

Outcomes 2003 Abstracts

COGNITIVE CHANGES WITH CORONARY ARTERY DISEASE: A PROSPECTIVE STUDY OF CABG PATIENTS AND NONSURGICAL CONTROLS

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Background. Cognitive impairment after coronary artery bypass grafting (CABG) is well recognized, but previous investigations have been limited by lack of an appropriate control group. We compared changes in cognitive performance at 3 and 12 months after CABG with those of a control group of patients with comparable risk factors for coronary artery disease (CAD) but without surgery.

Methods. Patients undergoing CABG (n = 140) and a demographically similar nonsurgical control group with CAD (n = 92) completed baseline neuropsychological assessment and were followed prospectively at 3 and 12 months. Cognitive function was evaluated with a battery of neuropsychological tests, assessing the cognitive domains of attention, language, verbal and visual memory, visuospatial, executive function, psychomotor and motor speed.

Results. CABG patients tested in their hospital rooms before surgery had lower scores for timed tests, but after adjustment for demographic variables and testing location, there were no statistically significant differences between the CABG and nonsurgical control subjects in baseline neuropsychological test performance. Both groups improved from baseline to 3 months; the only statistically significant group difference was a greater improvement for the CABG group in verbal memory. At 1 year, there were no significant differences between the two groups.

Conclusions. Prospective longitudinal neuropsychological performance of patients with CABG did not differ from that of a comparable nonsurgical control group of patients with CAD at 3 months or 1 year after baseline examination. This suggests that the previously reported cognitive decline during the early postoperative period after CABG is transient and reversible. Continued follow-up will determine if "late decline" is specific to CABG patients or if it also occurs in nonsurgical controls with similar risk factors for cardiovascular and cerebrovascular disease.

COGNITIVE DYSFUNCTION FOLLOWING CARDIAC SURGERY: EVIDENCE FOR A NATIONAL PATTERN OF INJURY

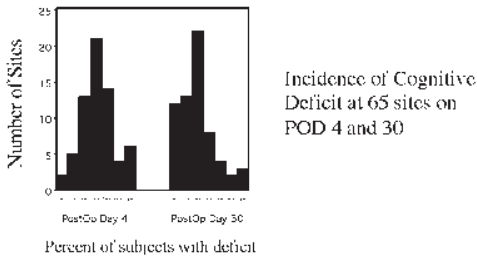
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Introduction. Despite multiple studies demonstrating frequent cognitive injury after cardiac surgery, it is often dismissed as an institution-specific complication. We therefore examined the incidence of cognitive decline in each of the 65 sites in a recent multicenter study of pexelizumab, a humanized scFv antibody fragment directed against the C5 complement component.

Methods. The Phase II Pexelizumab study was a study of 914 patients undergoing CABG or CABG+valve surgery. Cognitive function was assessed at baseline, day 4, and day 30 with the Rey AVLT, Animal Fluency, Clock Drawing, and Symbol-Digit tests. Cognitive deficit was defined using factor analysis as a decline of one standard deviation or more in at least 1 of the 4 domains. The site-specific incidence of cognitive deficit was calculated as the number of cases with a deficit at each site divided by the number of cases with scores. The likelihood that these deficit rates came from a population centered at 20% was tested with the Wilcoxon rank sum test. $P < 0.05$ was considered significant.

Results. The median incidence of cognitive deficit at day 4 and 30 was 50% (Q₁:40; Q₃:67) and 33.3% (Q₁:20; Q₃:49) respectively (range 0-100%). Only 4 sites experienced a deficit rate $< 20%$ ($p < 0.001$).



Conclusions. Cognitive dysfunction after cardiac surgery is a national and not just a local phenomenon with a 50% median incidence of deficit at day 4 and 33% incidence at day 30.

Issues: cognitive testing, control population

NEUROCOGNITIVE FUNCTIONS UNIMPAIRED BY MYOCARDIAL REVASCULARISATION SURGERY USING EXTRACORPORAL CIRCULATION

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Introduction. Coronary artery bypass graft surgery (CABGS) using cardiopulmonary bypass (CPB) is assumed to be associated with a decline of cognitive functions. This study was designed to characterize the neuropsychological deficits and psychosocial profiles of patients with coronary heart disease before and after CABGS and to analyse possible protective effects of oxygenator surface coating on neurological outcome.

Methods. From May until September 2002 35 selected patients (27 males 66 ± 8 y, 8 females 64 ± 8 y) undergoing CABGS were included in the study and prospectively randomised into 2 groups according to the type of hollow-fiber membrane oxygenator used (uncoated oxygenator (n = 20) versus phosphorylcholine coated oxygenator (n = 15)). Using a test battery, neurological and neuropsychological functions including memory, executive functions, concentration and general cognitive abilities were analysed before CABGS (A), 5-10 days (B) and 4 months after surgery (C). A control group of 10 patients (3 males, 7 females, age 61.2 ± 14 y) undergoing PTCA was selected and examined before and after intervention. Cognitive decline was defined as an impairment of ≥ 1 SD in at least 20% of the test items. In addition, several parameters indicating inflammation (C3a, β -thromboglobulin, IL6, PMN-elastase and P-selectin) were measured before and after 90 min CPB or, for shorter CPB time, at the end of CPB. Perioperative clinical data included aortic clamp time, duration of bypass, time to extubation, duration of stay at the ICU, blood loss and amount of blood transfused. For statistical comparisons student's t-tests for paired and unpaired data were used and p -values < 0.05 were considered to be statistically significant.

Results. Preoperative clinical data did not differ between all three groups. Postoperative outcome showed that 1 out of 35 patients suffered from stroke and died after 6 days (cause of death unknown), 2 patients had a symptomatic transitory psychotic syndrome. Mean hospital stay was 12 d. Neurocognitive investigation of all 34 CABGS-patients did not reveal a significant impairment post- versus preoperatively (9-Hole-Peg-Test: A: 0.05 ± 0.17 ; B: 0.08 ± 0.15 ; C: 0.07 ± 0.12 ; n.s.; verbal memory test and recognition trial: A: 0.4 ± 1.9 ; B: 0.2 ± 1.7 ; C: 0.3 ± 1.5 ; n.s.; reasoning test: A: 1.4 ± 3.6 ; B: 1.5 ± 2.7 ; C: 1.6 ± 2.2 ; n.s.; verbal frequency: A: 0.94 ± 3 ; B: 0.8 ± 3.5 ; C: 0.85 ± 3.2 ; n.s.; symbol digit modalities test: A: 3.1 ± 4.3 ; B: 5.5 ± 0.5 ; C: 6.2 ± 1.2 ; n.s.). Neurocognitive functions of the control group were also postinterventionally unaffected. Inflammatory parameters such as PMN-elastase (uncoated 256 ± 112 vs. coated 110 ± 61 , $p < 0.01$) and CRP (uncoated: 38 ± 34 vs. coated: 8 ± 7 , $p < 0.05$) were significantly increased in the uncoated oxygenator group, but no significant differences were observed for sP-selectin, β -Thromboglobulin and IL-6. Neurocognitive functions as well as clinical data such as time to extubation, time of ICU stay, hospital stay, amount of blood loss and blood transfused were comparable for both oxygenator groups.

Conclusion. In contrast to previous studies we could not find significant and permanent neurocognitive and neurological deficits following on-pump CABGS. The fact that for the uncoated versus phosphorylcholine coated oxygenator group more pronounced signs of inflammation were found was not reflected by a worse outcome for this patient group.

COGNITIVE DEFICITS FIVE YEARS AFTER SURGERY: ARE THEY DEPENDENT ON THE ANALYSIS?

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Background. Recent investigations into the incidence of neuropsychological deficits five years following surgery have failed to include a control group, and are thus unable to account for the confounding influence of aging.

Methods. With institutional approval and written consent, 70 of 110 patients who were administered a standardized neuropsychological assessment preoperatively, 7 days, and 6 months following surgery were re-examined five years postoperatively. Incidence of neuropsychological deficits was calculated using Reliable Change (RC) indices derived from a sample of 36 nonsurgical controls who were examined over identical time intervals. The standard deviation (SD) method was also used as a comparison.

Results. The incidence of deficits (RC method) on TMT B and Digit Symbol decreased significantly from 7 days to 6 months, and decreased further again at 5-year follow-up. The incidence of deficits on TMT A increased significantly from 7 days to 6 months, then decreased significantly at 5 years,

while the incidence of deficits on CVLT short delay free recall increased significantly from 7 days to 5 years. The percentage of patients displaying a deficit on ≥ 2 measures was 37% at 7 days, 31% at 6 months, and 27% at 5 years. Using the SD method the comparable incidence rates were 67% at 7 days, 34% at 6 months, and 67% at 5 years.

Conclusion. Age-related changes in neuropsychological performance must be accounted for when assessing the long-term impact of cardiac surgery on neuropsychological performance.

Issues: Confounding factors; Long-term follow-up

DIFFERENTIAL TEMPERATURE MANAGEMENT DURING CARDIOPULMONARY BYPASS SURGERY TO ACHIEVE CEREBRAL HYPOTHERMIA AND CORPOREAL NORMOTHERMIA IN HUMANS

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Objectives. Normothermic cardiopulmonary bypass (CPB) has become popular over the last decade as it has been shown to have various benefits although at a potentially increased risk of neurological injury compared to hypothermic CPB. A new technique which utilises a dual lumen aortic cannula (Cobra catheter, Cardeon Corp, Cupertino, Calif) to segment the aortic arch and achieve cerebral cooling in association with body normothermia has been described. The aim of our study was to investigate the thermal efficacy of this technique to achieve and maintain a temperature differential of greater than 5° C between the brain and the body during CPB.

Methodology. After ethical approval, 30 adult patients underwent CPB using the Cardeon Cobra cannula to differentially cool the brain while maintaining body normothermia. Nasopharyngeal (NPT) and bladder temperatures (BLT) were used as surrogates of brain and body temperatures. Brain (radial) and corporeal (femoral) mean arterial pressure (MAP) together with jugular bulb and mixed venous saturations were monitored to assess perfusion adequacy to cerebral and corporeal circulations.

Results. The catheter was successfully placed in all patients without any difficulty. The procedures performed were coronary artery bypass surgery (n = 23), valve (n = 2) and combined valve & graft (n = 5). A 3.2 ± 0.46°C differential between BLT and NPT was reached in all patients after 5.5 ± 3.6 minutes (p < 0.001). A 5°C differential was reached in 29 patients after 12 ± 7.5 minutes. The mean difference was 6.6 ± 1°C. MAP's were maintained above 50mmHg and venous saturations above 60% throughout.

Conclusions. Differential temperature management using the new aortic cannula is possible. Cerebral hypothermia can be achieved while maintaining corporeal normothermia with adequate perfusion to both circulations reliably. This could potentially give the benefits of hypothermic and normothermic CPB.

DO WE UNDERCOOL OR OVERHEAT THE BRAIN DURING CARDIOPULMONARY BYPASS?

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Background. Brain cooling is an essential component of aortic surgery requiring circulatory arrest. Inadequate cooling may potentiate brain injury. Conversely, brain hyperthermia during rewarming phase of cardiopulmonary bypass may lead to neurological injury. Conventional temperature monitoring sites may not reflect the core brain temperature (T°). We compared Jugular bulb venous temperatures (JB) during deep hypothermic circulatory arrest and normothermic bypass with Nasopharyngeal (NP), Arterial inflow (AI), Oesophageal (O), Venous return (VR), Bladder (B) and Orbital skin (OS) T°s.

Methods. 18 patients undergoing deep hypothermia (DH) and 8 patients undergoing normothermic bypass (mean bladder T° -36.29°C) were studied. For DH, cooling was continued to 15 ± C NP (mean cooling time - 66 minutes). At predetermined arterial inflow T°, NP, JB and O T°s were measured. A 6-channel recorder continuously recorded all T°s using calibrated thermocouples.

Results. During the cooling phase of DH, NP lagged behind AI and JB T°s. All these equilibrated at 15°C. During rewarming, JB and NP lagged behind AI and JB was higher than NP at any time point. During normothermic bypass, although NP was reflective of the AI and JB T° trends, it underestimated peak JB T° (p = 0.001). At the end of bypass, peak JB was greater than the arterial inflow T° (p = 0.023).

Conclusions. If brain venous outflow T° (JB) accurately reflects brain T°, NP T° is a safe surrogate indicator of cooling. During rewarming, all peripheral sites underestimate brain T° and caution is required to avoid hyperthermic arterial inflow, which may inadvertently, result in brain hyperthermia.

ENHANCED INSULIN SIGNALING WITH PREOPERATIVE DECADRON ADMINISTRATION IN THE OFF PUMP CORONARY ARTERY BYPASS PATIENT

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Introduction. Coronary bypass has long been established as the more durable procedure for multi-vessel coronary disease. Known metabolic and inflammatory disorders contribute to perioperative and postoperative complications, whether done on or off bypass. We have found that all patients undergoing CABG surgery exhibit moderate to severe insulin resistance, characterized by hypokalemia, hypomagnesemia, hyperurecemia, hyperlipidemia, endothelial dysfunction and increased intracellular calcium levels.²

Method. Between July 2002 and April 2003 all patients undergoing off pump surgery (n = 80) were given Decadron 1mgm/kgm preoperatively to reduce inflammation and insulin resistance. This was given after the induction of anesthesia, thus preventing increased patient agitation. We obtained cortisol, norepinephrine, glucagon and epinephrine levels on four consecutive patients from this group, preoperatively, and again four hours postoperatively. These patients were compared to patients who were done off pump between July 1997 and July 2002 (n = 680) and given Solu-Medrol.

Results. The insulin requirements in the group who received Decadron were reduced by nearly 75%, requiring 2-4 units/hour of insulin, compared to 15 units/hour in those patients who received Solu-Medrol. The cortisol, norepinephrine, glucagon and epinephrine levels were all within normal limits on those patients sampled.

Conclusions. Insulin signaling of Glucose Transport Protein 4, is enhanced with the reduction of inflammatory cytokines with the administration of Decadron.

	Solu-Medrol 500mgm (n = 630) July 1997-July 2002	Decadron 1mgm/kgm (n = 80) July 2002-April 2003
Intraoperative Insulin requirements	15 units/hour	2-4 units/hour

¹Perkowski David, et al. Optimizing Off Pump Coronary Artery Bypass Graft: Technical and Metabolic Aspects. The Heart Surgery Forum #2000-7753 4 (1):80-87, 2001. ²Perkowski David, et al. Paper presented at the 6th Annual Cardiothoracic Techniques and Technologies Meeting 2000, Bal Harbour, Florida, January 27-29, 2000.

NEUROPSYCHOMETRIC OUTCOMES FOLLOWING METABOLIC SUBSTRATE SUPPORT IN CARDIAC SURGERY

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Background and Objectives. Neuropsychometric (NP) impairment is a recognised complication of coronary artery bypass surgery (CABS). It is hypothesised that the administration of a glucose, insulin and potassium (GIK) solution provides myocardial protection and speeds recovery; however the effect of this solution on brain injury and NP outcomes is not known.

Methods. As a pilot sub-study of a double blind, randomised, placebo controlled clinical trial 68 patients were allocated to perioperative intravenous high-dose GIK (glucose 40%, insulin 70iu/L and K⁺ 100mEq/L - 0.75ml/kg/hr) at sternotomy and continued for 6 hrs following the cross-clamp release versus control. They underwent a standardised neurological and NP assessment (consisting of the NIH Stroke Scale and 9 NP tests) preoperatively, at 5-7 days and 8 weeks post CABS. A NP deficit is defined as a 20% decline in 2 or more test scores.

Results. The GIK and control groups were comparable for age, gender, cardiopulmonary bypass (CPB) time, number of distal anastomoses and baseline blood glucose. GIK patients had significantly higher peak blood glucose during the trial infusion (p < 0.0001). At 5-7 days an NP deficit was detected in 50% in the GIK group and 56.3% in the placebo group (p = 0.78). At 6 weeks 18.5% of the GIK group showed a residual deficit compared with 12.5% of the placebo group (p = 0.72).

Conclusions. These findings suggest that GIK therapy is not associated with an increased risk of brain injury following CABS despite relative perioperative hyperglycaemia.

ATHEROMATOUS DISEASE OF THE AORTA PREDICTS NEW ISCHEMIC BRAIN LESION AFTER CARDIAC SURGERY

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Introduction. There is ample evidence that post-pump cerebral injury after cardiac surgery is caused by macro- and micro- emboli.^{1,2} Atheromatous dis-

ease of the ascending aorta is associated with increased risk of perioperative stroke.³⁻⁵ This study evaluates the efficacy of intraoperative echocardiography in predicting postoperative brain lesions in patients undergoing CABG surgery.

Methods. With IRB approval and informed consent, a prospective cohort of 65 patients who underwent a comprehensive intraoperative transesophageal and epiaortic echocardiography were evaluated for new ischemic brain lesions utilizing magnetic resonance imaging (MRI) 4-7 days after CABG surgery. The MRI included Sagittal T1, Axial diffusion, axial echo-planar imaging (EPI) gradient echo, EPI fluid-attenuated inversion recovery, and phase contrast MR angiography sequences. Based on echocardiographic findings all patients were divided into two groups, a low risk group, representing the maximum height of atheromatous lesions of the ascending aorta and/or arch graded as ≤ 2 mm, and a high risk group graded as > 2 mm and/or mobile atheroma. Echocardiographic findings were communicated to the operating surgeon who was free to modify the operating technique. The data were analyzed with T-test and Fisher's exact test. Data expressed as mean (SD). A p value of < 0.05 was considered significant.

Table 1

	Low Risk Group (n = 46)	High Risk Group (n = 19)	P value
Preoperative			
Age, y	65 ± 5	68 ± 6	0.04
Male, n (%)	42 (91)	19 (100)	0.18
History of myocardial infarction, n (%)	13 (28)	7 (36)	0.49
Congestive heart failure, n (%)	1 (2)	1 (5)	0.43
Ejection fraction < 40%, n (%)	4 (8.7)	5 (26)	0.06
Hypertension, n (%)	30 (65)	16 (84)	0.12
Obstructive pulmonary disease, n (%)	3 (6)	2 (10)	0.58
Diabetes mellitus, n (%)	11 (24)	5 (26)	0.83
ACE inhibitors, n (%)	22 (47)	6 (31)	0.22
β-blockers, n (%)	19 (41)	8 (42)	0.95
Calcium channel blockers, n (%)	12 (26)	9 (47)	0.09
Nitrates, n (%)	20 (43)	15 (78)	0.09
Intraoperative			
No. grafts, n	3.6 ± 0.9	3.6 ± 1	0.96
Duration surgery, h	3.5 ± 0.7	3.6 ± 0.8	0.5
Postoperative			
Extubation time, h	9.1 ± 10.2	12.2 ± 16.2	0.42
Hospital LOS, d	6.5 ± 1.7	7.7 ± 3.3	0.09
AF, n (%)	15 (32)	9 (47)	0.26
Low Cardiac Output Syndrome, n (%)	6 (13)	2 (10)	0.77
IABP, n (%)	1 (2)	0 (0)	0.41

Results. Demographic data, surgical characteristics, and outcome data are shown in Table 1. A total of 40 patients (62%) completed MRI. 5 patients (12.5%) were identified with new ischemic brain lesions (Table 2). None of the patients had an overt clinical stroke. The prevalence of patients with significant aortic atheromatous disease (plaque height 5.3 ± 2.5 mm) was 29%. Half of these patients were found to have new ischemic brain lesions, when compared to none in the low risk group ($p < 0.001$).

Conclusions. We have demonstrated that patients with significant atheromatous disease of the ascending aorta and the arch are at high risk from developing new ischemic brain lesions (silent strokes) as detected by early postoperative diffusion-weighted MRI. Furthermore, patients without atheromatous lesions in these locations do not appear to suffer silent strokes. Interventional studies aimed at high risk group are required to reduce the incidence of cerebral infarctions after CABG surgery.

Table 2

	Low Risk Group (n = 30)	High Risk Group (n = 10)
MRI + ve	n = 0	n = 5
MRI - ve	n = 30	n = 5

1. Moody DM, et al. *Ann Neurol* 28:477-86. 2. Pugsley W, et al. *Stroke* 25:1393-9. 3. Davila-Roman VG, et al. *Stroke* 25:2010-16. 4. Mizuno T, et al. *Ann Thorac Surg* 70:1565-70. 5. van der Linden J, et al. *J Am Coll Cardiol* 38:131-5.

CURRENT MANAGEMENT OF ACUTE TYPE A AORTIC DISSECTION: A UK SURVEY

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Objective. There are no randomised trials of surgical management techniques for acute type A aortic dissection. In particular, there are many variations in the management of cerebral protection. "Best" practice, however, might be expected to include:- emergency operation, performance of an

open distal anastomosis during circulatory arrest ± adjunctive cerebral protective techniques, glue fixation of dissected layers, institution of orthograde flow following completion of the distal anastomosis, and post-operative aortic surveillance. Our aim was to investigate concordance with this approach in UK practice.

Methods. A detailed questionnaire was sent to all adult cardiac surgeons in the UK and Ireland (n = 190).

Results. There was a 50% completion rate.

Question	Number	Range/percentage
Mean number of procedures per surgeon (SD)	2.6 (2.2)	Range 0-9
Defer surgery to next list	16	19.3%
Use of Hypothermic Circulatory Arrest –Never	24	28.9%
HCA temperature nadir	16.6°C	Range 10-22°C
No additional cerebral protective adjuncts	35	42.2%
Retrograde cerebral perfusion	40	48.2%
Selective antegrade cerebral perfusion	14	16.9%
No glue fixation of dissected layers	23	17.7%
No restoration of orthograde flow	36	43.3%
No post-operative aortic surveillance	23	17.7%
Special interest clinic follow up	11	13.3%

Conclusion. The UK surgeon operates upon < 3 type A aortic dissections per annum. There is considerable variation of surgical practice. Accepted methods of cerebral protection are not widely adopted and postoperative follow up appears inadequate.

FAILURE OF RETROGRADE CEREBRAL PERFUSION TO ATTENUATE STROKE OR MORTALITY RISK DURING AORTIC ARCH SURGERY

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Objective. Although retrograde cerebral perfusion (RCP) has been associated with improved outcome following aortic surgery in several series, we have previously demonstrated the failure of RCP to attenuate both metabolic and neuropsychometric changes following aortic arch surgery. We aimed to investigate RCP as a risk factor for cerebrovascular accident (CVA) and mortality following hypothermic circulatory arrest (HCA).

Methods. A database comprising 250 patients undergoing HCA for arch surgery between 1993 and 2002 was analysed for 47 variables. Univariate analysis, and multivariate stepwise logistic regression analysis were performed. Propensity score analysis was then used to identify risk-matched cohorts between whom the results of HCA and HCA + RCP were compared for mortality rate.

Results. There were 41 deaths (16.4%, elective patients 12%) and 20 CVAs (8%). Seventy six patients underwent adjunctive RCP. There were 15 deaths in the RCP group (19.7%) and 26 in the HCA group (14.9%) ($p = 0.4$). There were 5 CVAs in the RCP group (6.6%) and 15 in the HCA group (8.7%) ($p = 0.6$). Primary univariate risk factors for death were: emergency status ($p < 0.001$), acute dissection ($p < 0.008$), renal failure ($p < 0.001$), 6 hour pO_2/FiO_2 ratio ($p = 0.001$), and use of inotropes ($p < 0.001$). Primary univariate risk factors for CVA were: emergency status ($p = 0.01$), previous CVA ($p = 0.02$), and higher central temperature on ITU return ($p = 0.01$). Multivariate analysis revealed, post-operative renal failure ($p = 0.02$) to be significantly associated with death. Preoperative haemodynamic instability ($p = 0.02$) was the only variable to be significantly associated with post-operative CVA. Propensity score analysis of the 2 largest cohorts revealed no difference in mortality between HCA and HCA + RCP ($p = 0.5$).

Conclusion. Retrograde cerebral perfusion does not affect CVA or mortality risk in aortic arch surgery.

PROPENSITY SCORE ANALYSIS REGARDING DISTAL AORTIC PERFUSION DURING DESCENDING THORACIC AORTIC ANEURYSM REPAIR

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Introduction. The preferred technique for spinal cord protection during surgical repair of descending thoracic aortic aneurysms (DTAAs) remains controversial. The purpose of this retrospective analysis was to determine if the use of distal aortic perfusion via left heart bypass (LHB) reduced the incidence of paraplegia in patients who underwent DTAA repair.

Methods. Over a 15-year period, 387 consecutive patients underwent surgical repair of DTAAs using either the "clamp-and-sew" technique (341 patients, 88.1%) or distal aortic perfusion via a left heart bypass circuit (46 patients, 11.9%). Data regarding patient characteristics, operative variables,

and outcomes were retrieved from a prospectively maintained database. The impact of LHB on the frequency of paraplegia was determined using univariate and propensity score analyses.

Results. There were 17 operative deaths (4.4%), including 11 patients (2.8%) who died within 30 days. Paraplegia occurred in 10 patients (2.6%). On univariate analysis, increasing age ($p = 0.03$), increasing aortic clamp time ($p < 0.001$), increasing red blood cell transfusion requirements ($p = 0.01$) and acute dissection ($p = 0.03$) were associated with increased incidence of paraplegia. Patients who received LHB had a similar incidence of paraplegia (2/46, 4%) compared to those treated without LHB (8/341, 2.3%; $p = 0.3$). Both matching and stratification propensity score analyses confirmed that LHB was not associated with reduced risk of paraplegia.

Conclusions. On retrospective analysis, the use of LHB during DTAA repair did not reduce the incidence of spinal cord injury. The “clamp-and-sew” technique remains an appropriate approach to DTAA repair. Issues: When should distal aortic perfusion be used? What is the role of propensity score analysis in cardiovascular surgical outcomes research?

CEREBRAL OXIMETRY BASED COMPARISON OF CEREBRAL PERFUSION WITH STANDARD VERSUS CONDENSED EXTRA-CORPOREAL CIRCUITS IN ADULT CARDIAC SURGERY

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Introduction. Prime volume in a circuit influences degree of hemodilution, on-pump hematocrit and hence cerebral saturations during CPB. Study compares cerebral saturations with Standard length and MAST Condensed length circuits.

Method. Fifteen patients in each group undergoing primary CABG, were age, BSA, CPB and X clamp times matched into—Std and Mast groups. On-pump Hct, prime volumes, and cerebral saturations were parameters studied. **Results.** Std circuit: prime volume was 1600-1800ml. Pre and on-pump Hcts were an average of 31% (29-35) and 22% (21-26) due to dilution. An average of 30% (25 to 41) drop in cerebral saturation from baseline (from 65-70 to 48-52 absolute number) was noted immediately after CPB instituted as prime volume displaced cerebral circulation. Recovery of saturation required average 3 to 5 minutes of CPB flows over 2.0 lit/m²/min. On pump cerebral saturations remained 20-30% below baseline throughout. A further drop of 5 to 10% in saturations was noted upon re-warming and de-clamping. Mild/mod hypothermia (32-35°C) and alpha stat strategy used. MAP 58-72mmHg. Mast Condensed circuit: Prime volume 700-800ml (reduced to zero with retrograde autologous prime). Pre and on-pump Hcts were 32% (29-34) and 30% (29-32). Only 4-6% drop in cerebral saturations from baseline noted at commencement of CPB. Recovery time was less than a minute at similar flows. Throughout CPB, saturations remained at or above baseline, with no drop upon de-clamping. Normothermia and alpha stat strategy used. MAP 60-70mmHg.

Conclusion. Condensed extra-corporeal circuits with high on-pump Hct, better preserve cerebral saturations and perfusion during cardio-pulmonary bypass.

INFLUENCE OF CARDIOTOMY SUCTION BLOOD SEPARATION DURING CPB

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Introduction. The intra-operative collection of blood in cardiac surgery is a part of perioperative management to economise on allogenic blood transfusion. By complete anticoagulation during the cardiopulmonary bypass (CPB) it is popular to suck off the blood, which is collected in pericard and pleura, with a blood suction and to return it to CPB. This intra-operative re-transfusion is critically considered under the aspect of the biocompatibility of the CPB by different studies, as an activation of biological system is expected through contact of the blood with air and re-transfusion of pericardial fluid as well as through mechanical stress of the blood suction.

Methods. 34 patients selected from April until September 2002 (26 males 64 ± 6 y, 8 female 63 ± 9 y) undergoing elective coronary artery bypass grafting surgery (CABGS) were involved in this prospective randomised study. During the operation suctioned blood was collected separately. Then it was re-transfused to the patient at the end of the operation (A, n = 14), or it was retained (B, n = 20). Inflammatory and haemolytic indicators such as PMN-elastase, P-selectin, IL-6, β-Thromboglobulin, blood count, free Hb, LDH, Haptoglobin, CK, CK-MB, CRP were determined before and at after 90 min. CPB. Additionally peri- and postoperative blood loss and blood transfusion were registered.

Results. Preoperative clinical data did not differ between groups. Systemic IL-6 level (A: 21 ± 9 vs. B: 14 ± 10, $p < 0.01$), PMN-elastase (A: 188 ± 120 vs. B: 110 ± 19, $p < 0.05$), CRP (A: 24 ± 29 vs. B: 6 ± 6, $p < 0.05$), CK-MB (A: 41 ± 16 vs. B: 29 ± 16, $p < 0.05$) at 90 min. after surgery were significantly increased in the non-CSBS group. Obviously the CSBS during the CPB can also have an advantage to save platelets (A: 158 ± 57 vs. B: 232 ± 45, $p < 0.01$) and Hb (A: 8 ± 1 vs. B: 9 ± 1, $p < 0.05$). Thus cardiotomy suction blood separation (CSBS) resulted in reduced platelet loss and inflammatory response together with a decrease in haemolysis in the CSBS treated groups. In all other parameters measured, including blood loss and blood transfusion requirements, no differences between the 2 groups were observed.

Conclusion. CSBS had a clear effect on blood activation parameters. The CSBS enables to separate a main part of blood activation and prevents its negative effects. Further studies should prove if re-transfusion of cardiotomy suction blood without cell saver is indicated at all in routine CABGS.

CUTTING COSTS OF HEART SURGERY: “FAST-TRACKING” VERSUS INTERVENTION FOR MAJOR MORBIDITY

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Background. Quality improvement (QI) projects aimed at reducing hospital costs from cardiac surgery involve two major strategies. Strategy #1 often involves some form of “fast-tracking” or benchmarking for routine patients. Strategy #2 assesses major morbidity and attempts to limit major complications such as operative mortality, respiratory failure, perioperative stroke or renal failure. We wondered what the impact of these two strategies might be on cost reduction.

Methods. A single year’s hospital charges for all 1221 cardiac operations performed were studied during a time period before fast-tracking was instituted at our institution. Multivariate predictors of increased hospital cost were identified from more than 100 preoperative and perioperative variables using a linear regression model. The contribution to hospital charges from both strategy #1 & #2 were compared using this model. Patients were divided into routine or complicated patients for purposes of this comparison. Routine patients were deemed most likely to benefit from fast-tracking and benchmarking procedures (strategy #1), while complicated patients were deemed most likely to benefit from interventions aimed at reducing major morbidity (strategy #2). Estimates of cost reduction were made assuming that 20% of routine patients could benefit from strategy #1 (fast-tracking) and that 20% of high cost patients could benefit from interventions to reduce mortality and morbidity (strategy #2).

Results. The average hospital charge for the entire cohort, excluding physician fees, was \$35,389 ± \$20,545. 118 of 1221 patients (9.7%) had the following serious postoperative complications: death (31 patients, 2.5%), renal failure (12 patients, 1.0%), Q-wave MI (12 patients, 1%), stroke (23 patients, 1.9%), sepsis/mediastinitis (18 patients, 1.4%), respiratory failure (42 patients, 3.4%), or low cardiac output requiring IABP (16 patients, 1.3%). Multivariate predictors (and their contribution to increased cost) for the entire cohort in order of decreasing importance were as follows: postoperative respiratory failure (\$47,455 per patient with respiratory failure), excess perioperative blood transfusion (\$227 per donor unit above average), stroke (\$21,779 per postoperative stroke), postoperative IABP (\$21,330 per patient), hematocrit immediately before CPB (\$443 per % below mean), CPB time (\$57 per minute above mean), STS predicted mortality (\$449 per % above mean), post-operative renal failure (\$10,580 per patient), hemodynamically unstable before operation (\$4,097 per event). The impact of two cost-reduction strategies based on this multivariate regression model is shown in the table.

	Complicated, high-cost patients (n = 118)	Uncomplicated, low-cost patients (n = 1103)
Length-of-stay (LOS)	18.1 ± 17.0	8.5 ± 5.8
Average charges	\$66,960 ± \$42,731	\$32,011 ± 12,461
Average room & board charges	\$14,717 ± 13,324	\$5,752 ± 4,060
Strategy #1—savings from 0.5 d reduced LOS in 20% of low-cost patients	—	\$459,951
Strategy #2—savings from 20% reduction in serious morbidity & mortality	\$519,405*	—

*P < 0.05 compared to strategy #1.

Conclusions. We conclude that focusing on reducing major postoperative complications is more likely to significantly reduce hospital costs compared to focusing on routine patient care issues as is done in “fast-tracking” methods. The best method to reduce hospital costs combines cost reduction strategies for both routine, low-cost patients and for high-cost, complicated patients. Issues: Strategies for cost reduction. Costs of major morbidity.

EFFICACY OF PREOPERATIVE CAROTID ULTRASOUND SCREENING IN 1139 CABG PATIENTS

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Background. Preoperative carotid ultrasound screening for all CABG patients is routine at our institution. The efficacy of this screening however, has not been clearly proven. We reviewed ultrasound scan results in order to determine if clear benefits arise from screening all patients.

Methods. All patients having surgery from Jan 2000 through Apr 2002 were reviewed. For those patients with carotid ultrasound results, we collected medical history, and operative and postoperative neurological outcome data. Our analysis attempted to identify patients who were at higher risk for significant carotid stenosis (> 70% in either ICA).

Results. Of 1139 patients who had carotid ultrasound, 12.0% had significant stenosis (2.9% bilaterally). By multivariate analysis, risk factors identified for carotid stenosis included peripheral vascular disease (p = 0.0001), previous CVA (p = 0.02), and carotid bruit (p = 0.0001). The postoperative stroke (6.7% vs. 2.7%, p = 0.02), mortality (7.3% vs. 1.2%, p = 0.0001) rates, and length of stay (9.8 days vs. 7.5 days, p = 0.0001) for carotid stenosis patients were significantly higher than those without stenosis. However, when logistic regression was used to construct a risk model to predict stenosis, this model had good specificity in detecting patients without stenosis (98.7%), but had poor sensitivity for predicting those with stenosis (11.7%). Thus, there appears to be some other factor(s) accounting for our inability to identify more patients with stenosis.

Conclusions. Patients with carotid stenosis levels > 70% in either carotid artery are at significant risk of postoperative morbidity after CABG. Preoperative factors associated with that risk are identifiable. However, attempts to create a risk model to predict which patients should be selected for carotid duplex screening were unsuccessful.

COSTS AND OUTCOMES ASSOCIATED WITH CORONARY ARTERY BYPASS GRAFT SURGERY: IMPLICATIONS FOR REDUCING BLOOD TRANSFUSION AND ADMINISTERING APROTININ

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Background. Overall hospital costs range \$25,860-33,142 for each coronary artery bypass graft surgery (CABG)[1-3]. CABG patients experiencing significant morbidity and mortality consume significantly more resources, including laboratory, blood bank, pharmacy, and costs incurred outside the operating room [2-3]. Operative death costs ~\$74,466, return to surgery for bleeding increases CABG costs to > \$60,000, and perioperative stroke adds ~\$18,000 to overall hospital costs [2,4,5]. Blood transfusion in CABG is associated with significant cost (mean, \$348) and poorer outcomes such as stroke and death [6-8]. Aprotinin (Trasylo), a broad-spectrum serine protease inhibitor, reduces blood loss and transfusion requirements, and modulates the systemic inflammatory response associated with cardiopulmonary bypass [9,10]. Full-dose aprotinin use in CABG reduces reoperations for bleeding and has been associated with a reduced incidence of stroke [9,11,12]. However, many pharmacy departments are concerned with the cost of full-dose aprotinin (direct pharmacy cost, \$1281.72).

Objective. The objective was to assess current US hospital costs of blood transfusion at institutions conducting CABG.

Method. A written survey was used to collect data from 5 US institutions' blood banks with active CABG programs (> 400 CABG procedures/year) during 2001.

Results. Mean administrative cost of transfusion (administration, transport, blood bank service, typing, cross-matching) was \$183. Additional unit costs varied by specific blood product and preparation methods (phereses, leukoreduction, irradiation +/- washing)*.

Blood Products	means \$/U	ranges \$/U
Fresh Whole Blood	147	130-164
Fresh Frozen Plasma	52	46-55
Platelet Concentrates*	95- 11	47-159
Platelets*	457-493	375-610
Red Blood Cells*	125-217	104-225

Conclusions. These data confirm the significant costs associated with blood transfusion [6] and show that immediate cost savings could be generated by reducing/eliminating blood transfusion, instituting standard transfusion triggers, and using approved pharmacologic strategies such as aprotinin to reduce transfusion needs. Further, catastrophic adverse outcomes associ-

ated with transfusion could be avoided by decreasing blood transfusion. Analysis of lifetime CABG costs associated with aprotinin use, perioperative transfusion, and outcomes is underway.

References: 1. Chest (2000)118:736; 2. JTCVS (1998)115:593; 3. JSurgRes (1998)76:124; 4. ATS (1996)61:S21; 5. ATS(2000)69:1053; 6. Transfusion (2001)41:522; 7.ATS (2002)74:1180; 8.ATS(2003)75:479; 9.Trasylool PI.(2001); 10.ATS (2001)71:745; 11. Circulation (1995)92:2236; 12.ATS(2003)75:479

CARDIAC SURGERY: PATIENT NUMBERS AND REVENUE

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Introduction. Cardiac surgery costs are under ever increasing scrutiny. The contribution of cardiac surgery to patient numbers and revenue streams is frequently not included in these debates.

Methods. Data from the Medicare Provider Analysis and Review File (Med-Par File) for 1999 on all of the 5000 hospitals that collect Medicare funds was used. Diagnosis Related Groups (DRGs) included were 103 through 109 (seven DRGs). Revenue over expenses (ROE) was adjusted to a per patient basis. Overall means are presented.

Results. These six DRG groups account for 2.1% of all hospital discharges (212,177 patients), a significantly higher percentage than the average for all other DRGs. An overview of these patients shows an average positive return on return over investment. Blood use is extensive in these patients, the lowest in DRG 104 at 60.4% and the highest in DRG 106 at 89.9% (excluding DRG 103, heart transplant).

DRG	Total patients (Medicare only)	ROE per pt	% use blood
103	455	\$1184.52	96.2%
104	34142	\$595.26	60.4%
105	27768	\$891.21	74.0%
106	3213	\$946.95	89.9%
107	84043	\$613.3	81.6%
108	5753	\$1056.66	78.2%
109	56803	\$514.52	75.6%

Conclusion. These data provide information on both the patient numbers as well as an overview of returns over expenses that certain cardiac surgery procedures provide to the institutions. Cardiac surgery is an important procedure that provides a large number of patients for the hospitals patient base. Cardiac surgery also provides returns over expenses and increases the hospitals revenue stream.

Issues: revenue, cardiac surgery, profit

RELATIONSHIPS BETWEEN NEUROPSYCHOLOGICAL DEFICIT AND QUALITY OF LIFE (QoL) FOLLOWING CABG SURGERY

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Introduction. This study aimed to assess neuropsychological (NP) dysfunction in patients following CABG surgery and to determine whether these deficits impacted on diverse aspects of their QoL, as assessed by both the patient and by their spouse.

Methods. Following approval by the Regional Hospital Ethical Committee and with patient consent, a longitudinal repeated measures study was effected. This provided one week pre-operative data (N = 71) on the recommended "core battery" for NP function for male patients undergoing CABG with CPB. Patients were retested two months (N = 62) and 6 months (N = 53) postoperatively. At each assessment, QoL was assessed using two self-report generic scales: MOS SF36 and the Sickness Impact Profile (SIP). Patient's carer assessment of their QoL was documented using the Functional Activities Questionnaire (FAQ). A 20% decline from an individual pre-operative test score defined a significant NP test deficit, and a significant test deficit on 20% of core tests was identified as an overall deficit.

Results. 42% and 26% of patients showed significant core cognitive deficits, respectively at 2 and 6-month follow-up. Self-reports of QoL indicated significant improvements in Physical (SIP, SF-36), Physical Role, Vitality (SF36) and Social (SIP, SF-36) dimensions at both post-operative times. However, there was no change in Emotional QoL (SF-36), nor change in QoL reported by the spouse (FAQ). The relationships of QoL and NP deficit were explored at 2 months. There were significant relations between core NP deficit and SF36 Physical Role Limitation, and Social Functioning (ps < 0.001) and General Mental Health (p < 0.05). QoL as assessed by the SIP were in the same predicted direction but were not significant. The relationship between NP deficit and the FAQ was also significant (p < 0.01) despite the lack of significant change in this measure.

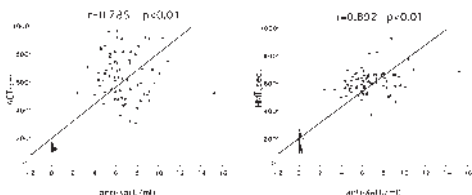
Conclusions. CABG surgery impacts on the QoL of male patients. Patients report improved physical function but the impact on emotional well-being appears more varied. Scales to measure QoL differ in their sensitivity to detect benefits and spouse ratings reflect more ambiguity concerning change. Nevertheless, QoL outcomes do relate to the extent of NP deficits 2 months post surgery.

A COMPARISON OF HEPARIN MANAGEMENT TEST AND ACTIVATED COAGULATION TIME WITH ANTI-XA HEPARIN CONCENTRATION DURING CARDIAC SURGERY

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Introduction. The purpose of this study is to compare the heparin measuring abilities of activated coagulation time (ACT, kaolin) and heparin management test (HMT) by comparing with anti-Xa heparin concentration. **Methods.** In cardiac surgical patients (heparin therapy at 300-400 U/kg), ACT and HMT were measured in duplicate and 6 times at predetermined intervals. Blood samples at each time were used to measure anti-Xa plasma heparin concentration with IL[®] heparin chromogenic assay. We compared the diagnostic accuracy of ACT and HMT with heparin concentration determined by anti-Xa assay. Linear regression analysis was used to compare HMT vs ACT against anti-Xa. P < 0.05 was required for statistical significance. **Results.** In duplicate measurements, ACT (ACT1: r = 0.816, ACT2: r = 0.862) and HMT (HMT1: r = 0.906, HMT2: r = 0.892) correlated well with anti-Xa plasma heparin concentration. The HMT had a significantly stronger correlation with anti-Xa activity than the ACT (mean ACT r = 0.785: p < 0.01, mean HMT r = 0.892: p < 0.01).



Conclusions. The ability of the HMT and the ACT to measure heparin concentration was similar. The HMT correlated more strongly and thus appeared to perform better than ACT in measuring heparin effect using anti-Xa activity. [1] J Cardiothorac Vasc Anesth 1999;13:53-7.

INCIDENCE OF SUBJECTIVE COGNITIVE COMPLAINTS IN CABG PATIENTS AND NONSURGICAL CONTROLS

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Background. A high frequency of self-reported memory complaints after CABG has been reported. Previous studies have concluded that such self-reported complaints often do not correlate with objective neuro-psychological test performance. We compared the incidence of self-reported symptoms in CABG patients to that of a nonsurgical control (NSC) group. **Methods.** Patients were asked at their 3 month and 1 year follow-up if they had experienced negative changes in any of the following areas: memory, calculations, reading, personality. For areas where there were statistical differences, we compared subjective reports to neuro-psychological test score data for each patient. **Results.** Patients reported the following complaints.

Complaint	3 month		1 year	
	CABG	NSC	CABG	NSC
Memory	28%	* 6%	39%	* 15%
Personality	23%	* 6%	18%	* 6%
Calculation	4%	2%	7%	5%
Reading	11%	* 4%	10%	5%

There were significant differences in the frequency of memory complaints between the two groups. Subjective complaints did not correlate with changes in the aggregate verbal memory domain scores. However, we did find an association between subjective memory complaints and lower performance on specific sub-test scores in verbal memory. **Conclusion.** These data suggest that subjective memory reports are more common in CABG patients than in nonsurgical controls, and may reflect

changes in cognitive processes that are not captured by traditional measures of new verbal learning and memory.

OUTCOMES IN PATIENTS REQUIRING TISSUE FLAP CLOSURE AFTER STERNAL WOUND INFECTION

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Introduction. Sternal wound infection is an uncommon, but devastating complication of cardiac surgery. Complex sternal wound infections often require tissue flap coverage of the involved area. The objective of this study is to examine the outcomes of patients requiring tissue flaps for closure after sternal wound infection. **Methods.** From 1/1/2002 to 12/31/2002, 3825 patients underwent cardiac surgery at the Cleveland Clinic Foundation. Of these, 94 (2.5%) had a post-operative wound infection requiring return to the OR. 11 of the 94 required tissue flap coverage of a complex sternal wound infection. Of the 11, 6 were men and the mean age was 66 years (range 43-81 years). **Results.** 8 of the 11 patients had CABG, 2 had AVR/CABG and 1 had a replacement of the ascending aorta. There were no hospital deaths. 6 of the patients were discharged to home while the other 5 were discharged to a skilled nursing facility. **Conclusion.** Tissue flap closure after sternal wound infection is uncommon after cardiac surgery. All patients in this study survived and the majority were discharged to home.

PRE-OPERATIVE CLOPIDOGREL DOES NOT ADVERSELY AFFECT POST-CARDIAC SURGERY MORTALITY AND MORBIDITY OUTCOMES

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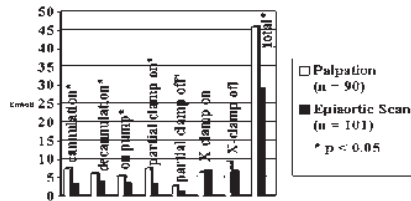
Introduction. To compare post-operative outcomes after primary coronary artery bypass, in two groups of patients, with and without pre-operative use of clopidogrel. **Method.** A retrospective analysis of a total of 113 CABG patients (2001-2002), divided into Group 1 of 75 patients (with clopidogrel) and Group 2 of 38 patients (without) is presented. **Results.** Average age was 66.6 years (53-84), 83 males and 30 females. Average bypass time 101.64 minutes (50-203), X clamp time 74.8 minutes (34-120), with average 2.9 grafts (0-5). Fifty five percent of Gr 1 and 50% of Gr 2 received Trasyloil during surgery. **Neurologic:** Gr 1 and Gr 2 had 4 and 3 patients with transient confusion. Motor deficits 1 (extremity weakness) and 0 respectively. **Cardiac:** 8 and 4 patients had atrial arrhythmias, 3 and 1 with pericardial effusion, 3 and 4 with pericarditis, 1 and 0 with endocarditis, and 2 and 0 with Q wave MI respectively. **Respiratory:** Increased chest tube drainage 1 and 0, prolonged ventilation 4 and 0, pleural effusion 3 and 8, atelectasis 1 and 0, pneumonia 0 and 1 and pulmonary embolism 1 and 1 respectively. **Hematologic:** Coagulopathy was 3 and 0, deep vein thrombosis 2 and 1, thrombocytopenia 1 and 4, anemia 5 and 0, 48% and 29% received transfusions respectively. **Renal:** Acute renal failure was noted in 1 and 1, chronic insufficiency in 2 and 0 respectively. **Other:** There was one death and one readmission for leg hematoma in each group, 3 and 0 prolonged hospitalisation, 4 and 1 total readmissions and 4 and 0 re-operations respectively. **Conclusion.** Comparative data analysis from our institution reveals no significant increase in morbidity or mortality from pre-operative use of clopidogrel.

EPIAORTIC SCANNING SIGNIFICANTLY DECREASES INTERVENTION-RELATED AND TOTAL CEREBRAL EMBOLI

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Palpation of the aorta is insensitive for detection of soft atheromatous plaque, while epiaortic scanning (EAS) has been shown to reliably detect otherwise unrecognized aortic atheroma.[1] Whether EAS prior to aortic instrumentation will decrease cerebral embolization has not been prospectively assessed. **Methods.** After institutional approval and informed consent, a total of 226 patients undergoing elective coronary artery bypass (CAB) surgery with use of cardiopulmonary bypass (CPB) were randomly assigned to either intraoperative palpation (Palp group) or palpation followed by EAS (EAS group). Numbers of cerebral emboli were detected and recorded using bilateral middle cerebral artery (MCA) insonation using 2 Medasonics[®] 2 MHz probes and correlated with intraoperative events. Differences between groups were assessed using t-tests for independent samples, where p < 0.05 was required for significance.

Results. MCA insonation was successful in 191 patients and demonstrated significantly fewer cerebral emboli associated with most intraoperative events, as well as significantly fewer total numbers of emboli in EAS group, as shown in the Figure.



Conclusion. Routine use of EAS is associated with significantly fewer cerebral emboli in comparison to intraoperative palpation of the aorta. [1] J Cardiothorac Vasc Anesth 1997;11:704-7

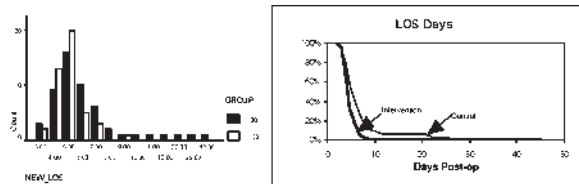
MONITORING CEREBRAL OXYGEN SATURATION SIGNIFICANTLY DECREASES POSTOPERATIVE LENGTH OF STAY: A PROSPECTIVE RANDOMIZED BLINDED STUDY

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INTRODUCTION. This study evaluated the impact of interventions to improve regional cerebral oxygen saturation (rSO2) on postoperative outcome after coronary artery bypass (CAB) surgery.

METHODS. After ethics board approval and written informed consent, patients were age stratified and randomly assigned to Control group (Group C) or Intervention group (Group I). Both groups had bilateral frontal electrodes to measure rSO2 during the operation, in Group I patients the monitor was visible and efforts to keep the rSO2 on levels $\geq 75\%$ of preinduction value by sequentially increasing perfusion pressure, pump flow, PaCO2 (< 35 mmHg), FiO2, decrease temperature ($> 37^\circ\text{C}$), increase PaCO2 > 45 mmHg, increase Hct ($< 20\%$); in Group C patients the monitor was covered and the patient was managed routinely. Statistical analysis used the Wilcoxon Rank Sums for asymmetrical distributions with $p < 0.05$ required for significance.

RESULTS. 98 patients were included in the study (54 Group C, 44 Group I), neurological complications were detected in 6 patients from the Group C [3 strokes] and in 5 patients in Group I [0 stroke], and were not statistically significant. When comparing length of stay (LOS) between the groups there was a significantly shorter LOS in the Group I with odds ratio in the control group for a 10 or more days length of stay in hospital of 7.58 ($p = 0.03$).



CONCLUSION. Monitoring and maintaining rSO2 above 75% of baseline was associated with a decreased length of stay in CAB surgery.

CARDIAC SURGERY: VALUE OF NEUROMONITORING

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Introduction. Study objectives were retrospective analysis of the use of multi-modality neurophysiologic monitoring with interventions to reduce morbidity associated with cardiac surgery in high-risk patients and as a result shorter ICU and Hospital stays.

Material and Methods. We performed a prospective study of consecutive high-risk patients ($n = 201$ in the neuro-monitored group and $n = 101$ in non-monitored group) who were admitted for cardiac surgery from May 2002 till December 2002. Patient's inclusion criteria were age (more than 70 years old), previous CVA, diabetes mellitus, hypertension, previous myocardial infarction, carotid bruits, redo cardiac surgery, valvular surgery, aortic reconstruction, thoracoabdominal surgery). Patient's exclusion criteria were: emergency surgery, presence of dense neurodeficit, malignant tumors, cirrhosis, recent stroke (less than 3 mo) and seizures. Medical history that

includes creatinine ≥ 1.6 , arrhythmia, LVEF $< 35\%$, unstable angina, previous CVA, PVD, COPD, carotid disease and above mentioned preoperative risk factors were collected. We evaluated postoperative complications that included neurological, cardiac, pulmonary, renal dysfunction and outcomes measures that included length of stay in the ICU and hospital. Cerebral hemodynamics was monitored with the measurements of the cerebral blood flow velocity (CBFV) and emboli, regional cerebral venous oxygen saturation (rCVOS) and function of central nervous system computer-processed EEG parameter, by TCD (transcranial Doppler) ultrasound, by NIRS (Near-Infrared Spectroscopy) and by computer-processed EEG parameter known as BIS (Bi-Spectral Index), respectively. Interventions algorithms were discussed and approved by all cardiac surgeons. The majority of significant CBFV, rCVOS and BIS changes were corrected by simple adjustment in perfusion, oxygenation or anesthetic administration.

Results. There were no differences with respect to age or gender across two groups. In comparing these groups, there were significantly shorter lengths of stay in the hospital ($p \leq 0.001$) and ICU ($p \leq 0.036$) and reduced post-operative neurological complications ($p \leq 0.001$) among the neuro-monitored group than in the non-monitored group. Subjects in the neuro-monitored group were significantly more likely to report unstable angina (45% versus 12%), moderate stroke risk factor (72% versus 62%), and LVEF $\leq 35\%$ (19% versus 5%) than non-monitored patients. There were no differences in the distribution of type of surgery across the two groups ($p = .511$).

Conclusion. High-risk monitored patients who underwent cardiac surgery had fewer occurrences of postoperative neurologic complications, lower hospital and ICU stay. TCD, NIRS and BIS continuous control provides an effective neuromonitoring tools to reduce the length of stay in the ICU and Hospital.

REDUCTION OF CEREBRAL EMBOLI DURING CARDIOPULMONARY BYPASS FOR CABG—BEYOND SINGLE CROSS CLAMP

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Objective. Single aortic cross clamp with epiaortic scanning have dramatically lowered intraoperative cerebral particulate emboli during CABG. Nevertheless further reductions are necessary to improve outcome. Techniques to classify emboli as gaseous or particulate facilitate intraoperative maneuvers to reduce emboli and improve outcome.

Methods. Sixty-three patients undergoing CABG with cardiopulmonary bypass had carotid emboli measured with Embolus Detection and Classification (EDAC) equipment using modified sonar ultrasound technology. Emboli were classified as gaseous or particulate and measured per cardiopulmonary bypass run. Based on experimental data, some patients were managed with minimal cardiotomy suction return of shed blood (SB) and modified aortic clamping to potentially reduce emboli (Table).

	Overall (n = 63)	Reduced SB and modified aortic clamping (n = 25)	Standard Technique (n = 38)
Gas emboli per patient	44 ± 79 (9)	32 ± 68 (9)	51 ± 86 (12.5)
Particulate emboli per patient	50 ± 101 (7)	45 ± 107 (4)	52 ± 97 (12.5)
Total emboli per patient	93 ± 172 (23)	77 ± 173 (16)	104 ± 171 (26)

Data is expressed as Mean ± SD (Median)

Results. Total particulate and gaseous emboli were almost equal during cardiopulmonary bypass. Using a protocol of reduced (SB) return and modified aortic clamping reduced both types of emboli over standard techniques. At cross clamp release there were 45.5 ± 92.2 (4) emboli where standard single clamp techniques were used. With modified techniques, carotid emboli were significantly reduced to 6.4 ± 14.5 (0) ($p < 0.003$).

Conclusion. EDAC Technology can classify cerebral emboli and identify surgical techniques to reduce cerebral emboli during cardiopulmonary bypass for CABG. Reducing shed blood return by way of avoiding cardiotomy suction and modified aortic clamping are techniques that appear to substantially reduce cerebral emboli during CABG.

REDUCTION OF CEREBRAL EMBOLI DURING CARDIAC SURGERY: INFLUENCE OF SURGEON AND PERFUSIONIST FEEDBACK

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Introduction. Cerebral emboli are known to occur during cardiopulmonary bypass (CPB). Such emboli are particularly common during surgical events (eg, crossclamping of the aorta) and perfusionist events (eg, injection of drugs into the CPB circuit). We compared the number of intraoperative cerebral emboli before and after surgeon/perfusionist feedback.

Methods. All patients underwent isolated coronary bypass grafting using standard surgical and perfusion techniques. The first group of patients was operated on between 1997-98 (EARLY, n = 34) and the second group between 2000-02 (LATE, n = 76). Between the two time periods, cardiac surgeons and perfusionists were given feedback regarding simple intraoperative maneuvers (eg, pursestring around the venous cannula, removal of air from syringes prior to drug injection) that could reduce the number of cerebral emboli during CPB. Emboli were quantified with transcranial Doppler monitoring (Multi-Dop X4, DWL; Sipplingen, Germany) of the middle cerebral artery.

Results. The two groups of patients were similar for all baseline and intraoperative demographics. The number of emboli per patient in the EARLY group was 207.5 ± 144.1 (mean \pm SD), which was significantly more than in the LATE group (126.2 ± 219.6 , $p = 0.02$). The reduction in emboli was particularly notable during surgical and perfusionist events: the total surgical and perfusion related emboli per patient was 177.4 ± 168.4 in EARLY patients versus 91.5 ± 173.8 in LATE patients, $p = 0.008$.

Conclusions. Cerebral emboli during cardiac surgery can be reduced with simple feedback to surgeons and perfusionists.

IDENTIFICATION OF TECHNIQUES ASSOCIATED WITH CHANGES IN EMBOLIC COUNT, HEMODYNAMICS AND CEREBRAL DESATURATION. I. SURGICAL

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Introduction. Cerebral emboli, hypoperfusion have previously been identified as risk factors for both strokes and cognitive decline. Significant hemodynamic changes have also been reported during off-pump CABG. Improvements in neurologic injury may be attained by preventing these iatrogenic phenomena. We have associated potentially modifiable intra-operative factors with these precursors of injury.

Methods. A prospective study was conducted of patients undergoing cardiac surgery. Associations were made between discrete surgical processes with measurements of 1) cerebral changes in blood flow and oxyhemoglobin desaturation, 2) emboli generation in the middle cerebral arteries and perfusion circuit, and 3) systemic hemodynamic changes. A video is made for each surgical case having synchronized images of: surgical site, bilateral transcranial Doppler of the middle cerebral arteries, and transcranial Doppler of the perfusion circuit.

Results. To date, we have studied 22 discrete surgical processes of care, and linked these to measurements of cerebral desaturation, embolism count, and hemodynamic changes.

Conclusions. We have created a comprehensive approach for associating discrete processes of care and precursors to neurologic injury.

Issues: Monitoring during CPB, Surgical techniques

IDENTIFICATION OF TECHNIQUES ASSOCIATED WITH CHANGES IN EMBOLIC COUNT, HEMODYNAMICS AND CEREBRAL DESATURATION. II. PERFUSION

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Introduction. Reductions in overall neurologic injury may be achieved by identifying modifiable perfusion-related techniques associated with precursors of neurologic injury.

Methods. A prospective study was conducted of patients undergoing cardiac surgery. Associations were made between discrete perfusion processes with measurements of 1) cerebral changes in blood flow and oxyhemoglobin desaturation, 2) emboli generation in the middle cerebral arteries and perfusion circuit, and 3) systemic hemodynamic changes. A video was made for each surgical case having synchronized images of: surgical site, bilateral transcranial Doppler of the middle cerebral arteries, and transcranial Doppler of the perfusion circuit.

Results. To date, we have studied 10 discrete perfusion processes of care, and linked these to measurements of cerebral desaturation, embolism count, and hemodynamic changes.

Conclusions. We have designed a system to allow comprehensive evaluation of discrete processes of cardiopulmonary bypass related to cerebral emboli, cerebral desaturation, and hemodynamic instability. This information may provide the knowledge necessary to redesign perfusion practices to reduce neurologic injury.

Issues: Monitoring during CPB, Perfusion methodology

CEREBRAL OXIMETRY DIRECTED PERMISSIVE HYPERCAPNIA ENHANCES CEREBRAL PERFUSION DURING CPB FOR HEART FAILURE SURGERY

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Introduction. Heart failure patients on CPB develop "neuro-endocrine" collapse, requiring vasopressors to counteract low resistance. Resulting cerebral vasoconstriction can be appropriately reversed by tailoring hypercapnia with cerebral oximetry.

Methods. Ten heart failure patients (NYHA class 4) undergoing surgical ventricular restoration with mean age 67 (58-81), 80% males, EF < 25%, average CPB 128 minutes (119-142), X clamp 62 minutes (52-70), grafts 2.2 under mild/mod. hypothermia were studied. Baseline and intra-operative arterial pH, pCO₂, pO₂, % change in cerebral saturations, MAP, Hct pre and during CPB were noted.

Results. Pre-op Hct (29-34) and intra-op Hct (21-28), MAP and Temp on CPB were 48-55mmHg, 28-35 celsius. Alpha stat strategy was used with pre-op pCO₂ (38 to 42mmHg) and pH (7.34-7.42). An average of 35 to 45% drop in cerebral saturations from baseline (70 to 45 - absolute numbers) was noted with CPB and vasopressors to maintain MAP above 60 (62-74mmHg). All other parameters maintained, only increase in pCO₂ by 28-45% (from 28mmHg to 44mmHg average), with pH drop from 7.44 to 7.30 effectively returned cerebral saturations to baseline.

Conclusion. Good MAP alone, from vasopressors is inadequate to maintain cerebral perfusion. Permissive hypercapnia, just sufficient to return cerebral oximetry to baseline is an important CPB management tool for heart failure patients.

A POST-HOC ANALYSIS OF THE EFFECT OF CARDIOTOMY SUCTION ON NEUROCOGNITIVE OUTCOME

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Methods. A post-hoc analysis was performed to compare neurocognitive outcome in patients who had undergone CABG with CPB and had been tested with neuropsychological tests. One group (n = 56) received shed blood by means of cardiomy suction during surgery but no autotransfusion after surgery; the other group (n = 50) received no shed blood or autotransfusion. Neuropsychological testing was performed the day before surgery and 5-7 days after surgery. The incidence of neurocognitive decline was calculated according to standard criteria.

Results. A higher degree of cognitive decline was seen in the patients receiving shed blood during surgery (45 of 56 patients) as compared to patients who did not receive shed blood (26 of 50 patients) when defining decline as a 20% drop in one or more tests. No differences were seen between the groups when decline was defined according to the 1 SD criterion.

Definition of decline	Shed blood	No shed blood	Significance
20% criterion	80.4 %	52 %	P < 0.005
1 SD criterion	37.5 %	40.0 %	n.s.

Conclusions. We should bear in mind that this preliminary analysis is made post-hoc and with groups separated in time, but by the same psychology and at the same institution, which affects the validity of the results. However these data suggests that the use of cardiomy suction during surgery could affect neurocognitive outcome. This study warrants further discussion whether the contaminations in the shed blood (SCADS, S100B, Cytokines etc) could directly affect the brain during surgery. One can also speculate which source of contamination is most harmful for the brain.

The Histologic Characteristics of Captured Particulate Emboli using the Embol-X Intra-aortic Filter During Cardiopulmonary Bypass

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Introduction. Particulate emboli are thought to play a significant role in the development of cardiac surgical complications. Intra-aortic filtration of particulate emboli may reduce the burden of this morbidity in cardiac patients.

Methods. A multi-institutional randomized trial was designed and enrolled 1289 patients at 22 centers. 645 patients were assigned to the treatment arm and received the Embol-X intra-aortic filter (Embol-X, Mountain View,

CA) while 644 patients were assigned to the control arm. All filters were examined for histologic evidence of particulate emboli.

Results. Particulate emboli were identified in 598 (96.8%) of 618 filters successfully deployed. The average surface area of emboli retrieved was 4.0 mm² (range 0–82.5 mm²). Fibrous atheroma was the most common histologic finding. Calcific atheromata were more commonly found in filters from valve patients (19%) than CABG patients (1%). No clinically evident complications attributed to the use of the filter were identified.

Conclusions. The use of the Embol-X intra-aortic filter is both safe and effective. The high emboli capture rate of 97% indicates that particulate emboli are common in cardiac surgery. The majority of these particulate emboli are of atheromatous origin.

Percent of Embol-X Filters Showing Particulate Emboli Grouped by Histological Characteristic		
Histological Description	Percent	(n)
Fibrous Atheroma	86%	(408)
Fibrocalcific Atheroma	3	(16)
Grumous Atheroma/Cholesterol	1	(6)
Medial Tissue	1	(3)
Fibrofatty/Adventitial tissue	2	(8)
Platelets/Fibrin	38	(178)
True RBC Thrombus/Clot	2	(10)

BRAIN DISTRIBUTION OF MICROEMBOLI DURING CORONARY ARTERY BYPASS GRAFT SURGERY

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Introduction. Emboli of cardiac or proximal aortic arch origin are generally assumed to distribute evenly between the cerebral hemispheres. Medical and ethical reasons prohibit testing this assumption clinically. However, coronary artery bypass graft (CABG) surgery offers a unique opportunity to test it. During CABG, gaseous and particulate emboli are inadvertently generated from cardiopulmonary bypass (CPB) or great vessel manipulation. These emboli are released into the systemic circulation at the level of the proximal aortic arch.

Objective. To assess the hemispheric distribution of emboli of cardiac or proximal aortic arch origin.

Methods. Twenty men (mean age: 67.6 years) undergoing first time CABG surgery on CPB at the Boston VA Medical Center were prospectively enrolled. They underwent preoperative carotid duplex ultrasonography of the internal carotid arteries, and intraoperative monitoring of both middle cerebral arteries (MCAs). A Nicolet Pioneer 2020 transcranial Doppler instrument was used. A trained technologist recorded to the hard drive all microembolic signals (MS) encountered during the course of each operation. Saves were subsequently reviewed and artifacts rejected. The MS count/MCA for the total duration of each operation constitutes the basis for this analysis.

Results. MS were detected in both MCAs in every patient. There was no significant difference between the mean number (mean ± SEM) of MS detected in the right (145 ± 51) and left (163 ± 57) MCAs. When the 7 patients with internal carotid artery > 50% stenosis or occlusion were excluded, the MS counts were slightly higher, but again there was no significant difference between the right (165 ± 72) and left (187 ± 82) sides. The number of MS was lower in patients with internal carotid artery disease (227 ± 119) when compared to those without (352 ± 154), but the difference did not reach statistical significance.

Conclusions. Microemboli of proximal aortic arch origin were evenly distributed between the 2 MCAs in this study. This could be of interest to investigators assessing the impact of embolism on the brain. The “protective effect” of moderate or severe internal carotid artery disease against microemboli requires further study.

ARTERIAL LINE EMBOLI IN TWO CURRENT GENERATION CARDIOPULMONARY BYPASS CIRCUITS: EFFECTS OF VENOUS AIR AND PULSATILE FLOW

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Background. Arterial emboli have been associated with air entrained into the cardiopulmonary bypass (CPB) circuit especially with vacuum assisted venous drainage (VAVD) and also with pulsatile flow CPB. A recently available oxygenator on the market (Jostra Quadrox) incorporates novel air elimination design.

Aims. We investigated *in-vitro* the ability of CPB circuits containing the Jostra Quadrox components to remove gaseous emboli following entrained venous air, compared to circuits containing the Medtronic Affinity components. Both gravity venous drainage (GVD) and VAVD were used. We investigated the influence of pulsatile flow on emboli in both circuits.

Methods. Using new CPB circuits, 25 ml volumes of air were introduced into the venous return line at an unrestricted rate using GVD and VAVD. Emboli counts were recorded over 3 minutes distal to the hard-shell venous reservoir (HSVR), oxygenator and arterial filter using a 2 MHz pulsed-wave Doppler. Emboli counts were also recorded using pulsatile and non-pulsatile flow.

Results. Following entrainment of 25 ml of venous air using GVD, the number of emboli detected downstream from the Quadrox HSVR was greater than that downstream from the Affinity HSVR. Similarly the number of emboli detected downstream from Quadrox oxygenator was greater than that downstream from the Affinity oxygenator. Emboli were detected distal to the arterial line filter in both circuits following entrainment of venous air using GVD, however, there was no significant difference between the two brands in the number of emboli detected (Table 1).

Table 1. Comparing Oxygenators (Adjusted means). Emboli counts over 3 mins following 25 ml of venous air using GVD

Position	Affinity	Quadrox	P-value
D/S HSVR	209.3 (154.9, 263.7)	396.0 (351.2, 440.7)	< 0.0001
D/S Oxygenator	179.5 (151.8, 207.2)	242.5 (220.6, 264.5)	0.0011
D/S Arterial Filter	145.8 (120.7, 170.9)	168.1 (147.0, 189.1)	0.1974

In the Jostra circuit both the Quadrox oxygenator and the QUART arterial filter significantly reduced the number of emboli. In the Medtronic circuit the Affinity oxygenator resulted in a small but significant reduction in emboli, however the Affinity filter did not reduce the number of emboli (Table 2).

Table 2. Mean Change and (CI) in Positions by Oxygenators. Emboli counts over 3 mins following 25 ml of venous air using GVD

	Affinity	Quadrox
D/S HSVR to D/S Oxygenator	46.3 (16.8, 75.8)	142.6 (86.9, 198.3)
D/S Oxygenator to D/S Arterial Filter	27.4 (-1.62, 56.40)	78.2 (22.5, 133.8)

Arterial line emboli were greater following 25ml of entrained venous air with VAVD compared to GVD in both the Jostra (p<0.0001) and Medtronic (p = 0.0009) circuits. Pulsatile flow resulted in significant numbers of emboli distal to the arterial line filter in one of two Jostra circuits and one of two Medtronic circuits.

Conclusions. Entrained venous air resulted in arterial line emboli with both the Jostra Quadrox and Medtronic Affinity CPB using GVD and these were exacerbated with VAVD. The cause of arterial line emboli using pulsatile flow requires further investigation. Entrainment of venous air during CPB remains hazardous, particularly during VAVD and conventional filtration methods never ineffectively remove resulting microemboli.

EVIDENCE SUPPORTING THE POTENTIAL FOR ADHESIVE EMBOLIZATION DURING CARDIOVASCULAR SURGERY

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Introduction. BioGlue is an adhesive that is currently being used to reinforce suture lines during thoracic aortic surgery. Previous reports have raised concern that adhesives may leak through suture-line needle holes and that resulting intraluminal glue may embolize. The purpose of this study was to determine if BioGlue leaks through suture-line needle holes of graft-to-graft anastomoses in polytetrafluoroethylene (PTFE) grafts.

Methods. Twenty-one end-to-end graft-to-graft anastomoses were created in PTFE tube grafts. Anastomoses were sewn with 2-0 (n = 7), 3-0 (n = 7), or 4-0 (n = 7) polypropylene suture. Each anastomosis was covered with BioGlue while the graft was stretched to simulate clinical use. After the adhesive had completely set, each graft was cut longitudinally and the entire lumen was inspected with magnification.

Results. BioGlue leaked through needle holes and was present on the luminal surface of 2 of the 21 anastomoses (10%). The leaks occurred in one anastomosis performed with 2-0 suture (SH needle) and one performed with 4-0 suture (RB needle). The intraluminal glue particles were easily dislodged.

Conclusions. BioGlue did leak through the suture-line needle holes of graft-to-graft anastomoses in PTFE grafts and were easily dislodged, supporting concerns regarding embolization. Similar studies using other graft

materials and aortic tissue are warranted to further investigate potential leakage into the lumen.
Issues: What strategies should be considered to minimize the risk of adhesive embolization during cardiovascular surgery?

DOES A PATENT FORAMEN OVALE INCREASE THE RISK OF CEREBRAL FAT EMBOLISM DURING TRAUMATIC FEMUR FRACTURE REPAIR?

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Introduction. Transcranial Doppler (TCD) allows the detection of cerebral fat emboli in patients with traumatic long bone fractures and during orthopedic surgery. In this setting the presence of a patent foramen ovale (PFO) may lead to paradoxical embolism and increase the cerebral embolic load. However the pathophysiological role of a PFO in this process remains poorly defined. We here present the intra-operative TCD findings in patients with and without a right-to-left shunt (RLS) undergoing traumatic femur fracture repair.
Methods. Adults with isolated femur fractures were enrolled within 24 hours of trauma. Daily and intraoperative TCD studies were performed until the resolution of all microembolic signals (MES). All patients were evaluated for the presence of a RLS with TCD. Patients were monitored daily for neurological deterioration. The local institutional review board approved the study.

Results. Inclusion criteria were met by 42 patients. During the course of hospitalization MES were detected in all patients. Neurological symptoms developed in 7/42 (17%) patients all of whom had a RLS. A RLS shunt was found in 14/42 (33%). MES were found intra-operatively in 40/42 patients, with 2 patients developing cerebral emboli only during surgery. The mean intra-operative embolic count differed significantly in subjects with and without a RLS and was 8.0 MES/h and 2.1 MES/h ($p < 0.05$), respectively. The embolic count in patients with a RLS and neurological symptoms was even higher (10.8 MES/h). No significant differences were detected in the intensity of MES between these two groups.

Conclusions. MES signals are found in the majority of patients undergoing femur fracture repair. The presence of a RLS shunt appears to augment the intra-operative cerebral embolic load by increasing the number rather than the size of cerebral emboli. These findings suggest that a PFO is an embolic factor associated with orthopedic surgery.

TEE DETECTION OF PARADOXICAL AIR EMBOLI IN A PATIENT WITH A SINUS VENOSUS ATRIAL SEPTAL DEFECT

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Introduction. Air embolism may contribute to neurological dysfunction following CPB [1]. We report on a case of paradoxical air embolism occurring in an otherwise healthy 20 year old female who presented for surgical closure of a sinus venosus ASD.

Methods. Following insertion of routine monitors, including an arterial line and double lumen central venous line, and induction of anesthesia, a multi-plane transesophageal echocardiography probe was inserted and a bicaval view obtained. Despite evidence of chronic left to right shunting, visible air emboli were seen crossing from the superior vena cava into the left atrium during positive pressure ventilation. The only obvious source of the air was from micro-bubbles entrained from an intravenous infusion through the central line.

Discussion. This case highlights the potential for right to left shunting through ASD's in patients undergoing positive pressure ventilation. While the incidence of ASD is uncommon, the incidence of patent foramen ovale may be as high as 25% (2). Diagnosis of patent foramen ovale is often achieved with micro-bubbles injected during a valsalva manoeuvre which demonstrates paradoxical emboli. This case highlights the need for careful monitoring and avoidance of microbubbles during cardiac surgical procedures.

[1] J Thorac Cardiovasc Surg 2001 Apr; 121(4):743-9.
 [2] J Am Coll Cardiol 2001 Sep; 38(3):613-23.

RIGHT AXILLARY CANNULATION FOR ANTEGRADE CEREBRAL PROTECTION

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Introduction. As an additional benefit to antegrade flow, axillary cannulation allows antegrade cerebral protection by clamping of the innominate

artery at time of circulatory arrest.

Methods. We reviewed our experience with the technique since its inception [1] in July of 1995 to February of 2003.

Results. Of one hundred sixty-three patients, one hundred twelve received brain protection through the axillary technique. Average population age was 69.3 years old, including 59 males (53%) and 53 females (47%). Hypertension was present in 84 patients (75%), diabetes in 23 (20.5%) and peripheral vascular disease in 19 patients (17%). Thirty-eight patients had emergent procedures including ten patients in shock (8.9%). Indications for axillary cannulation included aneurysmal disease in 38 patients, Type A aortic dissection in 38, severe atherosclerotic involvement of the aorta in 31, multiple redos in 3 and one descending thoracic aorta replacement and one vena cava tumor. Surgeries performed were divided in four groups: A-arch replacement (53), B-arch endarterectomy (17), C-ascending aorta replacement with opened distal anastomosis (36) and D-other (2). Mean circulatory arrest time were: A- 52.85 minutes, B-12.30 minutes, C- 24.08 minutes and D-27.5 minutes. Twenty-one (18.75%) of the procedures were redos. Stroke rate was as follows for each surgical group: A-7.55% (3 operative and one post-operative from atrial fibrillation), B-17.65% (3 patients), C-0% and D-0%. Mortality per group was: A-30.19% (16 patients including 6 emergent patients in shock), B-5.88% (one patient), C-13.88% (five patients including four patients in shock preoperatively) and D-0%. There were no hemorrhagic strokes, and no local neurovascular complications related to the cannulation technique.

Conclusions. Right axillary cannulation provides additional benefit of safe antegrade cerebral perfusion and protection in cases where circulatory arrest is needed.

[1] Yvon R. Baribeau, MD; Benjamin M. Westbrook, MD; David C. Charlesworth, MD; Christopher T. Maloney, MD. 1998. Arterial inflow via an axillary artery graft for the severely atheromatous aorta. Annals of Thoracic Surgery 66:33-7.

DO MINITHORACOTOMIES PRESERVE PULMONARY FUNCTION FOLLOWING CABG?

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Introduction. Transient declines in pulmonary function following coronary artery bypass grafting (CABG) via sternotomy are well documented. The impact of a minithoracotomy on postoperative pulmonary function is unknown. Postoperative pulmonary function was compared 4 days and 4 weeks after CABG utilizing these two techniques.

Methods. The patient cohort consisted of 39 elective CABG patients; 19 with sternotomy and 20 with minithoracotomy. Data was analyzed using Anova with Bonferroni's post test. A $p < .05$ was considered significant. Informed patient consent and institutional approval were obtained.

Results. Pulmonary function results were expressed as a mean percentage of pre-operative values \pm SD. There was no difference in lung function at 4 days. Minithoracotomy patients demonstrated improved recovery of FVC and MIP at 4 weeks. However this improvement is not clinically significant.

		4 Days		4 Weeks	
		% Control	p-value	% Control	p-value
FEV1	Thoracotomy	62 \pm 13	$p > .05$	90 \pm 9	$p > .05$
	Sternotomy	67 \pm 9		85 \pm 8	
FVC	Thoracotomy	64 \pm 15	$p > .05$	93 \pm 8	$p < .05$
	Sternotomy	66 \pm 8		84 \pm 8	
FEV1/FVC	Thoracotomy	98 \pm 6	$p > .05$	97 \pm 5	$p > .05$
	Sternotomy	101 \pm 6		101 \pm 7	
DLCO/VA	Thoracotomy	104 \pm 14	$p > .05$	97 \pm 7	$p > .05$
	Sternotomy	96 \pm 12		94 \pm 10	
MIP	Thoracotomy	76 \pm 15	$p > .05$	102 \pm 16	$p < .01$
	Sternotomy	73 \pm 16		84 \pm 12	

Conclusion. CABG using either a minithoracotomy or sternotomy results in a similar transient decline in pulmonary function. Therefore, the decision to perform a CABG through a minithoracotomy should not be based on preservation of respiratory function.

PERFUSION-ASSISTED BEATING HEART CABG WITH A MINIATURE BYPASS SYSTEM IS ASSOCIATED WITH IMPROVED OUTCOMES COMPARED TO TRADITIONAL CPB-SUPPORTED CABG

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Introduction. Patient performance indicators and outcomes were compared between patients supported with our standard bypass system during

CABG surgery and patients supported by a miniature circuit (COR-X₃, CardioVenton Inc., Santa Clara, CA) during beating heart surgery.

Method. Hematocrit, platelet count, CPK, ventilator times, pulmonary status, blood product usage and length of stay in 130 miniature circuit beating heart patients were compared retrospectively to a matched group of CPB-CABG patients.

Results. Significantly less hemodilution intraoperatively in the miniature circuit group resulted in a lower donor exposure rate and blood product utilization. The miniature circuit patients' postoperative pulmonary status was improved over the routine CPB-CABG group.

Conclusions. "Miniature circuits are associated with significant improvements in patient outcome indices, some of which have a material impact the cost of patient care."

Reference: Ann Thorac Surg 1999;67:99; Eur J Cardiothor Surg 2001;19:34; J Thorac Cardiovasc Surg 2002;124:655.

COGNITIVE FUNCTION IN PATIENTS AFTER CABG WITH AN OPTIMISED BLOOD-AIR MANAGEMENT

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Introduction. Target of our investigation was the measurement on cognitive and neurological complications with a totally modified aspiration management during extracorporeal circulation.

Material and Methods. The study was carried out as a prospective, randomised clinical trial involving 40 patients undergoing elective CABG surgery. The patients were randomly divided into two subgroups (20/20). Synthesis™ (Stöckert, Germany) was used in one subgroup with an optimised aspiration management. Bubbles were detected with Hatteland CMD20. S-100 B and standard clinical blood markers were collected pre-, intra- and postoperative. Pre- and the sixth postoperative day, a bedside neuropsychological test battery (Beck's Anxiety Inventory, D2 attention test, Trail Making Test, MMSE and Benton test) was performed.

Results. Sex, age, perfusion times and blood parameters were identical in both groups. There were no statistically significant differences in concentrations of S-100B, amount of blood loss and need for donor blood. The neuropsychological test results decreased after the cardiac procedure, but shows as well no differences between the two groups. The bubble outlet was lower in the Synthesis™ group.

Conclusion. Modification of perfusion management with an optimised air management, trends not to be an effective strategy to perform the cognitive neurological outcome in this small cohort.

RENAL DYSFUNCTION SCORES ARE A VALID SURROGATE MEASURE OF RENAL INJURY AFTER THORACOABDOMINAL AORTIC SURGERY

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Introduction. Although the Renal Dysfunction Score (RDS) is used as a surrogate measure for renal injury in clinical trials involving thoracoabdominal aortic surgery, it has not been validated in this setting. The purpose of this study was to determine if an elevated RDS is associated with increased early mortality in patients undergoing thoracoabdominal aortic aneurysm (TAAA) repair.

Methods. Over a 19-month period, data were collected prospectively from 306 consecutive patients without preexisting renal failure that underwent TAAA repair. Renal Dysfunction Scores (1-5) were assigned to each patient based on baseline and peak postoperative serum creatinine (Cr) levels as follows: (1) Cr elevation < 50% above baseline, (2) Cr elevation 50-100% above baseline, (3) doubling of Cr level but peak < 3.0 mg/dL, (4) doubling of Cr and peak \geq 3.0 mg/dL, and (5) acute renal failure requiring dialysis. Operative mortality was defined as death within 30 days of operation or during the initial hospitalization.

Results. Fifty patients (16.3%) had a RDS \geq 3. Operative mortality was 28% (14/50) for patients with RDS \geq 3 and only 4.7% (12/256) for those with RDS \leq 2 ($p < 0.0001$). Only 20 patients (6.5%) required hemodialysis (RDS = 5); these patients had a 35% mortality (7/20). The mean RDS was higher in non-survivors (2.8 ± 1.7) than in survivors (1.5 ± 1.0 , $p < 0.001$).

Conclusions. Increasing RDS was associated with increased operative mortality following TAAA repair. Renal dysfunction—defined as Cr level that doubles relative to baseline or the need for dialysis (RDS \geq 3)—was substantially more common than overt renal failure and appears to be a suitable surrogate measure of renal injury.

Issues: Why don't we have a standardized definition for renal failure? Will urinary biomarkers improve our ability to detect and quantify ischemic renal injury?

A NOVEL APPROACH TO IDENTIFYING MECHANISMS OF NEUROLOGIC INJURY AFTER CARDIAC SURGERY

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Introduction. A method for linking discrete surgical and perfusion-related processes of care with cerebral emboli, hypoperfusion and hemodynamic changes may offer opportunities for reducing overall neurologic injury for patients undergoing cardiac surgery.

Methods. Emboli and blood flow were measured bilaterally in the MCA and perfusion circuit every 8ms using Power M-Mode Doppler (Spencer Technologies, Seattle, WA). Cerebral desaturation was measured bilaterally every 30sec in the frontal lobe using NIRS (Somanetics, Troy, MI). Hemodynamic information was measured every 20sec using standard anesthesia equipment. Perfusion parameters were captured every 20sec (Stockert-Shiley, Freiburg, Germany). The above measurements and surgical technique were synchronized with a case video, using video from the surgical site, Doppler of the MCAs, and Doppler of the perfusion circuit (Keywest Technology, Lenexa, KS).

Results. Of 9 patients, we captured information on cerebral emboli/flow in 8 (7 bilateral, 1 unilateral), perfusion emboli in 8, cerebral desaturation in 8 (8 bilateral), hemodynamics (9), and video of the surgical site (9). Synchronization of signals was attained in 9 patients.

Conclusions. We developed and implemented a novel method for real-time associations between processes of surgical care and precursors of neurologic injury. A sophisticated understanding of the mechanism of neurologic injury will lead to the redesign of care.

Issues: Monitoring during CPB, Methods Development