A Change in Myocardial Preservation Strategies using the Quest Medical MPS 2 System

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Why the Change from variable ratio to the Quest MPS system

- A platform that would allow the flexibility to meet our demands today while allowing for future considerations.

- Potential to meet some of the perfusion best practice recommendations.

Murkin et al, 2006
The time had come to proceed from discussion of philosophy and the theory of change to our clinical initiation of change - merger process.

Factors that influenced change: discussions with Quest Medical Inc, the experiences and clinical outcomes previously published, surgeons and perfusionists willingness to change, clinical observations of the MPS 2 System with the Clinical Perfusionists at the Toronto General Hospital.
A 46 year old female, Rheumatic fever at age 2

- 87kg, 155cm with a BSA of 1.94

- Presented with dyspnea on fatigue, hypertension, chronic atrial fibrillation, suggestion of previous TIA.

- New York Heart Association class 3. Echocardiogram and TEE identified mitral valve regurgitation, mitral valve stenosis plus aortic stenosis and insufficiency secondary to rheumatic heart disease.

- She was scheduled for replacement of Aortic and Mitral Valve.
Equipment Used

- A Jostra HL 20 Heart Lung Machine.
- Terumo SX25 Oxygenator.
- Quart Arterial Line Filter.
- Newly acquired Quest MPS cardioplegia delivery system
Surgical Course

- A clean arch noted by TEE prior to cannulation.
- Aortic cannulation, bicaval venous cannula
- Retrograde cardioplegia into coronary sinus confirmed with TEE
- Initiation of extracorporeal circulation followed by delivery of cardioplegia via the Quest MPS system.
Surgical Course

- The aorta was opened and cardioplegia delivered antegrade via hand held cannula into the coronary ostia.

- Once satisfactory arrest was established attention was given to the rheumatic mitral valve. Which was replaced with a 25mm St.Jude Mechanical valve

- The mitral valve was seated uneventfully and attention was then given to the Aortic Valve.

- Myocardial protection maintained via intermittent doses of retrograde cardioplegia
The Aortic Valvectomy was then performed and it became evident the sino-tubular diameter of the patient was quite small.

A 23 mm sizer was able to be inserted and hence a 23 St Jude valve was selected and brought into place.

Upon seating the left side of the aortic valve it became evident that the right coronary ostia could not be visualized thus the valve could not be seated and was removed.
21mm St Jude valve was then selected and sutured into place. Upon attempting to seat the valve issues with size the sino-tubular junction created seating challenges once again!

The aortotomy was then extended through the sinotubular ridge down to the non coronary sinus the valve was removed and new sutures placed and the valve was then seated.

Myocardial preservation maintained throughout with intermittent doses of cardioplegia during the entire seating of the valve
The aortotomy was then closed under protection of retrograde cardioplegia.

De-airing was performed with the patient in trendelenburg.

Antegrade cardioplegia was then given to test the suture line of the aortotomy which required reinforcing.
Surgical Outcomes

- A cross clamp time of 4 hours and 30 minutes. 15 infusions of microplegia for a total of 16,129 cc’s via the MPS system.

- The patient resumed normal sinus rhythm shortly after the removal of the cross clamp.

- During the case Glucose and $K^+$ levels within normal limits.

- The patient was transferred to the Intensive care unit in a stable condition with minimal Intropic support.
Results that impressed us with this case report

- Normal glucose levels were maintained over this time frame.
- No need for Hemoconcentration during the case.
- Return of spontaneous rhythm shortly after removal of the cross clamp.
- The patient was successfully weaned from extracorporeal circulation with minimal intropic support and without the need of an IABP.
Cardioplegia Challenges at LHSC

- Merger of 2 hospitals with 3 different solutions
- Crystalloid
- 2 different variable ratio solutions
- Cold intermittent
- Continuous normothermic
“In all my work I have tried to embody the passionate conviction the world of ideas and the world of action are not separate as some would have us think, but inseparable parts of each other. Ideas in particular, are truly potent forces that shape the world………………

Avedis Donabedian

- The incorporation of new technology into practice is not a trivial matter but none the less critical for ensuring evidence based practices.

- The link between scholarly work and putting it into action is the responsibility of the provider.

- It is also the responsibility of the provider to have a means to evaluate the change. This is critical for evidence based practice.

Likosky J. Extra Corpor Technol.2006;38:297-301
An evidence-based review of the practice of cardiopulmonary bypass in adults: A focus on neurological injury, glycemic control, hemodilution and the inflammatory response.


- **Maintenance of Euglycemia.** Murkin...... There is both experimental and clinical evidence that hyperglycemia is associated with exacerbation of neurological injury and a variety of other adverse outcomes including wound infection and mortality.

- **Hemodilution** Defoe and colleagues.... Patients undergoing a single HCT value of 19% or less during CPB had twice the mortality as those who had a HCT of 25%. Significant association with intraoperative or post operative placement of an IABP.
Theories of Microplegia

- Reduced myocardial edema
- Reduced systemic hemodilution
- Improved metabolic and systemic recovery
- Better $O^2$ delivery and buffering capacities
- Improved $K^+$ and glucose control
- Reduced transfusion rates
- ??? Distribution  (Menasche, 1996)
Learning curves

- Hyperglycemia is no longer an issue
- Normothermic continuous cardioplegia was the greatest challenge with breakthrough beating, despite high K⁺ levels
- We have contacted at least 10 institutions

It's all about the additive
<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Amount</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>50cc syringe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15cc D50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8cc Nacl</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15u insulin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100mg xylocaine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10cc MgSO4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6mg Adenocard</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At 5cc Delivers/liter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5cc (750mg)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2cc</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5 units</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 mg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.0 gm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.6 mg</td>
<td></td>
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</table>
Intraoperative Blood Conservation Techniques
During CPB: Have We Reached A Plateau


- Retrospective analysis 230 patients undergoing elective/urgent cardiac surgery
- Aortic procedures, patients with a preoperative hgb 100g/L or less were excluded
- Demographic data, CPB transfusion rates, use of IABP, use of ultrafiltration were recorded.
- 6 weeks prior to the Quest MPS vs 6 weeks after the institution of the MPS (allowing for a 2 week training period)
## Demographics

### P-Values

<table>
<thead>
<tr>
<th></th>
<th>Ratio C/P</th>
<th>MPS</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI</td>
<td>30.7 (6.9)</td>
<td>28.4 (4.2)</td>
<td>.027</td>
</tr>
<tr>
<td>Pre-Op Hgb</td>
<td>137.3 (14.3)</td>
<td>137.8 (14.6)</td>
<td>.811</td>
</tr>
<tr>
<td>Low Hgb</td>
<td>82.7 (12.9)</td>
<td>83.3 (13.2)</td>
<td>.784</td>
</tr>
<tr>
<td>CPB (min)</td>
<td>99.7 (42.7)</td>
<td>107.7 (40.2)</td>
<td>.212</td>
</tr>
<tr>
<td>X/C (min)</td>
<td>59.0 (30.2)</td>
<td>71.9 (32.1)</td>
<td>.009</td>
</tr>
</tbody>
</table>
### Results

#### P values

<table>
<thead>
<tr>
<th></th>
<th>Ratio (mls)</th>
<th>MPS (mls)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total C/P</strong></td>
<td>4618.8 (3821)</td>
<td>5251.7 (4028)</td>
<td>.303</td>
</tr>
<tr>
<td><strong>Crystalloid</strong></td>
<td>688.4 (428.5)</td>
<td>61.1 (31.0)</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

- **Total C/P (mls)**: 4618.8 (3821) vs. 5251.7 (4028) with a P value of .303.
- **Crystalloid (mls)**: 688.4 (428.5) vs. 61.1 (31.0) with a P value of <.001.
### RBC Transfusion & U/F

<table>
<thead>
<tr>
<th></th>
<th>Ratio C/P</th>
<th>MPS</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td># of patients</td>
<td>10/79</td>
<td>11/87</td>
<td>.998</td>
</tr>
<tr>
<td>Transfused with RBC's</td>
<td>12.7%</td>
<td>12.6%</td>
<td></td>
</tr>
<tr>
<td># of patients</td>
<td>35/79</td>
<td>20/87</td>
<td>.004</td>
</tr>
<tr>
<td>requiring U/F</td>
<td>44.3%</td>
<td>23.0%</td>
<td></td>
</tr>
</tbody>
</table>

- **% Pts RBC**

- **% Pts U/F** [*]
Utilization of IABP

- 4 month period prior to and post initiation of Quest MPS.

<table>
<thead>
<tr>
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<th>Ratio C/P</th>
<th>MPS</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td># pts requiring IABP</td>
<td>27/369</td>
<td>19/402</td>
<td>0.17</td>
</tr>
</tbody>
</table>
Points of Clinical Interest

- Decrease in use of hemoconcentration during CPB.
- Greater control of glucose and potassium during CPB.
- Early findings have shown a trend (36%) toward decrease in IABP.
- 97% of patients who required an IABP received RBC transfusion.
- 53% of the patients who required an IABP received >4 units of PRBC.
In Retrospect!

- Did this change in myocardial strategies follow the guidelines of a “local quality improvement project” as well as “tracking our practice as it relates to evidence based best practices?”
- Could we have been more structured in our transition from theory into clinical practice?
- Have we been “successful” in enhancing our standard of clinical practice as it relates to evidence based guidelines?
In Conclusion

In our experience to date, the change to the MPS has provided us the ability to address a number of areas of concern for our patients that reach beyond myocardial protection which are consistent with best practice.

Special thanks to the team back home
Adds small titrations of myocardial protecting and arresting agents to achieve an aerobic diastolic arrest during cardiac surgery.
MPS

- Draws blood from the arterial line of the extracorporeal circuit.

- Uses Piston Pumps to deliver undiluted blood, arresting agents and additive solutions through the system.
Demographics

- #pts
- hbg
- bmi
- X-clamp
- CPB

Legend:
- Ratio
- MPS
## Additional examples of high volume CP

<table>
<thead>
<tr>
<th>Procedure</th>
<th>C/P Amount</th>
<th>Crystalloid (mls)</th>
<th>X-clamp time (min)</th>
<th>Blood Products</th>
<th>IABP</th>
<th>U/F</th>
<th>K+ Range mmol/L</th>
<th>Gluc. Range mmol/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVR/Cabg</td>
<td>17.1 L</td>
<td>108 ml</td>
<td>88</td>
<td>None</td>
<td>No</td>
<td>No</td>
<td>4.0 - 6.0</td>
<td>4.3 - 6.2</td>
</tr>
<tr>
<td>Redo MVR</td>
<td>22.7 L</td>
<td>200 ml</td>
<td>103</td>
<td>3</td>
<td>No</td>
<td>Yes</td>
<td>4.2 - 7.1</td>
<td>7.0 - 12.6</td>
</tr>
<tr>
<td>Bentall/Cabg</td>
<td>22.6 L</td>
<td>174 ml</td>
<td>201</td>
<td>None</td>
<td>No</td>
<td>Yes</td>
<td>4.6 - 5.8</td>
<td>5.9 - 7.0</td>
</tr>
<tr>
<td>AVR</td>
<td>15.5 L</td>
<td>123 ml</td>
<td>76</td>
<td>None</td>
<td>No</td>
<td>No</td>
<td>4.3 - 6.9</td>
<td>6.1 - 8.4</td>
</tr>
<tr>
<td>Bentall</td>
<td>29 L</td>
<td>1150 ml</td>
<td>117</td>
<td>None</td>
<td>No</td>
<td>Yes</td>
<td>3.9 - 5.5</td>
<td>3.4 - 13.0</td>
</tr>
<tr>
<td>MVR/AVR</td>
<td>16.1 L</td>
<td>200 ml</td>
<td>270</td>
<td>4</td>
<td>No</td>
<td>No</td>
<td>5.1 - 7.5</td>
<td>5.7 - 9.4</td>
</tr>
</tbody>
</table>
Results of study

Hbg 8.2 vs 8.3
# Units 3 vs 2
# uf 44/95 vs 24/97
% IABP 7.3 vs 4.7
Intraoperative Blood Conservation Techniques

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Ralley et al poster presentation at SABM Annual Meeting; Sept 6-9, 2007; Hollywood California.

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- Demographic data, CPB data transfusion rates, use of IABP, use of ultrafiltration were recorded.

- 6 weeks prior to the Quest MPS vs 6 weeks after the institution of the MPS (allowing for a 2 week training period)
Points of Interest

- Ratio C/P group: Longer CPB times were associated with RBC transfusions (p = .014 and .017 multivariable analysis)
- Ratio C/P group: U/F associated with RBC tx (p = .027)
- MPS group: U/F not associated with RBC tx (p = .267)
- Early findings have shown a 36% decrease in IABP requirements.
- 97% of patients who required an IABP received RBC transfusion.
- 53% of the patients who required an IABP received >4 units of PRBC
Conclusions

- No change in transfusion rates to date
- Gained tighter ranges in $K^+$ and glucose levels
- Reduced U/F
- Trend towards reduced IABP utilization
The MPS utilizes the theory that enhanced myocardial protection is offered by limiting the dilution load to only the drugs delivered, thus reducing myocardial edema and associated hemodilution.

Oxygen delivery is enhanced as a result of the higher hct of the cardioplegia perfused.