cognitive change at 6 days and degree of recovery at 8 weeks were identified as predictors of change in NP score to 5 years.

**CONCLUSIONS:** This suggests that even over a 5 years period operative damage is detectable. Vulnerability to short-term deterioration, and 'resilience' or ability to recover over a few weeks from operative insult are important predictors but of unknown mechanism.

### VIDEOMICROSCOPY OF FAT MICROEMBOLI IN CEREBROCORTICAL VESSELS

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**INTRODUCTION:** Fat or lipid microemboli (LME) have been implicated as a cause of cerebral dysfunction after orthopedic procedures and cardiopulmonary bypass. As a model of cerebral LME in rats, we injected fat into the jugular vein and observed the passage of LME through cerebrocortical vessels. We report the appearance time of LME and the transient regional vessel occlusion time.

**METHODS:** After institutional ACUC approval five anesthetized, ventilated Sprague-Dawley rats underwent craniotomy with the head in a stereotaxic frame. The dura was reflected. A Cytoscan™ videomicroscopy probe placed on the surface of the brain continuously recorded images of the cerebral vessels on videocassette tape. A catheter was placed in the SVC for injection of fat and drugs. Human marrow fat was collected from surgical waste during femoral reaming and an aliquot injected into the SVC. In four rats epinephrine (up to 5 Φg/kg) was given to increase perfusion pressure. Post-mortem, brain was stained with osmium tetroxide for fat. Variables are expressed as mean ± SEM.

**RESULTS:** We obtained good visualisation of the microcirculation and observed LME in all rats. We focussed our analysis on arterial vessels 65 ± 8 Φm in diameter. In four rats, after the injection of fat (0.3 ml) there was a decrease in mean BP from 121 ± 8 to 27 ± 7 mmHg (p<0.02) and P<sub>a</sub>O<sub>2</sub> from 339 ± 60 to 75 ± 20 mmHg (p<0.02). After epinephrine, mean BP increased to 158 ± 6 mmHg (p<0.02) and 20 to 100 LME per rat were seen over a 5 minute period. Three rats had complete occlusion of arterial vessels for 10, 16 and 202 seconds before reperfusion. On histologic examination, a large amount of cortical intravascular fat was present. One rat injected with 0.2 ml fat did not require epinephrine and only one LME was seen after fat injection. This rat had the least amount of intravascular fat at post mortem examination.

**CONCLUSIONS:** Vascular occlusion is transient and depends upon the size of LME and the perfusion pressure. This may be a model for studying cerebral microvascular reperfusion injury leading to a better understanding of the mechanism of cerebral dysfunction following fat embolism.

### A NEW METHOD FOR REMOVING SCADS FROM SHED MEDIASTINAL BLOOD

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**INTRODUCTION:** Debris and fat from the mediastinum enter the circulation via cardiomy suction during CPB operations. These emboli are probably the cause of SCADS (Small Capillary Arteriolar Dilatations), and suggested a risk factor for adverse neurological outcome after cardiac surgery. As cardiomy suction still is felt necessary by a majority of surgeons, discontinuation of this practice is not an option. The available methods for blood wash today are inadequate and cannot separate these fat emboli from the blood.

**METHODS:** A new method of particle separation, using ultrasonic standing waves in nano-tech structures was used to separate fat emboli and blood cells continuously. Shed blood collected from the pericardium was processed in this series.

**RESULTS:** Preliminary results show a complete elimination of fat emboli in the processed portion of the shed blood.

**Discussion:** These early in vitro tests show that fat emboli can be separated from red blood cells due to the inherent physical properties of these particles. Ultrasonic standing wave particle separation is a new method that may give us possibility to improve techniques, and hopefully outcome, in cardiac surgery.

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**INTRODUCTION:** Vacuum-assisted venous return allows the use of smaller venous lines in cardiac surgery. We sought to determine if this technique also has clinical advantages over conventional gravity drainage.

**METHODS:** Between 2/99 and 7/99, vacuum-assisted venous return was used during 150 valve operations. It was compared with 83 valve operations using the first version of vacuum-assist between 4/97 and 1/98 and also with 124 valve operations using gravity drainage between 1/97 and 4/97. Priming volume, hematocrit, red blood cell usage, blood product usage and chest tube drainage were compared multivariably. The comparisons were covariate and propensity matching adjusted for dissimilarities between the groups.

**RESULTS:** Vacuum-assisted priming volume was  $1.4 \pm 0.4$  l in the latest version,  $1.7 \pm 0.4$  l in the earlier and  $2.0 \pm 0.4$  l for gravity drainage ( $P < 0.0001$ ). This resulted in higher hematocrits during bypass,  $27 \pm 5\%$ ,  $26 \pm 4\%$  and  $25 \pm 4\%$ , respectively, at the beginning, ( $P < 0.0001$ ) and  $30 \pm 4\%$ ,  $28 \pm 4\%$  and  $27 \pm 4\%$ , respectively, at the end ( $P < 0.0001$ ). Red cell transfusions were used in 17% of the recent vacuum-assisted patients, 27% of the earlier vacuum-assisted patients and 37% of gravity patients ( $P = .001$ ). Total blood product usage was 19% for the most recent vacuum-assist, 27% for the earlier vacuum-assist and 39% for gravity drainage ( $P = .002$ ). 12-hour chest tube drainage was less after the final version of vacuum-assist (median 200ml, 95% <450ml) than the earlier version (median 250ml, 95% <600ml) and less than gravity drainage (median 250ml, 95% <700ml) ( $P < 0.0001$ ).

**CONCLUSIONS:** Vacuum-assisted venous return results in 1) higher hematocrits during bypass, 2) fewer patients requiring blood products, and 3) less postoperative chest tube drainage.

### THE EFFECT OF LEUCOCYTE DEPLETING ARTERIAL LINE FILTERS ON MICROEMBOLI AND NEUROPSYCHOLOGICAL OUTCOME FOLLOWING CABG SURGERY

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**INTRODUCTION:** The aim of this study was to examine the impact of leucocyte depleting (LD) arterial line filters on microemboli and cognitive performance.

**METHODS:** Between April 1999 and September 2001, 192 patients scheduled for elective CABG were randomised to receive the test Pall LG-6 (LD) filter or either the Avecor affinity or Pall AV6 as controls. A trained neuropsychologist, blind to the patient group, administered a standard battery of 9 neuropsychological tests pre surgery and at 6 weeks after surgery. Intra-operatively, strict anaesthesia, surgical and perfusion protocols were observed. Microemboli were detected during cardiopulmonary bypass using a 2 MHz transcranial Doppler (TCD) probe to insonate the right middle cerebral artery and counted offline.

**RESULTS:** No pre operative differences were found between the groups. Significantly less microemboli ( $p < 0.0001$ ) were found in the LD group (26.5 sd 31.9) compared to the Avecor (79.3 sd 52.2) and AV6 (75.4 sd 67.8). Analysis of the neuropsychological performance of the 161 patients who were assessed pre operatively and at 6 weeks showed better performance in all but one of the nine tests in the LD group although this difference failed to reach significance ( $p = 0.07$  1-tailed test).

**CONCLUSIONS:** LD filters were found to markedly reduce microemboli. On neuropsychological testing the group who received LD filtration showed a trend towards better performance in comparison to those on a standard filter. These findings suggest that using LD filters in CABG surgery may offer increased protection to the brain.

### TRANSCRANIAL DOPPLER (TCD) CHARACTERISTICS OF DIFFERENT EMBOLIC MATERIALS DURING IN-VIVO TESTING

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**INTRODUCTION:** TCD identifies microemboli in the brain circulation. However, it is unknown if emboli of different size and composition can be distinguished. We used human data and then attempted to confirm in an animal model whether characteristics of Doppler embolic signals could be used to differentiate between embolic materials of different composition.

**METHODS:** After ethics/IRB approval, HITS (High-intensity transient signals) were analyzed in patients with a patent foramen ovale at the time of the bubble contrast test and during their surgery for joint replacement. In 3 anesthetized dogs, microspheres (50 $\mu$ m and 125 $\mu$ m), fat (60-100 $\mu$ m), and air bubbles (30-70 $\mu$ m) were injected through the internal carotid artery and HITS detected by TCD in the brain circulation. HITS were analyzed based on their relative intensity increase, duration and Doppler frequency shift, and their usefulness assessed by Receiver Operating Characteristic Curves.

**RESULTS:** In humans, intensity (area=0.80) and frequency (area=0.73) were useful to separate between air bubbles and emboli of presumed solid composition. Signal duration was the least accurate predictor (area=0.32). In animals, intensity was very good for distinguishing between microspheres and air bubbles (area=0.94) or between microspheres and fat (area=0.94). However, it was only a fair discriminator between fat and air bubbles (area=0.64). The signal duration (area=0.54-0.76) and frequency shift (area=0.54-0.63) were not as good as the intensity to classify emboli.

**CONCLUSIONS:** The HITS intensity best discriminated the embolic composition in our human and animal studies. Further advances in this area will require synthesis of embolic material of homogeneous and graded sizes.

**GASEOUS MICROEMBOLI GENERATION DURING CPB: THE ROLE OF ARTERIAL FILTER PURGE INTO THE CARDIOTOMY RESERVOIR**

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**INTRODUCTION:** Although particulate emboli are most associated with brain injury, gaseous microemboli account for the majority of the embolic events recorded by transcranial Doppler during cardiopulmonary bypass (CPB).<sup>1</sup> Medialstinal blood is typically aspirated into the cardiotomy reservoir (CR), which empties into a venous reservoir (VR). The blood coming from the CR has been identified as a source of lipid and gaseous ME. We hypothesized that modifying the CPB circuit design could reduce the embolic load emanated from the CPB apparatus. We report our results using a post CR inline filter in clinical practice.

**METHODS:** The CPB apparatus configuration included the CR (BARD-Lifestream, 3500 ml, 33µm), a post CR filter (COBE Sentry, 21µm). Two synchronous EDAC (Embolus Detection and Classification System) emboli detectors were positioned pre-CR filter and post-CR filter. This configuration was evaluated on 3 patients. After CPB was initiated, embolic activity was recorded as the route of the arterial filter purge was modified.

Standard Route: Arterial Purge line ? CR inner filter ? exit CR ? post CR filter  
Alternate Route: Arterial Purge line ? VR.

**RESULTS:** The post-CR filter reduced the GME that the CR internal filter failed to capture by 95.0 ± 2.9%. Rerouting the arterial purge line (directly into the VR) also resulted in a 95% reduction of the GME detected by the post CR transducer.

	Patient 1	Patient 2	Patient 3	Mean ± SD
GME Pre Filter	299,143	276,436	146,034	240,538 ± 82,626
GME Post Filter	9,770	9,093	12,144	10,336 ± 1,602%
GME Removal	96.7%	96.7%	91.7%	95.0 ± 2.9%

**CONCLUSION:** GME are generated by a fountain produced within the CR from the blood streaming from the arterial filter purge line. The use of additional GME trapping filters or an improved arterial purge technique can be used to reduce the total GME burden.

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**CLINICAL TRIAL OF THE NEUROPROTECTANT CLOMETHIAZOLE IN CORONARY BYPASS GRAFT SURGERY: A RANDOMIZED CONTROLLED TRIAL**

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**INTRODUCTION:** The neuroprotective property of clomethiazole has been demonstrated in several animal models of global and focal brain ischemia. In this study we investigated the effect of clomethiazole on cerebral outcome in patients undergoing coronary artery bypass surgery.

**METHODS:** 245 patients scheduled for coronary artery bypass surgery were recruited at two centers and prospectively randomised to clomethiazole edisilate (0.8%), 225 ml (1.8 mg) loading dose followed by a maintenance dose of 100 ml/h (0.8 mg/h) during surgery, or 0.9% NaCl (placebo) in a double-blind trial. Coronary artery grafting was completed during moderate hypothermic (28-32°C) cardiopulmonary bypass. Plasma clomethiazole was measured at several intervals during and up to 24 hours after the end of infusion. A battery of eight neuropsychological tests was administered preoperatively and repeated 4-7 weeks after surgery. Analysis of the change in neuropsychological test scores from baseline was used to determine the effect of treatment.

**RESULTS:** Neuropsychological assessments were completed in 219 patients (110 clomethiazole; 109 placebo). The mean plasma concentration of clomethiazole during surgery was 66.2 µmol/L. There was no difference between the clomethiazole and placebo group in the postoperative change in neuropsychological test scores.

**CONCLUSION:** Clomethiazole did not improve cerebral outcome following coronary artery bypass surgery.

**ANTIFIBRINOLYTICS DECREASE THE MRI RELATED CLAUSTROPHOBIA AFTER CARDIAC SURGERY**

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**INTRODUCTION:** A risk of perioperative stroke in uncomplicated cardiac surgery is generally perceived to be 1-3%. Recently, diffusion- (DWI) and perfusion-weighted (PWI) magnetic resonance imaging (MRI) have been identified as a valid measure of perioperative neurologic injury. Anxiety related cancellation rate of MRI in the general population is 4-10%.<sup>1</sup> The aim of this study was to determine a prevalence of claustrophobia in patients undergoing MRI after coronary artery bypass graft (CABG) surgery.

**METHODS:** A substudy of 311 patients scheduled for CABG surgery, initially randomized to receive either tranexamic acid (TA) or placebo control were assessed with postoperative MRI for early graft occlusion. Patients with a history of claustrophobia were excluded. TA 100mg/kg or placebo was administered prior to sternotomy. A standard fast-track anesthesia was utilized.<sup>2</sup> Systemic temperature was allowed to drift to 33°C during cardiopulmonary bypass (CPB). Hematocrit was maintained between 20-25%. Perfusion pressure during CPB was maintained between 50 and 70mmHg. Patients were rewarmed to 37°C prior to weaning from CPB.

**RESULTS:** A total of 237 patients underwent MRI procedures during the early and intermediate postoperative periods. Patients who received TA were less likely to experience claustrophobia. (Table below). Patients with claustrophobia were on average 5 years younger.

	TA (n = 147)	No TA (n = 164)	P value
MRI performed	118	119	0.558
MRI cancelled	29	45	0.111
Claustrophobia	12	27	0.028
Other	17	18	0.893

**CONCLUSION:** Postoperative claustrophobia may be pertinent to central nervous system injury. Antifibrinolytics decreased the prevalence of MRI related claustrophobia from 18.5% to 9.2% after CABG surgery. Caution should be exercised in using MRI as an outcome measure of CNS injury unless patients with claustrophobia are included in the analysis.

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### AORTIC ARCH REPAIR WITH A NEW CEREBRAL PROTECTION STRATEGY: COMBINED INTERMITTENT ANTEGRADE AND RETROGRADE CEREBRAL PERFUSION

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**INTRODUCTION:** The ideal cerebral protection strategy during hypothermic circulatory arrest (HCA) remains unknown. Many surgeons use either antegrade (ACP) or retrograde (RCP) cerebral perfusion. Because these two perfusion techniques have distinct mechanisms of cerebral protection, we propose that combining them may provide superior cerebral protection. The purpose of this report is to describe our initial experience with combined ACP/RCP.

**METHODS:** Eleven patients have undergone graft repair of the ascending aorta and transverse aortic arch using HCA with combined intermittent ACP/RCP. Antegrade perfusion was delivered via a balloon perfusion catheter placed in the innominate or left common carotid artery. Retrograde perfusion was administered via a superior vena caval cannula. The mean perfusion times included: 43±12 min circulatory arrest, 7±5 min ACP, 6±5 min RCP, and 156±40 min total cardiopulmonary bypass.

**RESULTS:** All 11 patients survived. One patient awoke with left upper extremity weakness due to an embolic right occipital cortical stroke. One patient developed dysphagia and left facial weakness on postoperative day 8.

**CONCLUSIONS:** Our initial results with combined intermittent ACP/RCP during aortic arch repair have been favorable. This new cerebral protection strategy deserves further investigation.

### REDUCTION OF STROKE FOLLOWING OFF-PUMP CORONARY ARTERY BYPASS

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**INTRODUCTION:** One factor underlying the failure to observe greater stroke reduction in off-pump coronary artery bypass (OPCAB) may be that decreased early neurologic complications are offset by increased delayed complications.<sup>1</sup> Reported thrombotic complications<sup>2</sup>, procoagulant activity<sup>3</sup>, and reduced platelet dysfunction<sup>4</sup> after OPCAB have supported the potential benefit of prophylactic antiplatelet and/or anticoagulant therapy<sup>3</sup>. We proposed that postoperative administration of Plavix and lovenox would reduce stroke incidence in OPCAB.

**METHODS:** 589 patients underwent OPCAB performed by a single surgeon between July 1997 and December 2001. Of those, 330 were operated on prior to routine postoperative administration of Plavix and lovenox. Stroke incidence in the OPCAB groups was compared to that in patients who underwent conventional on-pump surgery (n=80).

**RESULTS:** Physician-diagnosed stroke was 8.7% (n=7) in the on-pump group, 1.5% (n=5) in the OPCAB group prior to Plavix/lovenox and 0% in the OPCAB group following Plavix/lovenox. Overall analysis (Chi-square) indicated a significant difference across groups (p<.01). Specific comparisons indicated reduced stroke incidence in both off-pump groups compared to the on-pump group (p<.01), as well as reduced stroke incidence among off-pump patients receiving Plavix/lovenox versus those who did not (p<.05).

**CONCLUSIONS:** Prophylactic use of Plavix and lovenox postoperatively reduces stroke incidence in OPCAB.

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	On-Pump	OPCAB	OPCAB+Prophylaxis
Post-Op CVA	7 (8.75%)	5 (1.54%)	0 (0.0%)
No CVA	73 (91.25%)	319 (98.45%)	256 (100.0%)
Total	80	324	256

### CORONARY ARTERY BYPASS: THE INCREASING ROLE OF OFF-PUMP SURGERY IN A LARGE COMMUNITY HOSPITAL

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**OBJECTIVE:** In the recent past there have been dramatic changes in surgical myocardial revascularization—changes that are driven by a desire to improve outcomes while reducing costs and by patient demand. Coronary artery bypass without cardiopulmonary bypass has become an increasingly common technique to achieve these ends. This study compares the clinical and economic outcomes of myocardial revascularization with sternotomy without cardiopulmonary bypass (OPCAB) with conventional coronary artery bypass grafting (CCAB) at a large community medical single institution.

**METHODS:** The charts of 1,172 patients undergoing coronary bypass grafting via a median sternotomy at the Lehigh Valley Hospital in Allentown, PA, between January 1, 1999 and June 30, 2000 were retrospectively reviewed. Patients who underwent revascularization through a thoracotomy with or without cardiopulmonary bypass and those who had concomitant carotid endarterectomy were excluded. We compared the mortality, complications, hospital days, and total inpatient costs between these groups. Continuous outcomes were compared using the Student's t-test; binary outcomes were compared using a chi-squared test. Logistic regression was used to estimate risk of mortality due to conversion to standard incision.

**RESULTS:** OPCABs accounted for 11.08% (45/406), 17.18% (67/390), and 35.37% (133/376) of the procedures in the first, second, and third 6-month periods, respectively. OPCAB and CCAB patients were similar in regard to age, gender, race, ejection fraction, left mainstem stenosis, and major comorbidities. CCAB patients had a higher incidence of previous coronary bypass grafting (7.66% vs. 2.45%) but a lower incidence of other prior cardiac surgical procedures (0.43% vs. 2.04%) compared to OPCAB patients. Postoperatively OPCAB patients had a lower incidence of stroke (0.41% vs. 2.80%), sternal wound infection (0.00% vs. 0.43%), red blood cell transfusion (50.40% vs. 64.50%), and readmissions within 30 days (0.82% vs. 3.34%). There were no significant differences in total hospital costs, length of stay, or the incidence of perioperative myocardial infarction, postoperative atrial fibrillation, or renal insufficiency in the two groups. There was a trend toward decreased mortality, fewer pulmonary complications, and shorter duration of ventilator support in the OPCAB patients, but none of these differences were statistically significant. OPCAB patients had a higher incidence of reoperation for graft dysfunction (2.86% vs. 0.43%), and 8.16% (20/245) required conversion to CCAB. The adverse effects of conversion to CCAB included increased cost (\$35,547 vs. \$17,987, p=0.0441), length of stay (13.3 days vs. 7.9 days, p=0.0195), and mortality (5.00% vs. 0.44%, p=0.0300).

**CONCLUSION:** The early clinical and economic outcomes of myocardial revascularization without cardiopulmonary bypass are equal to or better than conventional bypass procedure outcomes in most patients in our academic community hospital setting.

**PERIOPERATIVE CHANGES IN DW-MRI IN PATIENTS UNDERGOING OPCAB OR CONVENTIONAL CABG**

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Preliminary evidence suggests that patients undergoing off-pump coronary artery bypass (OPCAB) may be at less risk of neurological and cognitive complications than those undergoing conventional coronary artery bypass grafting (CABG). This study was undertaken to determine whether there were any structural changes demonstrable of perioperative diffusion weighted magnetic resonance imaging (DW-MRI) of the brain in either patient group.

**METHODS:** 12 patients undergoing OPCAB and 14 undergoing CABG underwent neurological and cognitive testing preoperatively and at 5 to 7 days and 3 months postoperatively. DW-MRI was also performed preoperatively and prior to hospital discharge.

**RESULTS:** Using Fischer's exact test with  $p < 0.05$  required for significance, there were no statistically significant differences in cognitive performance or neurological examination at any time between groups. On postoperative study 2 patients in CABG group and 1 patient in OPCAB had evidence of new single or multiple acute cerebral infarcts, 2 of 3 patients having decrease in cognitive scores, but none of which were clinically detectable.

**CONCLUSION:** In this small study, the incidence of structural brain lesions was similar independent of mode of surgery suggesting that some factor common to both, ie. use of partial occlusion clamp on aorta, may be etiologic.

**OUTCOMES OF OFF-PUMP SURGERY: A PROSPECTIVE RANDOMISED STUDY WITH CONVENTIONAL BYPASS**

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**BACKGROUND:** Surgical techniques to minimise exposure to cardiopulmonary bypass (CPB) have gained popularity, however there is still limited published prospective randomised data to support their use, and long term outcomes remain to be demonstrated. The aim of this study was to determine if off-pump coronary artery bypass graft (CABG) surgery provides myocardial and cerebral protection comparable to conventional CABG surgery.

**METHODS:** With institutional approval and written consent, 53 elective patients requiring surgery for multiple vessel disease were randomised to receive either CABG surgery with CPB (n=29) or off-pump CABG surgery using the Octopus II<sup>®</sup> stabilising system (n=24). Troponin T was measured preoperatively, and at 2, 4, 6, 8, 10, 12, 24, and 72 hours after initiation of grafting. A neuropsychological assessment was performed preoperatively (n=53), one week (n=53), and 6 months (n=45) postoperatively.

**RESULTS:** The two groups were comparable on risk factors, surgical parameters, and clinical outcome, including the composite clinical end point (prolonged LOS or ICU stay or 30d mortality). At 6 months, the off-pump group significantly reduced their incidence of deficits on the verbal memory domain (\* $p < 0.05$ ), and displayed a significant reduction in the overall severity of neuropsychological deficits ( $p < 0.01$ ). Troponin T release was reduced in the off-pump patients (repeated measures ANOVA  $p = 0.05$ ).

Domain (% patients with deficits)	On-pump 7 days	Off-pump 7 days	On-pump 6 months	Off-pump 6 months
Memory	20.7%	33.3%	16.7%	9.5%*
Co-ordination	20.7%	8.3%	8.3%	0
Attention	41.4%	37.5%	29.2%	19.0%

**CONCLUSION:** Off-pump surgery using the Octopus II<sup>™</sup> stabilising system results in a decreased myocardial insult compared with conventional CABG surgery with CPB, whilst providing similar early clinical outcomes. Our data supports the belief that there may also be some neuropsychological benefit associated with off-pump surgery.

What rules should be in place to bring new technology to the operating room? How long before we see the results of some large randomised trials supporting off-pump surgery?

**THE OCTOPUS TRIAL: LIMITED EFFECT OF OFF-PUMP BYPASS SURGERY ON COGNITIVE OUTCOME**

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**Introduction** The Octopus Trial was designed to directly compare off-pump and on-pump coronary bypass surgery (CABG). It was assumed that off-pump and on-pump CABG have similar cardiac outcome, but that cognitive outcome would be better in patients operated without cardiopulmonary bypass (CPB).

**Methods** Between 1998 and 2000, 281 patients were included in the study and randomly assigned to off-pump and on-pump coronary bypass surgery. Cognitive performance of the participants was determined by psychologists, blinded for randomization, who administered 10 neuropsychological tests with 11 main variables at baseline, at four days, at three months and twelve months after surgery. As a dichotomous outcome measure, we defined Cognitive Decline as a decrease in an individual's performance of at least 20% from baseline, in at least 20% (i.e. three) of the main variables. As a continuous cognitive outcome measure, we calculated the mean of the change in cognitive performance on each test (Standardized Change Score, SCS). Results No differences in measures of cardiac outcome were observed.<sup>1</sup> Patients undergoing CABG without cardiopulmonary bypass had improved cognitive outcome at 3 months. The effect, however, was smaller than anticipated and became negligible at 12 months.<sup>2</sup>

Cognitive status at 4 days, 3 months and twelve months, compared to baseline performance\*

	4 days after surgery			3 months after surgery			12 months after surgery		
	off-pump (n=111)	on-pump (n=108)	p	off-pump (n=128)	on-pump (n=120)	p	off-pump (n=130)	on-pump (n=122)	p
CD	49%	57%	0.28	21%	29%	0.15	31%	34%	0.67
SCS	-0.10	-0.08	0.80	0.19	0.13	0.03	0.19	0.12	0.09

\* CD denotes Cognitive Decline, SCS Standardized Change Score (medians). A SCS greater than 0 reflects improved performance in comparison to baseline performance.

**DISCUSSION:** Several reasons may be considered to explain why the beneficial effect of off-pump surgery on cognitive outcome was limited. 1. Factors other than CPB may cause cognitive decline after CABG. It is conceivable that undergoing anesthesia or undergoing major surgery affects cognitive function. 2. The off-pump technique may be a new source of cognitive decline. Exposure of the posterior cardiac wall frequently leads to decreased cerebral perfusion pressure. 3. The effects of an off-pump technique may be more marked in older patients with more extensive aortic disease and co-morbidity. 4. Improved cognitive outcome by using an off-pump technique may only become clearer in the long term. 5. Methodological flaws of defining decline cause the presumed high incidence of cognitive decline after CABG. The true size of the problem may be much lower than assumed.<sup>3</sup>

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### THE IMPORTANCE OF INTRAOPERATIVE VARIABLES AS PREDICTORS OF MORBIDITY FOLLOWING CARDIAC PROCEDURES

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**INTRODUCTION:** Traditionally outcomes assessment of cardiac surgery has tracked preoperative variables as indicators of risk. Preoperative variables are both difficult to modify and limited in their impact on outcome. Consequently, study was undertaken to compare the relative importance of preoperative variables to those variables that indicate how patients are treated during their operation and subsequent hospitalization. Excessive blood utilization was used as a typical morbidity.

**METHODS:** A retrospective analysis was performed in 4,444 patients who underwent cardiac surgery over a 4 year period. Multivariate logistic predictor variables of excessive blood product transfusion (defined as greater than 10 units of non-autologous donor exposure) were measured.

Variable	Relative risk (95% C.I.)
On ventilator at 24 hours post-op	3.23 (2.50 – 4.17)
Postoperative inotropic support	2.42 (1.93 – 3.04)
Type of operation (non-CABG)	1.81 (2.31 – 2.51)
Unstable hemodynamics in OR	1.74 (1.08 – 2.79)
Hematocrit at start of CPB	0.913 (0.894 – 0.933)
Redo procedure	1.54 (1.11 – 2.14)
ACT at start of CPB	1.200 (1.001 – 1.304)
Surgeon	1.09 (1.05 – 1.13)
Cardiopulmonary bypass time	1.01 (1.06 – 1.011)

**RESULTS:** Analysis of the frequency of blood product transfusion revealed that 10% of the patients consumed 70% of all of the non-autologous blood products. In the high transfusion group, mortality was increased 10-fold compared to patients who received less than 10 units of blood products, i.e. 15% (77/509) versus 1.4% (56/3935),  $p < 0.001$ . Significant multivariate predictors of excessive postoperative transfusions are shown in the table. This risk model is much different, and much more predictive, than the model that only considers preoperative variables.

**CONCLUSION:** The findings show that intraoperative and postoperative variables are more important indicators of outcome than are preoperative risk factors. These results suggest that maintenance of intravascular volume, aggressive ventilator care, meticulous heparin management, minimization of CPB time, and optimal intraoperative myocardial protection could result in a significant reduction in excessive postoperative blood transfusion. Quality improvement initiatives that focus on intraoperative variables may be more productive than efforts at preoperative risk reduction.

### COGNITIVE SELF-ASSESSMENT ONE YEAR AFTER SURGERY: A COMPARISON BETWEEN ON- AND OFF-PUMP CABG

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**INTRODUCTION:** Only a few studies have reported on the incidence, severity, and course of subjective cognitive functioning after CABG. The purpose of this study was to explore if there is an increase in self-reported cognitive failures and complaints one year after CABG. A second objective was to evaluate whether there is a difference in self-reported cognitive failures between on- and off-pump CABG.

**METHODS:** Informed consent and institutional approval for the study were obtained. The Cognitive Failures Questionnaire (CFQ) was administered preoperatively and 1 year postoperatively to 68 CABG patients that were randomized to on- (N=29) or off-pump (N=39) surgery. Multivariate repeated measures analyses of variance were performed with CFQ total score and CFQ complaints score as dependent variables, and treatment as independent variable.

**RESULTS:** There was no overall difference between pre- and postoperative CFQ total score ( $F=0.729, p=0.4$ ) or CFQ complaints score ( $F=0.734, p=0.4$ ).

**CONCLUSIONS:** There is no increase in cognitive failures and complaints one year after CABG in either on-pump or off-pump CABG.

### STROKE AFTER CORONARY ARTERY BYPASS GRAFTING: AN UPDATED PREDICTION MODEL

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**INTRODUCTION:** Determine the incidence, consequences, and predictive factors for stroke following CABG and compare them to those of a population of patients evaluated 10 years earlier at our institution.

**METHODS:** Prospective evaluation of 2771 patients operated upon between January 1997 and December 2000. Preoperative risk factors were obtained before surgery, and postoperative outcomes were determined on each postoperative day before discharge. Stroke was defined as a focal neurological deficit lasting for 24 hours or more. All strokes were confirmed by neurological consultation and, in most instances, by imaging. Logistic regression analyses were performed to determine risk factors for these outcomes.

**RESULTS:** In the earlier population ( $n=1750$ ), 3.9% of patients had a stroke, and those patients had a length of hospital stay (LOS) of 22.4 days, a mortality rate of 19%, and five factors were required for stroke prediction (past CVA, hypertension [HTN], age, presence of a carotid bruit and diabetes mellitus). The current population has a stroke incidence of 2.6% with a LOS of 17.5 days and 22% mortality. The new model for stroke includes only three preoperative risk factors: past CVA (OR 2.1,  $p=0.04$ ), HTN (OR 2.0,  $p=0.04$ ) and age ( $>65-75$  years, OR 2.4,  $p=0.01$ ;  $>75$  years: OR 5.0,  $p<0.01$ ).

**CONCLUSIONS:** Predictive models for risk of stroke after CABG developed in the past may not be applicable to current populations of patients. Further investigation would be necessary to determine why some previous factors may no longer predict risk.

### LACK OF PREMORBID COGNITIVE ESTIMATES INVALIDATES CONCLUSIONS REGARDING COGNITIVE DECLINE AFTER CABG

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**INTRODUCTION:** We examined change in the cognitive functioning of on-pump and off-pump CABG patients.

**METHODS:** After obtaining IRB approval and informed consent, 17 patients were randomly assigned to receive on-pump (n=8) or off-pump (n=9) CABG. Patients were administered seven neuropsychological tests, including those recommended by the statement of consensus (1), prior to surgery, and at 6 days, 4 months, and 16 months post-surgery. Alternate forms of the measures were administered when available. Data were analyzed with several strategies routinely utilized to assess this population (2).

**RESULTS:** Although baseline cognitive functioning was comparable between groups, on average patients scored  $\geq 1$  SD below the age-related norms on 35% of the measures with some patients scoring below average on 75% of the measures (Range=0.06-0.75; SD=0.21)! The overall low baseline scores made it impossible to detect consistent patterns of cognitive decline.

**CONCLUSIONS:** Conclusions regarding cognitive decline following CABG could not be drawn in this sample due to the lack of premorbid IQ estimates. Consideration of premorbid IQ estimates is essential for evaluating pre-op scores on neuropsychological measures. Discrepancies in premorbid IQ and low baseline performance may indicate cognitive impairment prior to surgery. Finally, future studies should consider other potential moderator variables, such as socioeconomic status, disease status, and education, in addition to IQ, when evaluating the effects of CABG on cognitive functioning.

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### INVESTIGATION OF CEREBRAL DYSFUNCTION DURING AND AFTER HYPOTHERMIC CARDIOPULMONARY BYPASS IN BABOONS

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**Purpose:** Cerebral complications after cardiopulmonary bypass (CPB) with or without deep hypothermic circulatory arrest are often related to the regional cerebral oxygen saturation (rSO<sub>2</sub>) levels in pediatric heart surgery patients. When cerebral dysfunction occurs, the rSO<sub>2</sub> levels are significantly decreased (more than 20% compared to the pre-CPB level). The objective of this study was to investigate the effects of hypothermic CPB (27°C) on regional cerebral oxygen saturation levels using near-infrared spectroscopy (NIRS) in baboons.

**METHODS:** The study involved seven baboons (mean weight, 15 kg). A novel NIRS INVOS Pediatric Cerebral Oximeter, which has advantages of being non-invasive and continuous (in real-time), was used. The NIRS sensor was placed on each animal's forehead. After initiation of CPB, all animals were subjected to 20 minutes of core cooling, 60 minutes of hypothermic CPB while the aorta was cross-clamped, and 30 minutes of normothermic CPB. During CPB, the mean arterial pressure and pump flow was 50-60 mmHg and 100 ml/kg/min, respectively. The rSO<sub>2</sub> levels were recorded before CPB, during CPB, and 30, 60, 120, 180, and 360 minutes after CPB.

**RESULTS:** The total duration of CPB was 135 minutes. The rSO<sub>2</sub> levels did not change during normothermic CPB compared to the pre-CPB levels (47%  $\pm$  8.5% vs. 46.7%  $\pm$  8.1%, p = NS). The rSO<sub>2</sub> levels were slightly increased during hypothermic CPB at 27°C (53.5%  $\pm$  6%), and at the end of CPB (49%  $\pm$  7.1%). There were no decreases in rSO<sub>2</sub> levels after 30 min (51.8%  $\pm$  8.9%), 60 min (52.8%  $\pm$  10.2%), 120 min (53.2%  $\pm$  6%), 180 min (52.2%  $\pm$  11.1%), and 360 minutes (54.2%  $\pm$  15.7%) post-CPB.

**CONCLUSIONS:** In our baboon model, there was no sign of cerebral dysfunction after full-flow hypothermic CPB with 60 minutes of aortic cross-clamping. The NIRS INVOS Cerebral Oximeter is an excellent tool to monitor the rSO<sub>2</sub> during and after CPB.

### A COGNITIVE COMPARISON OF CARDIAC ASSIST DEVICES WITH END-STAGE HEART FAILURE COHORTS

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**INTRODUCTION:** Neuropsychological impairment is frequently associated with cardiac disease, open-heart surgery, and coronary artery bypass surgery. Neuropsychological assessments for transplant candidates are routine in most transplant centers. To date, cognitive data for patients receiving cardiac devices are not available. This study compared in-patients identified for mechanical cardiac assist devices (MCAD) with end-stage heart failure (ESHF) in-patients on cognitive measures including memory, motor, strength, and processing speed.

**METHODS:** Cognitive data for 53 (28M/25F) potential MCAD patients (21-69y/o, x 51.9) was collected. MCAD etiology included: ischemic (20), idiopathic (19), postpartum cardiomyopathy (1), and structural (1). MCAD candidates were compared with 298 (245m/53f) ESHF in-patients (17-68y/o, x 49.42) on all cognitive measures. ESHF etiology included: ischemic (153), idiopathic (100), structural (10), congenital (25), viral (1), and other (1).

**RESULTS:** MCAD candidates were significantly different from ESHF in-patients across all cognitive domains (p < .001). ESHF patients performed better than MCAD candidates on all measures with the exception of non dominant grip strength.

**CONCLUSIONS:** Prospective cardiac assist device patients differ from other end-stage heart failure patients on cognitive measures. Clinical significance of such differences was considered. Factors such as severity of heart disease, the impact of other organ system involvement, and level of inotropic support may account for these differences.

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### PEDIATRIC PHYSIOLOGIC PULSATILE PUMP ENHANCES CEREBRAL AND RENAL BLOOD FLOW DURING AND AFTER CARDIOPULMONARY BYPASS WITH DEEP HYPOTHERMIC CIRCULATORY ARREST IN A NEONATAL PIGLET MODEL

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**PURPOSE:** To date, controversy over the benefits of pulsatile flow after pediatric cardiopulmonary bypass (CPB) still continues. Our objectives of this study were 1) to quantify the pressure and flow waveforms in terms of hemodynamic energy, using the energy equivalent (EEP) formula, for direct comparisons, and 2) to investigate the effects of pulsatile versus nonpulsatile flow on cerebral and renal blood flow during and after CPB with deep hypothermic circulatory arrest (DHCA) in a neonatal piglet model.

**METHODS:** Fourteen piglets (mean weight of 3kg) underwent perfusion with either the hydraulically driven dual-chamber physiologic pulsatile pump (n = 7) or a conventional nonpulsatile pump (n = 7). After initiation of CPB, all animals were subjected to 25 minutes of core cooling (18°C), followed by 60 minutes of DHCA, 10 minutes of cold reperfusion, and 40 minutes of rewarming. Mean arterial pressures (MAP) were maintained at 45 to 50 mmHg in both groups. Radiolabelled microsphere technique was used to determine the cerebral and renal blood flow.

**RESULTS:** Pulsatile pump produced significantly higher hemodynamic energy (from MAP to EEP) compared to the nonpulsatile pump during normothermic CPB (12.9% $\pm$ 3.2% vs. 0.7% $\pm$ 0.5%, p < 0.0001), hypothermic CPB (15.3% $\pm$ 4% vs. 0.9% $\pm$ 0.9%, p < 0.0001), and after rewarming (16.3% $\pm$ 4.5% vs. 0.7% $\pm$ 0.5%, p < 0.0001). Global cerebral blood flow was significantly higher in the pulsatile group compared to the nonpulsatile group during CPB (104 $\pm$ 12 ml/100gm/min vs. 70 $\pm$ 8 ml/100gm/min, p < 0.05). In the right and left hemispheres, cerebellum, basal ganglia, and brain stem, blood flow resembled the global cerebral blood flow. Pulsatile pump improves renal blood flow (94 $\pm$ 20 ml/100gm/min vs. 22 $\pm$ 20 ml/100gm/min, p < 0.05) after CPB.

**CONCLUSIONS:** Pediatric physiologic pulsatile pump generates significantly higher hemodynamic energy, enhancing cerebral, and renal blood flow during and after CPB with DHCA in this model.

**CASE REPORT: GME FROM VENOUS CANNULA DETECTED BY ARTERIAL INFLOW MONITORING**

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**CASE REPORT:** Neuropsychologic impairment and consequential long term cognitive deficits are well documented complications following cardiopulmonary bypass (CPB).<sup>1</sup> Although particulate and lipid emboli are more likely to cause significant brain injury, gaseous microemboli (GME) account for the majority of the embolic events recorded by transcranial Doppler.<sup>2</sup> We describe how embolic monitoring of the arterial inflow line during CPB provided opportune information for corrective action during CPB. The extracorporeal circuit was configured with an EDAC (Embolus Detection and Classification System) transducer positioned distal to the arterial filter outflow. The EDAC system relies upon new technology, based on SONAR, designed specifically for emboli quantification. After initiation of CPB, > 28 emboli per sec were detected in the arterial inflow line. The perfusionist was unable to identify any apparent cause of GME, i.e. low venous reservoir levels. The purse-string suture surrounding the venous cannula was inspected and found to allow entrained air. The resulting GME exited the cava and exceeded the GME handling capability of the CPB apparatus. The figure (150 sec histogram) below indicates the immediate reduction of GME following purse-string suture repair.

**CONCLUSION:** GME emanating from the CPB apparatus will go unnoticed if neither the patient nor the arterial inflow line is monitored. Effective embolic monitoring during CPB can provide important feedback to the surgical team in their effort to reduce the potential for a negative outcome following cardiac surgery.

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**INTRAOPERATIVE RISE IN S100B AND NSE DURING CABG COMES FROM MEDIASTINUM AND NOT BRAIN**

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**INTRODUCTION:** S100B and NSE have been shown to rise during CABG with a peak at the end of bypass. This was thought to be a sensitive reflection of cerebral damage from bypass, but the high S100B found in post-op mediastinal drainage suggested a possible non-cerebral cause for at least some of the rise.

**METHODS:** 21 patients undergoing elective CABG, 11 on bypass @ 32°C with scavenged mediastinal blood recirculated (ON) and 10 off-pump with no recirculation (OFF). Arterial S100B and NSE were assayed at 8 points over the operation, and samples of mediastinal shed blood collected. Data were analysed using repeated ANOVA.

**RESULTS:** ON showed the classic rise in S100 and NSE with a peak at the end of CPB (S100B  $2.7 \pm 0.7$ , NSE  $15.4 \pm 3$  mcg.L-1), OFF showed no significant rise for S100B or NSE. Mediastinal blood had very high S100B (ON  $31.6 \pm 6$ , OFF  $30.2 \pm 8$  mcg.L-1).

Mediastinal NSE was also very high (>200 mcg.L-1) but there was marked haemolysis. ANOVA confirmed that surgical technique did not explain the observed changes ( $p=0.58$ ) but site of sampling (arterial v. mediastinal) was very strongly associated ( $p<0.001$ ).

**CONCLUSIONS:** Intra-operative rise in S100B and NSE appears to be due to recirculation of mediastinal blood containing high levels of neuroproteins. NSE may be due to haemolysis, but the source of S100B is obscure. It seems unlikely to be from adipose tissue since there is no rise after sternotomy. The source of this high S100B must be found before the significance of a rise in peri-operative S100B or NSE can be determined

**SURFACE MODIFICATION OF EXTRACORPOREAL CIRCUITS: IS THERE REALLY AN IMPACT ON THE PATHOPHYSIOLOGY OF CARDIOPULMONARY BYPASS?**

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**INTRODUCTION:** Target of our investigation was to measure the effect of surface modified circuits SMAR<sub>x</sub>T (Cobe<sub>inc.</sub> Denver, USA) on neurological complications in combination with a totally modified aspiration management.

**METHODS:** The study was performed as a prospective randomized clinical trial comprising 100 patients undergoing elective CABG surgery. The patients were randomly divided in two subgroups. In one subgroup a circuit with surface modification (SMAR<sub>x</sub>T), in the other arm untreated circuits were used. The aspiration management was optimized as follows: totally closed system, no coronary suction, modified vent, cell saver, no shed blood re-transfusion. Clinical markers and blood analysis of the daily routine were collected pre-, intra- and postoperatively. The trial focus was on the neurological outcome. We performed a bedside neuropsychological test battery (Beck's Anxiety Inventory (BAI), d<sub>2</sub> test of Attention (d<sub>2</sub>), Trail Making Test (TMT), Benton Test) preoperative, three and six days after the intervention.

**RESULTS:** No clinical- or blood markers showed any significant differences between the both groups. Likewise the clinical outcome was equivalent in all patients. The cerebral capability was reduced three days postoperative and recovered after the sixth day to preoperative levels. Both study groups had statistic similar results with a small trend to the control group. However, the practicability of a neuropsychological testing in the first three days after cardiac procedures is reduced. Only 20 % of all patients could complete the complex testing.

**CONCLUSION:** In the present trial the use and usefulness of extracorporeal circuits treated with surface modifying additives has to be reviewed critically. In this small cohort, the proof of possible improved neurological benefits could not be shown, but this problem is also present in off-pump studies.

**S100B AND NSE LEVELS FROM THE JUGULAR BULB DURING CEA**

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**INTRODUCTION:** Serum levels of S100B and NSE measured 24 hours after carotid endarterectomy (CEA) correlate with cognitive injury. The purpose of this study was to determine if serum levels of these markers change within the intraoperative period when measured from the jugular bulb (JB).

**METHODS:** 30 patients scheduled for elective CEA were anesthetized with a general anesthetic. They were monitored with routine monitors as well as with an EEG and a radial arterial catheter.

During surgery the facial vein was cannulated with a 6 Fr Fogarty irrigating catheter on the same side that the CEA was being performed. It was passed to the level of the JB. 5-10 cc serum samples were obtained from both the JB and a radial artery catheter before, 15 minutes after clamping and within 5 minutes after unclamping the carotid artery. All samples were analyzed using an immunoluminometric assay (LIA-mat Sangtec 100 and LIA-mat NSE; AB Sangtec Medical, Bromma, Sweden). The different time periods were compared by Students T-Test.

**RESULTS:** Serum levels of S100B increased significantly within 15 minutes after clamping the carotid artery. These levels returned to baseline within 5 minutes of unclamping the carotid artery. No significant increases in NSE were demonstrated from the JB. No increases in either marker were seen from samples obtained from the radial artery.

**CONCLUSION:** Increases in S100B from the JB do not reflect injury to neurons. It may indicate changes in the blood brain barrier, because S100B increases rapidly without a concomitant increase in serum concentrations of NSE.

**NOVEL ANTI-FACTOR D MONOCLONAL ANTIBODY INHIBITS COMPLEMENT AND LEUKOCYTE ACTIVATION IN A BABOON MODEL OF CARDIOPULMONARY BYPASS**

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**PURPOSE:** Patients undergoing cardiopulmonary bypass (CPB) frequently manifest a generalized systemic inflammation that is associated with complement and leukocyte activation. The objective of this study was to investigate the effects of inhibition of the alternative complement pathway on systemic inflammation and tissue injury, using a novel monoclonal antibody (Mab), anti-factor D Mab 166-32, during hypothermic CPB in baboons.

**METHODS:** Fourteen baboons (mean weight, 15 kg) underwent hypothermic CPB. Seven of them were treated with a single injection of anti-factor D Mab 166-32 (5 mg/kg) and the other seven animals were given saline as control. After initiation of CPB, all animals were subjected to 20 minutes of core cooling (rectal temperature, 27°C), followed by 60 minutes of aortic cross-clamping, 25 minutes of rewarming, and 30 minutes of normothermic CPB. Blood samples were collected before CPB, during CPB, and 1, 2, 3, and 6 hours after CPB. Assays were performed to measure neutrophil and monocyte activation using flow cytometry for CD11b expression, ELISA for complement activation (C3a, sC5b-9 and Bb) and IL-6 production, and myocardial injury for CK, CK-MB, and LDH levels.

**RESULTS:** The following results were documented after 6 hours of CPB (mean±SD).

Assay	Control	Mab 166-32	p value
Bb (ng/ml)	547±155	147±38	0.0001
C3a (µg/ml)	24±15	10±5	0.0001
sC5b-9 (ng/ml)	167±53	82±51	0.0001
IL-6 (pg/ml)	104±54	71±27	0.0002
CD11b (neutrophils)	8.9±4.5	4.8±1.6	0.0001
CD11b (monocytes)	5.7±3	3.6±1	0.001
CK-MB (IU/L)	336±145	204±73	0.03

CK and LDH levels were also significantly lower in the antibody group.

**CONCLUSIONS:** The alternative complement pathway plays a major role in systemic inflammation during CPB. Inhibition of complement activation via the alternative pathway by anti-factor D Mab 166-32 significantly reduces leukocyte activation, and myocardial injury in our baboon model.

**NUTRITIONAL SUPPLEMENTATION WITH MYOVIVE® REPLETES ESSENTIAL CARDIAC MYOCYTE NUTRIENTS AND REDUCES LEFT VENTRICULAR SIZE F**

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CHF depletes the myocardium of carnitine, coenzyme Q10 and taurine, substances known to influence mitochondrial function and cell calcium. We hypothesized that feeding patients a liquid nutritional supplement which contained these nutrients would not only increase myocardial concentrations but would also improve ventricular function.

**METHODS:** Forty patients with grade III or less left ventricular function undergoing coronary artery bypass surgery were randomized to a double-blind trial of MyoVive® (M) or placebo (P). Radionuclide ventriculography was performed at randomization and just prior to surgery, after an average of 35±9.2 days of supplementation. Myocardial biopsies were collected at the time of surgery and analyzed for carnitine, coenzyme Q10 and taurine concentrations (adjusted for protein content).

**RESULTS:** The groups were well matched. Minor exceptions included M vs P for digoxin (7 vs 0 respectively, p=0.0087) and age (62±11.0 vs 69.5±5.0 respectively, p=0.0395). Biopsy samples revealed significantly higher concentrations of coenzyme Q10, taurine, and carnitine in the supplemented group in comparison with the placebo group (138.2±39.9 and 56.7±3.1 nmol/g wet weight (p<0.005), 13.1±4 and 7.9±2.8 mmol/g wet weight (p<0.002), 1735.4±798.5 and 1237.6±43.1 nmol/g wet weight (p=0.056 and p=0.028 one tailed) respectively. The end diastolic volume (EDV) fell by -7.5±21.7 in the supplemented group while increasing by 10.0±19.8 in the placebo group, the difference was statistically significant (p=0.037). The supplement was found to be safe and tolerable.

**CONCLUSIONS:** Supplementation increases myocardial coenzyme Q10, taurine and carnitine concentrations and is associated with a reduction in Left Ventricular End Diastolic Volume in patients with CHF prior to revascularization. Since reduction in LVED results in improved prognosis, supplementation could potentially show improved outcomes in larger studies.

**CEREBRAL BLOOD FLOW MONITORING USING TRANSCRANIAL DOPPLER ULTRASOUND DURING ACUTE TYPE A AORTIC DISSECTION**

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**INTRODUCTION:** Acute Type A aortic dissection is associated with a significant risk of permanent and temporary neurologic deficits (TND). These deficits may result from cerebral mal-perfusion that occurs before and during cardiopulmonary bypass (CPB). The use of transcranial doppler ultrasound (TCD) to monitor cerebral blood flow (CBF) during these repairs allows confirmation of adequate CBF when establishing arterial cannulation during CPB. The purpose of this study was to analyze the use of TCD during repairs of acute Type A dissection with regard to neurologic outcome.

**MATERIALS AND METHODS:** A prospective study of patients undergoing repairs of acute Type A aortic dissection was performed. Repairs included CPB, profound hypothermic circulatory arrest (PHCA), and retrograde cerebral perfusion (RCP). Patients in which the TCD was used to monitor CBF during repair (Group 1) were compared to those without TCD (Group 2). Perioperative factors were analyzed and mortality and neurologic outcomes were reported.

**RESULTS:** Between 9/2001 and 2/2002, 18 cases of acute Type A dissection were repaired. TCD was used in 61% (11/18) cases (Group 1). TCD confirmed antegrade CBF during CPB and reversed CBF during RCP in 100% (11/11) cases. 30-day mortality was 16.7% (3/18). Two patients presented with preoperative stroke, one in each group. One operative death occurred in each group not allowing evaluation of postoperative outcomes.

Table 1: Outcomes comparing Group 1 (with TCD) versus Group 2 (without TCD)

	Group 1	Group 2	P-value
Mortality	9.1% (1/11)	28.6% (2/7)	P<0.27
TND	20.0% (2/10)	66.7% (4/6)	P<0.06
Stroke	0.0% (0/10)	0.0% (0/6)	P=1.0

**CONCLUSIONS:** Transcranial Doppler ultrasound consistently demonstrated antegrade CBF during CPB and retrograde CBF during PHCA with RCP. Although no significant difference in mortality, stroke, or TND were observed, TCD might provide a method for confirming the adequacy cerebral blood flow during repairs of acute Type A aortic dissection.

### IMPACT OF COATED OXYGENATORS ON BLOOD USE: A PROSPECTIVE RANDOMIZED TRIAL

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**INTRODUCTION & METHODS:** This randomized, prospective clinical trial examines the impact of the use of a coated circuit (Trillium™ biopassive surface coating) on clinical outcomes after cardiopulmonary bypass (CPB) that may be induced by contact of blood elements with foreign surfaces. The study consisted of 98 consecutive patients randomly assigned to either a CPB circuit that consisted of a Trillium-coated Affinity open reservoir oxygenator or a CPB circuit with an uncoated Affinity open reservoir oxygenator. The operative procedure performed on all 98 patients consisted of either coronary artery bypass graft (CABG), valve or a combination of the two. Exclusion criteria consisted of patients that presented to the operating room in circulatory arrest.

**RESULTS:** Table 1 shows results of independent predictors of use of units of blood products. Significant, independent predictors of units of blood products are: treatment (Trillium coated group), peripheral vascular disease (PVD), IABP, interaction of treatment group and predicted stroke, gender, and use of Amicar. The use of blood products, in turn, explains over 62% of the variance in development of any post-operative complications (postop atrial fibrillation, pulmonary edema, pneumonia, and post operative CVA).

**CONCLUSIONS:** These data provide an example of how a particular treatment impacts an intermediary clinical outcome that, in turn, impacts the final clinical outcome of interest. The impact of this particular treatment on the development of postoperative complications takes place through its significant reduction in units of blood products utilized.

Table 1: Independent predictors of units blood product

Outcome	Coefficient	p-value
Treatment (Trillium coated)	-2.80	0.0322
PVD	4.15	0.0094
IABP	2.63	0.0549
Treatment * pred stroke	-0.79	0.0008
female	2.69	0.0179
Amicar	-2.85	0.0070

+significant @ p <0.05

### CLINICAL OUTCOMES OF COMPLETE X-COATING CIRCUIT IN MAST: CONDENSED BYPASS SETTING

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**PURPOSE:** To present clinical outcome and blood utilization data of a preliminary clinical trial using a complete X-coating circuit in a condensed setting.

**METHODS:** Twenty (n=20) consecutive coronary surgery patients were studied prospectively. Range, mean and percentage were calculated for age, BSA, respiratory support times, ICU length of stay (LOS), hospital LOS and intra-operative transfusion requirements. Two patients in extremis, operated on emergently were excluded from statistical analysis. MAST system utilized X-coating tubing, cannulae and Capiox SX18 oxygenator.

**RESULTS:** Average age was 65 years (52-78 yr.), average BSA 1.85 (1.60-2.45) with 65% being males. Average CPB time was 103 minutes (60-180 minutes) with clamp time 67 minutes (40-129 minutes). Average intra-operative platelet count was 152,000 (120-205K). Average immediate postoperative count was 150,000 (106-204K). Percentage change in platelets ranged from -22% to +44%. There was no mortality. Average respiratory support time was 9.6 hours (4-26 hours) with 78% having less than 24 hours stay and 94% less than 48 hours stay. Average hospital LOS was 6.4 days (4-11 days) with 89% discharged by 7 days.

**CONCLUSION:** Complete X-coating circuit is safe and improved outcome parameters in our institution.

### THE COMBINATION OF STROKE AND ENCEPHALOPATHY AFTER CORONARY ARTERY BYPASS GRAFTING

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**INTRODUCTION:** Much attention has been paid to stroke associated with CABG but less is paid to patients with diffuse brain dysfunction. In this study, stroke and encephalopathy were examined as an aggregate outcome.

**METHODS:** Prospective evaluation of 2771 patients operated upon between January 1997 and December 2000. Preoperative risk factors were obtained before surgery, and postoperative outcomes were determined on each post-operative day before discharge. Stroke was defined as a focal neurological deficit lasting for 24 hours or more with confirmation by neurologist. Encephalopathy included patients with delirium, coma, or seizures. Logistic regression analyses were used to determine risk factors for these outcomes.

**RESULTS:** Incidence of stroke and encephalopathy was 9.5% with a length of hospital stay (LOS) of 15.8 days and mortality of 11.6%. Patients without either had a LOS of 6.6 days and mortality of 1.4%. The predictive model includes five preoperative risk factors: past CVA (OR 2.3, p<0.01), hypertension (OR 1.7, p<0.01), presence of a carotid bruit (OR 1.6, p=0.02), diabetes mellitus (OR 1.4, p=0.02), and age (>65-75 years, OR 1.7, p<0.01; >75 years: OR 3.6, p<0.01). Time on cardiopulmonary bypass was predictive of postoperative encephalopathy (p<0.01) but not of stroke.

**CONCLUSIONS:** The aggregate of encephalopathy or stroke occurs in about 10% of patients after CABG and can be predicted before surgery by using factors readily available preoperatively.

### NEUROCOGNITIVE DECLINE AFTER CORONARY ARTERY BYPASS GRAFTING: ON-PUMP VERSUS OFF-PUMP

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**INTRODUCTION:** Some degree of neurocognitive decline has been reported in 20-60% of Coronary Artery Bypass Grafting (CABG) patients. The aim of this study is to compare neurocognitive decline in on pump and off pump CABG patients.

**METHODS:** This is a longitudinal, prospective study conducted in CABG patients and approved by the institutional IRB. Five neuropsychological tests (Wechsler Memory Revised Scales-Verbal Paired Associates, Faces I, Letter-Number Sequencing, Spatial Span, and Wechsler Adult Intelligence Scales-Digit Symbol Subtest) were administered preop, 2 weeks, and 3 months postop. We defined cognitive decline as a deviation of  $\geq 1$  SD on 20% of tests.

**RESULTS:** Twenty-four CABG patients, 12 on pump and 12 off pump, underwent the neuropsychological testing, 16 (67%) were males, and mean age was 64.5 $\pm$ 12 (38 to 81) years. There were no deaths and one on pump stroke. At 2 weeks, 22 patients (92%) completed the testing; 5 showed evidence of decline. At 3 months, 19 patients (79%) completed the testing; 6 (32%) showed decline. Two (16.7%) on pump patients and 3 (30%) off pump patients showed decline at 2 weeks, p=0.46. At 3 months, 2 (22.2%) on pump, and 4 (40%) off pump patients showed decline, p=0.41.

**CONCLUSIONS:** We found no significant difference in neurocognitive decline between on pump and off pump.

**ISSUES:** Choosing the appropriate neurocognitive tests to use and managing the study drop out rate.

**COMPARISON OF SIX PEDIATRIC CARDIOPULMONARY BYPASS PUMPS DURING PULSATILE AND NONPULSATILE PERFUSION IN PIGLETS**

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**PURPOSE:** To determine whether the pulsatile or nonpulsatile perfusion mode yields the greatest hemodynamic energy during cardiopulmonary bypass (CPB), we evaluated six pediatric pumps in a neonatal piglet model. We compared the pumps in terms of energy equivalent pressure (EEP), which is the ratio between the area beneath the hemodynamic power curve and the area beneath the flow curve.

**METHODS:** Thirty-nine piglets (average weight, 3 kg) were subjected to CPB with a hydraulically driven physiologic pulsatile pump (PPP; n=7), Jostra HL-20 pulsatile roller pump (Jostra-PR; n=5), Stockert SIII pulsatile roller pump (SIII-PR; n=6), Stockert SIII mast-mounted pulsatile roller pump with a miniature roller head (SIII-Mast-PR; n=7), Stockert SIII mast-mounted nonpulsatile roller pump (SIII-Mast-NP; n=7), or Stockert CAPS nonpulsatile roller pump (CAPS-NP; n=7). Once CPB was begun, each animal underwent 20 minutes of hypothermia, 60 minutes of deep hypothermic circulatory arrest (DHCA), 10 minutes of cold reperfusion, and 40 minutes of rewarming. The pump flow rate was maintained at 150 ml/kg/min and the mean arterial pressure (MAP) at 45 mmHg. In the pulsatile experiments, the pump rate was kept at 150 bpm and the stroke volume at 1 ml/kg.

**RESULTS:** During normothermic CPB (15 minutes on pump), the following results were documented:

Pump	% Change (from MAP to EEP)	% Change (from ECCP to EEP)
PPP	13±3*	46±13*
Jostra-PR	5±1**	13±2**
SIII-PR	4±1**	9±1**
SIII-Mast-NP	-0.2±1.8	1.3±1.8
SIII-Mast-PR	-0.3±1.6	1.2±3
CAPS-NP	1±0	2±0

\*P<0.05, PPP vs. other groups; \*\*P<0.05, Jostra-PR & SIII-PR vs. other groups; ECCP = extracorporeal circuit pressure.

The PPP produced the greatest hemodynamic energy. Compared to all the other pumps except the PPP, the Jostra-PR and SIII-PR pulsatile pumps produced a significantly higher average increase in pressure (from MAP to EEP and from ECCP to EEP). During hypothermic CPB and after rewarming, the results did not differ from those seen during normothermic CPB. The SIII-Mast-PR failed to generate higher hemodynamic energy than the nonpulsatile pumps because it had a miniature roller head.

**CONCLUSIONS:** Because the PPP, Jostra-PR, and SIII-PR pumps generated higher hemodynamic energy than the other pumps, pulsatile perfusion may improve blood flow to vital organs during CPB.

**DOES CLOPIDOGREL (CL) CONTRIBUTE TO INCREASED BLOOD LOSS FOLLOWING CORONARY ARTERY BYPASS SURGERY (CABG)?**

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**INTRODUCTION:** Clopidogrel is an inhibitor of platelet aggregation and is used following PTCA. However, its effect on bleeding following CABG is unknown.

**METHODS:** Prospective data on 312 consecutive patients undergoing urgent/emergent CABG from June 1999 to March 2001 was evaluated. Patients were divided into: Clopidogrel within 4 days prior to CABG (n=41), clopidogrel within 5 to 8 days prior to CABG (n=39) and no clopidogrel (n=232). Inter-group differences were analyzed. A p<0.05 was considered significant.

**RESULTS:** Preoperative risk factors were not different among the groups. Outcomes are as follows (mean ± SD):

	CL#4 days	CL 5-8 days	No CL	P-value
Death (%)	2.4	0	4.5	0.187
Reoperation for bleeding (%)	14.6	2.6	1.7	0.003
Blood loss-first 24 hours (ml)	1044±750	528±250	573±329	<0.01
PRBC (Units)	4.2±4.6	0.6±1.1	1.1±1.8	<0.001
FFP (Units)	3.7±5.1	0.3±0.9	0.8±2.0	<0.001
Platelets (Units)	3.6±5.0	0.3±1.1	0.6±2.1	<0.001
Total blood products (Units)	12.2±15.4	1.2±2.0	2.6±5.7	<0.001
ICU LOS (days)	4.9±8.6	1.3±0.8	2.2±4.3	<0.05
Total LOS (days)	19.5±27.4	9.1±6.5	9.9±12	<0.05*

\*For Clopidogrel # 4 days vs No clopidogrel only.

**CONCLUSION:** Clopidogrel within 4 days prior to CABG is associated with increased transfusion requirements, ICU and hospital length of stay and reoperation for bleeding.

**COAGULATION ACTIVATION AFTER CABG: TWO-MONTHS FOLLOW-UP**

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**INTRODUCTION:** Patients undergoing cardiopulmonary bypass frequently manifest alterations of the haemostatic/thrombotic profile that are triggered by contact of blood with artificial surfaces of the bypass circuits, by the surgical trauma, and by ischemia-reperfusion injury. The behavior of hemostatic variables immediately after and in the time frame that spans from few hours to 2-3 days after cardiac surgery is widely documented. In order to assess whether the coagulation activation persists for prolonged periods of time after the intervention, we have evaluated the haemostatic/thrombotic profile of patients who underwent CABG with the use of cardiopulmonary bypass during 2-months follow-up.

**METHODS:** Twenty-six patients (age range 50-75) with no renal or liver disease were selected for the study. Blood samples were collected before the intervention and at different time points postoperatively (day 4, 8 and every 15 days up to two months after surgery). Measurement of hemostatic variables was carried out in plasma from sixteen patients. Evaluation of tissue factor activity, determined as procoagulant activity, was performed in peripheral blood mononuclear leukocytes obtained from ten patients. All patients gave informed consent to participate in this study that was approved by the Ethical Committee of our hospital.

**RESULTS:** Antigenic levels of clottable fibrinogen, prothrombin fragment F1.2, D-dimer, and thrombin-antithrombin complex were significantly elevated during the first week after the intervention compared to preoperative values. Prothrombin fragment F1.2 returned to normal within 15 days, fibrinogen within 30 days, thrombin-antithrombin complex normalized at 45 days, while D-dimer was still significantly higher 60 days postoperatively respectively to baseline. There was a trend towards an increased procoagulant activity from peripheral blood mononuclear leukocytes 4 days after surgery, while no changes of factor VII measured either as antigen or in its coagulant and activated forms were recorded.

**CONCLUSIONS:** A marked activation of the haemostatic/thrombotic system occurs after cardiopulmonary bypass and lasts for at least two months thereafter. This finding suggests that these alterations might account for the increased thrombotic risk of these patients during the postoperative period.

### PERFUSION OF THE RENAL ARTERIES WITH COLD BLOOD: A NEW ADJUNCT FOR RENAL PROTECTION DURING THORACOABDOMINAL AORTIC ANEURYSM SURGERY

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**INTRODUCTION:** Despite recent advances, renal failure remains a major complication of thoracoabdominal aortic aneurysm (TAAA) repair. To further reduce the incidence of renal dysfunction, we have developed a new technique that uses cold blood renal perfusion; the purpose of this report is to illustrate the use of this new renal perfusion strategy.

**METHODS:** A 22 year-old man with Marfan syndrome underwent a Crawford extent III TAAA repair. Using a modified left heart bypass circuit, the celiac axis and superior mesenteric artery received continuous normothermic blood perfusion and the renal arteries received intermittent boluses of 4°C blood. Left kidney temperature was maintained between 12.5 and 20.0°C. Core body temperature ranged 31.6-33.0°C following aortic clamping. Right and left renal ischemic times were 31 min and 52 min, respectively.

**RESULTS:** The patient's postoperative course was uneventful. His renal function remained normal and he was discharged on postoperative day five.

**CONCLUSIONS:** This new perfusion system delivers blood to the kidneys, achieves deep renal hypothermia (<20°C), maintains acceptable systemic temperatures, and can be incorporated into commonly used left heart bypass circuits. We are currently comparing this strategy with cold crystalloid renal perfusion in a randomized clinical trial to determine which technique provides better kidney protection.

### THE EFFECT OF CARDIAC DISEASE ON HEMODYNAMIC RESPONSE TO COGNITIVE ACTIVATION

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**INTRODUCTION:** We compared the cerebrovascular reactivity elicited by cognitive tasks in candidates for cardiac surgery and healthy controls, by using transcranial Doppler ultrasonography (TCD).

**METHODS:** After informed consent, the preoperative measurement of task-induced cerebral blood flow velocity (BFV) changes in 52 candidates for coronary artery bypass graft surgery, who did not suffer from carotid artery stenosis, (mean age 59 years, SD 7.7, 48 men, 4 women) was compared with the functional BFV measurement of 52 healthy controls (mean age 58 years, SD 7.2, 48 men, 4 women). Patients and controls were matched according to age, gender and estimated IQ. A 2-Mhz pulsed-wave TCD unit recorded continuously and bilaterally BFV changes in the middle cerebral artery during 5 (verbal and visuospatial) cognitive tasks. Absolute BFV values during baseline and activation were monitored. Relative increase of the BFV was calculated from the immediately preceding baseline to the following activation.

**RESULTS:** Analyses of variance (ANOVA) assured that the patients and control groups did not differ significantly in demo-graphics. To evaluate the effect of activation, a MANOVA with condition as within-subjects factor (absolute BFV during baseline vs absolute BFV during activation) showed a bilateral increase in absolute BFV during activation compared with the preceding rest period for both patients and controls ( $F_{5,99}=67.5, p<.001$ ). A significant interaction effect for condition and side was found ( $F_{5,99}=31.7, p<.001$ ). A MANOVA with group (patients vs controls) as between subjects factor showed no significant group effect for BFV during baseline and relative increase. For absolute BFV values during activation, we found a significant difference between the two groups ( $F_{5,98}=2.4, p<.05$ ) with cardiac patients showing a lower BFV during activation. Univariate analyses showed a significant between-subjects effect for all cognitive tasks. An overall significant lateralization effect was found with verbal tasks showing a higher percentage change in favor of the left hemisphere and with visuospatial tasks showing a higher percentage change in favor of the right hemisphere.

**DISCUSSION:** Absolute BFV values measured by TCD during activation were significantly lower in candidates for cardiac surgery compared to healthy controls. Future research should focus on the possible explanations of this phenomenon and on its long term detrimental effect. The results of this study can contribute to a better etiological understanding of neurocognitive impairment in cardiac patients.

### REGIONAL SPINAL CORD MONITORING USING TRANSCUTANEOUS NEAR INFRARED SPECTROSCOPY

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**INTRODUCTION:** A major obstacle to preventing paraplegia after thoracic aortic surgery is the inability to monitor spinal cord perfusion. We hypothesized that near infrared spectroscopy (NIRS) would detect regional spinal cord ischemia.

**METHODS:** Transcutaneous NIRS sensors were placed in the midline over the upper (T6-T7) and lower (T9-T11) thoracic vertebrae of four progressively larger pigs. Segmental arteries (T6-L1) were sequentially ligated while monitoring regional oxygen saturation (rSO<sub>2</sub>) using a NIRS oximeter. Histopathology was used to compare the degrees of ischemia in the upper and lower spinal cord (USC and LSC, respectively).

**RESULTS:** Baseline rSO<sub>2</sub> levels in the USC and LSC were similar (69±9% vs. 68±12%; p=0.9). After ligating segmental arteries, mean rSO<sub>2</sub> levels were 65±9% in the USC and 41±10% in the LSC (p=0.01); compared to baseline, this corresponded to a 6±8% reduction in the USC and a 39±12% reduction in the LSC (p=0.003). This regional difference in degree of ischemia was confirmed microscopically: LSC sections had more ischemic neurons than USC sections (21±14 vs. 9±9; p=0.002).

**CONCLUSIONS:** Transcutaneous NIRS detected intraoperative spinal cord ischemia in animals weighing up to 70 kg. The potential utility of spinal NIRS in patients undergoing thoracic aortic surgery warrants investigation.

### JUGULAR VENOUS OXYGEN SATURATION DURING EXTRA CORPOREAL WHOLE BODY HYPERTHERMIA

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**INTRODUCTION:** Hyperthermia (HT) has been successfully employed since the 1970s in cancer patients in whom it showed positive results consisting of complete or partial clinical remissions. Its rationale was based on the fact that core temperatures  $\geq 42^{\circ}\text{C}$  induce cytotoxic effects that are higher in malignant cells than in normal cells. HT was also applied for the treatment of Human Immunodeficiency Virus (HIV) and recently a benefit for patients co-infected with Hepatitis C Virus (HCV) was observed. We report the effect of whole-body HT on global cerebral oxygenation and hemodynamics during the procedure.

**PATIENTS AND METHODS:** Ten patients with chronic hepatitis C, genotype I, not responding to interferon treatment, were subjected to experimental whole-body HT under general anesthesia. Esophageal temperature was raised to 41.8°C during two hours by passing blood from the femoral vein through a short external circuit including a heat exchanger, back to the contralateral femoral vein. a-stat management was employed during the procedure. Jugular venous blood temperature and jugular venous oxygen saturation were measured continuously by a fiberoptic catheter, inserted via the jugular vein in the jugular bulb. Blood flow velocity in the middle cerebral artery was measured concomitantly.

**RESULTS:** Jugular venous oxygen saturation increased in all patients from 56% at baseline to 74% at 41.8°C and increased further to 80% at stable hyperthermia during the 2-hrs plateau phase. Mean flow blood velocity in the middle cerebral artery doubled during warming to 41.8°C.

**CONCLUSION/ISSUES FOR DISCUSSION:** Cerebral hyperthermia per se is not associated with low jugular bulb saturation. Assuming that flow velocity increase reflects cerebral blood flow changes, cerebral oxygen consumption does not appear to increase during warming.