Introduction: Coagulopathy leading to excessive blood loss, blood product transfusion, and adverse outcomes is a major complication of cardiac surgery with cardiopulmonary bypass. Current management of coagulopathic bleeding relies on conventional coagulation testing that have long turnaround times and are not able to detect important coagulation defects such as fibrinolysis, platelet dysfunction, or specific factor deficiencies. These shortcomings hamper management, forcing clinicians to delay therapy until the results become available or resort to empiric therapy based on their clinical judgment. These strategies are inefficient and potentially harmful because they can lead to underuse of blood products in some patients, leading to excessive blood loss and possibly re-exploration, and to overuse of blood products in others. Individualized blood management using a transfusion algorithm that employs point-of-care coagulation tests may alleviate these problems.

Methods: An integrated transfusion algorithm (Figure) that employed viscoelastic (ROTEM) and aggregometric (Platelet Works) point-of-care tests, as well as an objective measure of blood loss, was incorporated into routine practice at our hospital on January 2013. Following REB approval, we retrospectively compared the transfusion and clinical outcomes of patients operated from January to July 2013 (post-algorithm) to those operated on during 2012 (pre-algorithm), using multivariable Poisson regression (with robust confidence limits) to adjust for baseline differences.

Results: Patients had similar characteristics pre- and post-algorithm. Incorporation of this algorithm into routine practice was associated with a significant (P < 0.0001) reduction in blood transfusion rates. Red blood cell transfusions decreased by 12% (from 52% pre-algorithm to 40% post-algorithm), platelet transfusions decreased by 15% (from 34% to 19%), and plasma transfusions decreased by 21% (from 34% to 13%). Post-algorithm, there was also significant improvement in clinical outcome such as re-exploration rate (P<0.001), major blood loss (P<0.0001), refractory coagulopathy (P<0.002) and acute kidney injury (P<0.008). Nadir and discharge hemoglobin concentrations were similar, suggesting that reduced transfusions were not due to a more restrictive transfusion strategy.

Conclusion: Individualized blood management using transfusion algorithm that employs point-of-care coagulation tests can reduce transfusions and improve outcomes. Whether these results are generalizable to other centres, however, needs to be determined.

References:
2. Transfusion. 2008; 48: 2S-30S
Intraoperative Algorithm – Patient Blood Management for CVS

During CPB: Re-warmed

Collect blood for ROTEM and PlateletWorks

Post-CPB: Protamine (1.1 mg / mg initial heparin dose) or until ACT within 25% of baseline (if normal at baseline)

Measure POC INR; Send samples for Standard Coagulometry

Measure Blood Loss (Must use Simultaneous method)

Sponges Weight < 60 gm (or no sponges weighed)

No Blood Products

(MCF-APTEM)/[(MCF-EXTTEM)] > 1.5

or

130 ≤ 95%

Tranexamic acid 2 – 4 gm

FEP 15 ml/kg (3 – 5 U)

Platelets 1 pool

If meet criteria for more than one blood product type:
- Sponges 60 – 120 gm, must treat in order of steps that meet criteria (1 – 4), one at a time
- Sponges > 120 gm, can combine steps and give products together

* New antiplatelet drugs may require more than 1 pool of platelets for reversal
† Use ideal body weight to calculate dosing

Sponges Weight ≥ 60 gm

MCF-EXTTEM < 40 & MCF-FIBTEM ≥ 7 mm

or

< 75% or < 75,000 Functioning Platelets

(PLT NR Coil)

or

Clepidogrel* within 5 days of surgery

CT-EXTTEM > 100 s

or

POC INR > 2.0

MCF-FIBTEM ≤ 7 mm

Platelet 1 pool

Consider PCC/FFP/PRC failure; volume resuscitate or on maintenance

Cryoprecipitate 10 U

or

Fib Cocr. 50 mg/kg†
Introduction: The surgical stress response, which causes increased secretion of catabolic hormones and catecholamines as well as the release of inflammatory cytokines, has been the focus of a number of preventive perioperative strategies. The stress response, that clinically manifests in tachycardia, hypertension, arrhythmias, increased myocardial oxygen consumption, hypercoagulability and impaired immune function, has been implicated in a number of adverse perioperative outcomes (1). High spinal anesthesia (HSA) for cardiac surgery has previously been shown to blunt the surgical stress response (2). Although a previous retrospective observational study demonstrated that HSA was associated with a shorter time to extubation, decreased post-operative morphine requirements and a trend towards shorter intensive care (ICU) and hospital length of stay (LOS) (3), its overall relationship to patient outcomes is not clear. The purpose of this study is to investigate if the use of HSA is associated with a reduction in adverse perioperative outcomes.

Methods: Following Institutional research ethics board approval, we conducted a retrospective chart review to identify patients having had cardiac surgery under spinal anesthesia at our institution from December 2003 until December 2010. The HSA group was compared to a control group of patients whom were matched according to age, sex, procedure, surgeon and date of surgery. The primary outcome was a composite of major morbidity including death, stroke and re-operation for bleeding. Secondary outcomes include factors such as time to extubation, ICU and hospital LOS, post-operative delirium and twenty-four hour analgesic requirements. Data was analyzed using Chi-Square or Fishers’ Exact Test, Student T test and conditional logistic regression.

Results: Three hundred and six patients were studied (n=153 HSA group; n=153 controls). The HSA and control groups had similar demographics except more patients in the HSA group had a preoperative diagnosis of COPD (18 versus 9%, p=0.02). Intraoperatively, the groups were similar with no significant differences in type of surgery performed, cardiopulmonary bypass time, aortic cross clamp time, intraoperative hemoglobin, or glucose levels. The HSA group had significantly less intraoperative administration of opioids (p=0.0001), ketamine (p=0.01) and insulin (21 versus 42%, p=0.0001). Postoperatively, the HSA group was extubated in the operating room more frequently (78 versus 48%, p=0.0001), had less nausea and vomiting (12 versus 43%, p=0.0001), required less morphine and acetaminophen use (p=0.0001), and trended towards fewer postoperative transfusions (p=0.10). However, there were no significant between group differences in the composite primary outcome (Odds Ratio 1.50, 95% Confidence Interval 0.72-3.11), ICU LOS (p =0.80), or hospital LOS (p =0.60).

Discussion: Although the use of high spinal anesthesia for cardiac surgery reduced the requirements for postoperative analgesia, suggesting an improvement in patient quality of recovery, it did not appear to reduce the overall incidence of major adverse outcomes nor impact hospital LOS. These benefits need to be balanced with the risk of neuraxial hematoma formation.

References:
1. Dynamics 2007 18: 14-20
3. Dynamics 2009 20: 18-24
Odds Ratios for Perioperative Outcomes

- Delirium: 1.13 (0.43, 2.92)
- Excessive PONV: 0.19 (0.10, 0.36)
- Post-operative Transfusion: 0.65 (0.3, 1.08)
- Vasopressor Use at 24 hours: 1.5 (0.69, 2.25)
- Vasopressor Use at 12 hours: 1.30 (0.79, 2.14)
- Post-operative Atrial Fibrillation: 1.21 (0.70, 2.08)
- Re-intubation: 1.14 (0.41, 3.15)
- Extubated in Operating Room: 5.18 (2.72, 9.88)
- Reoperation for Bleeding: 1.56 (0.67, 3.59)
- Primary Outcome (Death, Stroke, Re-operation for Bleeding): 1.50 (0.72, 3.11)
39116 - MULTICENTERED RANDOMIZED CONTROLLED TRIAL OF INHALED MILRINONE

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Introduction: Pulmonary hypertension is a major cause of mortality and morbidity in patients undergoing valvular and complex heart surgery as it can lead to right ventricular (RV) failure. Inhaled milrinone (iMil) has been used for the treatment of pulmonary hypertension (1-2) but its safety and pre-emptive effects in facilitating separation from cardiopulmonary bypass (CPB) and preventing right ventricular dysfunction have not been studied in patients undergoing high-risk valvular surgery.

Methods: This study has been approved by the institutional Ethics Committee and patient informed consent was obtained. High-risk cardiac surgical patients with preoperative pulmonary hypertension were randomized in a double-blind fashion to receive iMil or placebo. The inhalation occurred after the induction of anesthesia and before surgical incision and CPB. The hemodynamic effects on ventricular function were evaluated by means of pulmonary artery catheterization and transesophageal echocardiography. The primary outcome was the level of difficulty in weaning from CPB.

Results: A total of 124 patients were randomized. There was no baseline difference between the two groups except for more women and consequently a lower weight mean in the iMil group. The mean EuroSCORE II was 8.0±2.6 and the baseline average systolic pulmonary artery pressure (PAP) was 59±9 mmHg. The use of iMil was associated with lower diastolic PAP (p=0.0339) and higher mean systemic to pulmonary arterial pressure ratio (p=0.0113) with no systemic hypotension. However, no advantage in terms of separation from CPB (easy in 72% in control vs 70% in the iMil group; p=0.240) and RV failure (15% vs 14%; p=0.941) was observed. Patients in both study groups showed an increase in mortality with RV failure (22%), compared with those without RV failure (1.9%) (p=0.0002). Predictors of RV failure were the EuroSCORE II (OR 0.64, 95%CI 0.48-0.86) and RV systolic area (OR: 0.81, 95% CI 0.70-0.94).

Conclusion: In this high-risk cardiac surgery cohort, the pre-emptive use of inhaled milrinone is associated with favorable hemodynamic effects which do not translate in improvement of clinically relevant end-points.

References:
INTRODUCTION: Tumor excision and microsurgical free flap reconstruction (FFR) is a mainstay treatment of head and neck malignancies. These lengthy and complex surgical procedures are associated with considerable postoperative morbidity and excessive crystalloid administration is known to worsen outcome (1). The purpose of this study was to determine the effects of goal-directed fluid management (GDFM) based on continuous SV monitoring on volume and composition of fluids administered during FFR.

METHODS: After the Research Ethics Board approval, and informed consent, 80 consecutive patients undergoing FFR were enrolled and randomly allocated to the study and control groups. SV was monitored in both groups using arterial pulse wave analysis (FloTrac/Vigileo™ Edwards Lifesciences, Irvine, CA) and recorded for postoperative off line analysis. In the study group, a GDFM algorithm was used to guide fluid administration as follows: after achieving a steady state anesthesia, a Volume Loading Step-VLS (250 ml of Voluven™, Fresenius Kabi, Canada) was administered. If the SV increased > 10% the patient was considered to be a positive fluid responder. The VLS was repeated until the increase in SV was < 10%. The SV obtained when the response to intravascular fluid administration was lost was considered the optimized SV. After SV optimization, intravascular volume was maintained with continuous infusion of 0.5 ml/kg/hr of Ringer’s Lactate. No additional fluid boluses were administered unless SV decreased by 25% from the optimized SV and the same VLS strategy was repeated as described above. In the control group, the SV measurements were concealed and not used for clinical management.

RESULTS: Three patients were lost from the study group after randomization due to failure to complete the FFR surgery: study group (n = 37), control (n = 40). Demographics, ASA class, type of cancer, type of free flap, duration of surgery, urinary output and blood loss were similar in the study and control groups. Intraoperatively, the study group received less crystalloid and total fluid but more colloid (Voluven™). There was no difference in the length of hospital stay or incidence medical or surgical complications.

DISCUSSION: GDFM significantly decreased the volume of crystalloids, but increased the volume of colloids administered in the operating room to patients undergoing FFR procedures. As a result, there was a decrease in the overall fluid gain, but there were no detectable difference in patient outcome.

REFERENCES:
Comparison of types and volume of fluid administration during FFR.

<table>
<thead>
<tr>
<th>Intraoperative Fluid Administration</th>
<th>Study Group N = 37</th>
<th>Controls N = 40</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total volume (ml)</td>
<td>3060 ± 1416</td>
<td>4130 ± 1469</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Crystalloids (ml)</td>
<td>2178 ± 1045</td>
<td>3836 ± 1072</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Colloids (ml)</td>
<td>882 ± 371</td>
<td>294 ± 397</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Fluid balance (ml)</td>
<td>2130 ± 1014</td>
<td>3213 ± 990</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>
Background: Accurately predicting patients’ blood requirements preoperatively is crucial to ensure that appropriate blood products are ordered and that blood saving techniques are used when indicated (1). Past literature has identified underlying endocarditis as a potential predictor of blood requirements (2). However, it was not clearly determined if the predictive nature of endocarditis was due to the more complex surgery or to the underlying inflammatory process, which has been shown to have detrimental effects on blood coagulation (3). This study will investigate what factors of endocarditis, if any, are predictive of perioperative or postoperative blood transfusion in aortic valve replacements (AVR).

Methods: After REB approval, data was obtained from a center-specific database as well as chart review. 662 consecutive AVR cases (isolated AVR, AVR plus root repair/replacement or AVR plus pericardial patch, excluding AVR for aortic dissection) with aortic insufficiency of 3 or higher since 1995 were analyzed. Cases of remote endocarditis were excluded. Univariate analysis was performed using Fisher’s exact test and χ2 test to identify variables that may be associated with transfusion of any allogenic blood product (pRBC, FFP, platelets, or cryoprecipitate). A multivariate logistic regression was generated to identify independent predictors of perioperative blood transfusion. In-hospital mortality was also examined univariately.

Results: The two groups vary significantly on several variables (Table 1). Unadjusted transfusion rates in patients with no endocarditis, treated endocarditis and active endocarditis (microorganisms found at time of surgery) were 32%, 60% and 79% (p< 0.001), respectively. Independent predictors of any transfusion were urgent/emergent surgery (OR=2.845; 95% CI = 1.285-6.299), moderate-severe preoperative anemia (OR = 11.629; 95% CI = 5.687-23.779), preoperative renal failure (OR = 3.836; 95% CI= 1.595-9.226), BMI 70 (OR = 2.935; 95% CI = 1.585-5.434) and non-isolated AVR (OR = 3.589; 95% CI = 2.162-5.956). Endocarditis was not an independent predictor of transfusion (OR = 0.748; 95% CI = 0.35-1.601). Unadjusted in-hospital mortality in patients with and without endocarditis was 7.6% and 2.1% (p<0.01), respectively.

Discussion: Aortic valve endocarditis is not independently associated with allogenic blood transfusion in AVR. Unadjusted transfusion rates are higher in patients with endocarditis. This appears to be due to the higher prevalence of many independent predictors of blood transfusion within the endocarditis group.

References:
### Table 1: Patient Characteristics

<table>
<thead>
<tr>
<th>Patient Characteristic</th>
<th>Endocarditis</th>
<th>Non-endocarditis</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>no. (%)</td>
<td>no. (%)</td>
<td></td>
</tr>
<tr>
<td>Endocarditis</td>
<td>92 (100)</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>80 (87)</td>
<td>389 (68)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Procedure Type</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Isolated AVR</td>
<td>37 (40)</td>
<td>468 (82)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>AVR +/-root +/- patch</td>
<td>55 (60)</td>
<td>102 (18)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Urgent/Emergent</td>
<td>37 (40)</td>
<td>28 (5)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Redo</td>
<td>32 (35)</td>
<td>129 (23)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Preoperative anemia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hb normal</td>
<td>11 (12)</td>
<td>428 (75)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Mild anemia</td>
<td>20 (22)</td>
<td>88 (15)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Moderate-Severe</td>
<td>61 (66)</td>
<td>54 (10)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Peripheral Vascular Disease</td>
<td>10 (11)</td>
<td>51 (9)</td>
<td>0.55</td>
</tr>
<tr>
<td>Insulin dependent Diabetes</td>
<td>24 (26)</td>
<td>90 (16)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Hypertension</td>
<td>38 (41)</td>
<td>302 (56)</td>
<td>0.011</td>
</tr>
<tr>
<td>Congestive Heart Failure</td>
<td>40 (43)</td>
<td>158 (28)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Ejection Fraction &lt;40</td>
<td>17 (19)</td>
<td>69 (12)</td>
<td>0.03</td>
</tr>
<tr>
<td>Renal Failure (Cr &gt;176)</td>
<td>28 (30)</td>
<td>26 (5)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>COPD</td>
<td>14 (15)</td>
<td>89 (16)</td>
<td>0.123</td>
</tr>
<tr>
<td>Body Mass Index</td>
<td></td>
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<tr>
<td>Less than 25</td>
<td>26 (28)</td>
<td>170 (30)</td>
<td>0.123</td>
</tr>
<tr>
<td>25 to 29.9</td>
<td>37 (40)</td>
<td>229 (40)</td>
<td>0.123</td>
</tr>
<tr>
<td>Over 30</td>
<td>29 (32)</td>
<td>171 (30)</td>
<td>0.123</td>
</tr>
<tr>
<td>Age</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Less than 50</td>
<td>30 (33)</td>
<td>134 (24)</td>
<td>0.025</td>
</tr>
<tr>
<td>50 to 59</td>
<td>23 (25)</td>
<td>105 (18)</td>
<td>0.025</td>
</tr>
<tr>
<td>60 to 69</td>
<td>18 (20)</td>
<td>116 (20)</td>
<td>0.025</td>
</tr>
<tr>
<td>70 or above</td>
<td>21 (23)</td>
<td>215 (38)</td>
<td>0.025</td>
</tr>
<tr>
<td>Surgery Era</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1995-2000</td>
<td>22 (24)</td>
<td>100 (18)</td>
<td>0.329</td>
</tr>
<tr>
<td>2001-2006</td>
<td>28 (30)</td>
<td>197 (35)</td>
<td>0.329</td>
</tr>
<tr>
<td>2007-2012</td>
<td>42 (46)</td>
<td>273 (48)</td>
<td>0.329</td>
</tr>
</tbody>
</table>
39246 - SPECKLE TRACKING OF THE AORTA AND GENERATION OF PRESSURE-VOLUME LOOPS

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Introduction: Reduced aortic compliance is associated with mortality in hypertensive patients, impaired systolic and diastolic heart function, reduced coronary blood flow, and the pathophysiology of hereditary aortopathies. Measures of aortic compliance often ignore the contribution of longitudinal stretch to aortic volume change, assume uniform aortic expansion during systole and are unable to evaluate compliance throughout the cardiac cycle. Speckle tracking imaging (STI) tracks echocardiographic tissue motion, provides values for velocity or strain, and has been validated using cardiac MRI and sonomicrometry. Our hypothesis is that STI of the proximal ascending aorta, in conjunction with invasive pressure monitoring, will allow measurement of aortic volume change and produce pressure-volume loops similar to those previously obtained from invasive animal studies, a first step in more precisely measuring aortic compliance.

Methods: This study received local ethics committee approval. Data was acquired during general anesthesia for endovascular abdominal aortic repair. Transesophageal echocardiography was performed and the volume change of the aortic root and proximal ascending aorta was calculated using STI-based radial velocities and longitudinal strain rates from the mid-esophageal aortic valve long axis view. Aortic flow was calculated with LVOT diameter and pulsed-wave Doppler from the transgastric long axis view. Aortic pressure was derived by recording radial artery pressure and using a validated transfer function. Graphs were generated for aortic pressure, aortic flow and the rates of change of aortic pressure (dP/dt) and volume (dV/dt). Aortic pressure as it relates to aortic volume and pressure-volume loops were also graphed. All graphs were produced using Maple v16.0 (MapleSoft, Waterloo, Ontario).

Results: Thirty-five data sets were acquired from 18 patients (89% male, aged 71 +/- 7 years, MAP 80.7 +/- 13.9mmHg). Three graphs were produced for each patient: 1) aortic pressure, aortic flow, dP/dt and dV/dt (Fig1A), 2) aortic pressure and volume change (Fig1B) and 3) pressure-volume loop (Fig1C).

Discussion: Our STI-based method of calculating aortic volume change allows for the production of pressure-volume loops comparable to those previously obtained. This will allow for the evaluation of aortic compliance in a more precise fashion than other non-invasive approaches. Furthermore, it will be possible to calculate compliance in systole and diastole as well as evaluate visco-elastic properties of the aorta. In addition to further validation of our STI technique, future studies should evaluate changes in aortic compliance associated with ageing, cardiovascular disease, aortic aneurysm, heritable aortopathies and following surgical interventions on the aorta.

References:
2. J Am Coll Cardiol 1994;24:1406-14
39264 - HIGH VENOUS PRESSURE A RISK FOR LIVER INJURY & DEATH IN HEART SURGERY

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Michael Acker, MD - Surgery, University of Pennsylvania
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Introduction: Post-operative liver failure (POLF) following cardiac surgery in patients with pre-existing cirrhosis is associated with high mortality. Chronic venous hypertension may lead to congestive hepatopathy and liver fibrosis but there is little data on the risk of POLF in this group. Our objective was to study the incidence of POLF and the resulting mortality in cardiac surgery patients with high baseline central venous pressure (CVP). We also evaluated several perioperative factors as predictors for POLF.

Methods: This study received local ethics committee approval. Data was retrospectively acquired of on-pump cardiac surgeries over a 15-month period with a CVP of 20-40 mmHg following induction of anesthesia. Emergency cases were excluded. POLF was defined as 1) post-operative serum total bilirubin, AST or ALT levels greater than 2.0 mg/dL, 100 IU/L or 100 IU/L respectively within 48 hours and 2) increase greater than twice pre-operative levels. Both 7-day and 30-day mortality were assessed. Data included in the analysis for risk factors of ALF are shown on Table 1. POLF and non-POLF groups were compared with paired t-tests, Chi-squared tests, as well as univariate and multivariate regression analysis (SPSS v.21, IBM, Armonk, NY).

Results: A total of 1465 cases were evaluated with 9.1% (134/1465) meeting high CVP criteria. Following exclusion of emergency cases, 106 patients were analyzed. POLF occurred in 34.0% (36/106) of cases with a 7-day mortality of 22.2% (8/36) and 30-day mortality of 27.8% (10/36) compared with 2.9% (2/70) and 2.9% (2/70) in the group without POLF (P<0.001). POLF and non-POLF patients had similar pre-operative STS mortality (3.02% vs 2.40%, p=0.45) and STS mortality/morbidity (21.23% vs 18.11%, p=0.4) scores. Patients with POLF had lower pre-op albumin levels and BMI (P<0.01). There were trends towards CVP (p=0.06) and more inpatients (p=0.06) in the POLF group. No factors were significant in univariate or multivariate analysis, though higher CVP, low BMI and inpatient status trended as possible predictors for POLF.

Conclusion: Patients with pre-operative venous hypertension are at increased risk for developing POLF, which is associated with high mortality. Our hypothesis is that these patients suffer from occult congestive hepatopathy and liver fibrosis which is exacerbated perioperatively. Their risk is not captured by traditional risk stratification models and is challenging to predict. Future research should 1) analyze the entire spectrum of CVP to identify the threshold for elevated POLF risk, 2) involve larger sized studies to aid in developing POLF prediction models, 3) incorporate non-traditional pre-op lab tests that correlate with liver fibrosis and 4) determine how best to reduce POLF risk in this group.

References:
4. Int J Cardiol 2013; 166:554-558
### Table 1. Factors for Analysis

<table>
<thead>
<tr>
<th>Patient</th>
<th>STS Mortality</th>
<th>STS Morbidity + Mortality</th>
<th>Age</th>
<th>BMI</th>
<th>Inpatient (Y/N)</th>
<th>Procedure</th>
<th>Redo sternotomy (Y/N)</th>
<th>DHCA (Y/N)</th>
<th>CPB time</th>
<th>Total crystalloid volume</th>
<th>Total blood product volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratory</td>
<td>Pre-op T-Bili</td>
<td>Pre-op Alb</td>
<td>Pre-op Hgb</td>
<td>Pre-op Cr</td>
<td>Pre-op liver dysfunction (Y/N)</td>
<td>Hemodynamic</td>
<td>CVP</td>
<td>MAP</td>
<td>mPAP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Echocardiography</td>
<td>Pre-op LVEF</td>
<td>Pre-op RV function</td>
<td>Pre-op TR severity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Abbreviations: Alb, Albumin; BMI, Body Mass Index; CPB, Cardiopulmonary Bypass; Cr, Creatinine; CVP, Central Venous Pressure; DHCA, Deep Hypothermic Circulatory Arrest; Hgb, Hemoglobin; LVEF, Left Ventricular Ejection Fraction; MAP, Mean Arterial Pressure; mPAP, Mean Pulmonary Artery Pressure; RV, Right Ventricle; STS, Society of Thoracic Surgeons; T-Bili, Total Bilirubin; TR, Tricuspid Regurgitation.
Increased radiographic opacification of the right versus left hemithorax has been observed in patients who have undergone minimally-invasive cardiac surgery at our institution. Significant complications occurred in several of these patients. We believe this finding represents an underreported variant of reexpansion pulmonary edema and sought to characterize its incidence, risk factors and morbidity.

Methods: Institutional Review Board approval was obtained before data collection commenced. We retrospectively reviewed all cardiac surgery cases that combined a right-sided thoracotomy approach with cardiopulmonary bypass at our institution for the period January 1, 2005 to December 31, 2012. Reexpansion pulmonary edema was defined on the first postoperative day chest radiograph as relatively increased opacification of the right versus left hemithorax involving at least 20% of the chest field, not better explained by atelectasis. Two independent investigators reviewed each radiograph for presence of reexpansion pulmonary edema. Patient data was obtained from a prospectively collected database maintained by The Division of Cardiac Surgery or directly from the patient record.

Results: 278 patients underwent minimally-invasive cardiac surgery employing a right-sided thoracotomy and cardiopulmonary bypass during the study period. 277/278 chest radiographs were available for review. Of these, 68 (25%) were positive for reexpansion pulmonary edema by our definition (κ for radiograph interpretation = 0.47 [95% confidence interval 0.35-0.59, p <0.001] — indicating moderate agreement). Patients with reexpansion pulmonary edema were more likely to: have a lower postoperative p/f ratio (205 vs. 270, difference 65 [95% confidence interval of difference 36-93], p <0.001), require vasoactive medications for greater than 24 hours (31% vs. 9%, p = <0.001), require mechanical ventilation for greater than 24 hours (33% vs. 2%, p <0.001), have longer intensive care unit lengths of stay (median 2 days [interquartile range 1-4] vs. 1 day [interquartile range 1-2], p <0.001), have longer hospital lengths of stay (7 days [interquartile range 5-11] vs. 6 days [interquartile range 5-7], p = 0.001), and require tracheostomy (6% vs. 0% p = 0.014). Mortality was higher in patients with reexpansion pulmonary edema (4% vs 0%, p = 0.014). On multivariate analysis, reexpansion pulmonary edema was independently associated with chronic obstructive pulmonary disease (odds ratio 4.44 [95% confidence interval 1.28-18.6], p = 0.02), pulmonary hypertension and/or right-ventricular dysfunction (odds ratio 2.95 [95% confidence interval 1.41-6.15], p=0.004) and increasing cardiopulmonary bypass time (odds ratio 1.019 [95% confidence interval 1.011-1.027] per minute of additional bypass time, p <0.001).

Discussion: Reexpansion pulmonary edema following minimally-invasive cardiac surgery occurs more commonly than previously reported and is associated with peri-operative morbidity. Risk factor factors have been identified. Research is required to determine if risk of reexpansion pulmonary edema should be considered when evaluating patients for minimally-invasive cardiac surgery.

References:
Introduction: Fluid responsiveness is an important issue in cardiac anesthesia and in the critical care unit. The concept of goal directed therapy has been shown to be associated with improved outcome in several types of surgery. However, cardiac output instruments have to be available in order to apply this concept clinically. Capnography and the FloTrac/EV1000 allow estimation and measurement of the cardiac output. The FloTrac/EV1000 uses the arterial pressure from which is derived stroke volume. In addition, respiratory variations allow the measurement of the variation of the ejection volume (VVE) every 20 seconds. The relationship between capnography and the FloTrac/EV1000 using the thermodilution-derived cardiac output (TDCO) obtained with the pulmonary artery catheter has not been reported. The objective of this study was to correlate cardiac output measurement between capnography, FloTrac/EV1000 during a passive leg raising (PLR) maneuver.

Methods: Following approval by the ethics and research committee and patient informed consent obtained, 50 patients undergoing cardiac surgery were recruited. A total of 3 PLR maneuvers were performed: one in the operating room (OR) before cardiopulmonary bypass and two in the intensive care unit (ICU). A positive response to PLR was defined as an increase in TDCO or the FloTrac cardiac output (FTCO) ≥ 15%, a increase in end-tidal carbon dioxide (ETCO2) ≥ 2% and a reduction of the VVE ≥ 13%. Pearson correlation coefficients were used to calculate correlation between variables. Kappa statistics were used to evaluate concordance between measurements. McNemar testing was used to compare the distribution between responders and non-responders. A non-significant test indicates that there is no difference between the proportions of responders when comparing two different methods. P <0.05 was considered significant.

Results: Responders following PLR in the OR, ICU#1 and ICU#2 were 32%, 20% and 36% (TDCO), 42%, 26% and 40% (ETCO2), 56%, 38% and 40% (FTCO), and 26%, 34% and 44% (VVE). Correlations between all four variables (TDCO, ETCO2, FTCO and VVE) were all significant after the first PLR (p<0.05), only significant for ETCO2 and FTCO in the second PLR (p=0.0022) and no correlation was observed at the third PLR. When all measurements were pooled, responders and non-responders after PLR were identical between TDCO and ETCO2 in 72% (Kappa 0.37, p<0.0001), with TDCO and FTCO in 67% (Kappa 0.32, p<0.0001) and with TDCO and VVE in 62% (Kappa 0.17, p=0.0442). P-values of McNemar test for the same three comparisons were 0.16, 0.0014 and 0.0627.

Conclusion: In patients mechanically ventilated before and after cardiac surgery, the correlation between variables used in estimating cardiac output are different in the OR compared to the ICU. When using TDCO as a reference, changes in ETCO2 compares favorably to variables measured using the FloTrac/EV1000 in order to identify fluid responsiveness.
Introduction: Left ventricular (LV) diastolic dysfunction, defined as the ratio of the peak velocity of early mitral inflow (E) to the early diastolic mitral annular velocity (e'), is a predictor of major adverse cardiac events (MACE) in patients presenting for non-cardiac surgery.\(^1\) Diastolic function is dependent upon LV afterload, which may change as following aortic stent deployment.\(^2\)\(^3\) We examine the effect of LV afterload on E/e' in patients undergoing endovascular repair (EVAR) of their abdominal aortic aneurysms.

Methods: Conjoint Health Research Ethics Board approval and patient consent was obtained. Following induction of general anesthesia, patients presenting for EVAR had a detailed trans-esophageal echocardiographic exam, prior to and following deployment of the endovascular stent. Central aortic pressure was derived from a corrected radial artery pressure wave using a generalized transfer function.\(^4\) Aortic flow was measured using LV outflow tract velocity and diameter. Afterload was defined as systemic vascular resistance (SVR) and characteristic impedance (Z0).\(^5\) Spectral Doppler of the early diastolic mitral valve inflow and the average of septal and lateral wall tissue velocities were used to calculate E/e'. Statistical analysis was performed using Analyse-it v.2.26.

Results: All results are presented as Mean±SD. There were 18 patients (16 male) who completed the study with an average age of 71±7 years. There were no differences in mean BP (78.5±11 v. 83±16 mmHg), E/e' (10.6±1.2 v. 9.7±0.7) or SVR (1697±514 v. 1564±504 dynes-s/cm\(^5\)) prior to or following EVAR. Z0 decreased slightly following EVAR (149±68 v. 120±85 dynes-s/cm\(^5\), p=0.04). Multi-linear regression modeling using SVR and Z0 as independent predictors of E/e' (8.87-0.028*Z0+0.003*SVR, p=0.02) demonstrated that 24% of the variation in E/e' can be attributed to LV afterload (Figure 1).

Discussion: Changes to LV afterload account for nearly a quarter of the variability in diastolic function. While there was no increase in LV afterload following stent deployment the results may have been moderated by the anesthetic agent. Anesthetics, vasoactive agents and surgery can have a considerable, but as yet ill-defined, effect on the LV afterload and diastolic function with possible beneficial or detrimental changes in the incidence of MACE.

References:
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