# Department of Perfusion

| Revision history (tab in last cell to add a new row \| to be deleted once finally approved) | | | |
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**Cardiac Perfusion Unit Protocol**

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An electronic version of this document is available at [www.insert.website.here.com]

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# 1. Perfusion Team

The Perfusion Department is normally staffed by 4 full time qualified (CCP) Perfusionists and when appropriate a Trainee Perfusionist additional to the 4 CCP qualified staff.

There is a Perfusionist in-house from approximately 0730 to 1700 each weekday. Outside of these hours, full coverage is supplied by 2 Perfusionists an Emergency on-call and a Priority on-call, the emergency on-call is available to be onsite within 30 minutes.

All Perfusionists can be contacted via switch.

Consultant Paediatric Cardiac Perfusionist – Director

Paediatric Cardiac Perfusionist – Clinical Leader

Paediatric Cardiac Perfusionist – Advanced

Paediatric Cardiac Perfusionist - Advanced

+/- Trainee Perfusionist

# 2. Equipment

## a. Hardware

### i. Bypass Hardware

Stockert S5 Heart Lung Bypass Machine

Stockert 3T Heater/Cooler Unit

Terumo CDI 500

Haemochron Junior Signature

Fresenius C.A.T.S. SMART Cell Saver

### ii. ECMO Hardware

Maquet Rotaflow

Maquet Rotaflow 2

Maquet Cardiohelp

Maquet HU35 ECMO Heater

Spectrum M3/M4

Sechrist blenders (including one with Co2 addition ability)

## b. Disposables

### i. Oxygenators

Terumo Oxygenators are utilised for most of the bypass cases.

We currently have 4 oxygenator sizes available.

Baby FX 05, 2) Maquet Paed, 3) FX 15 (30), 4) FX 25

### ii. Circuit

We have 3 customised tubing circuits available. All circuits are coated with Phisio Coating.

Under 5kg Neonatal 0 – 900 mls

3/16" Circuit

3/16" Pump boot

Neonatal/Infant 0 – 1500 ml/min

¼" circuit

¼" pump boot

Sorin CSC 14 Cardioplegia Heat Exchanger

Paediatric 1500 – 3000 ml/min

¼" circuit

3/8" pump boot

Sorin CSC 14 Cardioplegia Heat Exchanger

Child/Adult > 3000 ml/min

3/8" Circuit

3/8" or ½" pump Boot

Sorin CSC 14 Cardioplegia Heat Exchanger

Arterial/Venous (AV) Loops

Five AV loops are available – selection is based on patient size and flow

3/16" – 1/4"

1/4" – 1/4"

1/4" – 3/8"

3/8" – 3/8"

3/8" – 1/2"

Pump Boots

Sterile ¼" , 3/8" and ½" Pump Boots are also available separately

NB: Circuits are assembled by LivaNova based in Melbourne, Vic.

Hemoconcentrators

Maquet BC 20 plus

Sorin DHF 02

Sorin DHF 06

A hemoconcentrator is used in every case for ZBUF (zero balance ultrafiltration) and MUF (modified ultrafiltration). The hemoconcentrator is connected to the arterial pressure monitoring line via a 3 way tap and returned to the circuit via a filtered port on the top of the oxygenator. The inflow to the hemofilter is restricted by positioning a gate clamp on the inlet side.

CDI 500 Blood Gas Monitoring

The CDI 500 is used to continuously monitor arterial blood gases in addition to haemoglobin and venous saturations. The arterial sensor is positioned in the circuit oxygenator recirculation line. The CDI is calibrated with the first arterial blood gas (taken within 10 minutes of commencing CPB) taken from the sampling manifold. The venous cuvette sensor is positioned in the venous line tubing just prior to blood entering the reservoir. The CDI500 updates every 20 seconds. This is a trend monitor. Formal blood gasses must be measured on average every 20-40 minutes.

### iii. Cannula

We have several types of cannula available;

**Arterial**

| | |
|---|---|
| DLP | 6, 8, 10, 12, 14, 16, Fr |
| EOPA | 18, 20, 22, 24 Fr |

**Venous**

| | |
|---|---|
| Two Stages Small | 29/37 Fr |
| Two Stages Medium | 32/40 Fr |
| Two Stage Large | 36/46 Fr |
| Medtronic | 10, 12, 14, 16, 18, 20, 22, 24, 28 Fr Metal Tipped |

**Peripheral**

Medtronic Biomedicus 10, 12, 14, 15, 16, 19, 21 Fr

Medtronic 15, 17, 19, 21, 23 Fr

Avalon 13, 16, 19, 23, 27 Fr

Maquet 21, 23, 25 Fr multi-stage

### iv. ECMO Disposables

1/4" Circuit with Jostra Rotaflow pump head – Bioline Coated

3/8" Cardiohelp Circuit

Quadrox iD – Bioline coated PMP membrane oxygenator

## 3. Flow Calculations

Flow is calculated based on patient BSA.

BSA is calculated by the Du Bois Formula;

$$BSA = (W^{0.425} \times H^{0.725}) \times 0.007184$$

Full Flow is considered 3.0 L/m$^2$/min.

For patients approximately 15kg and over, a lower rate of 2.6 L/m$^2$/min is used.

For patients over 45kg, a lower rate of 2.4 L/m$^2$/min may be used.

## 4. Equipment Selection

The appropriate circuit is calculated in an excel spread sheet upon entering the patient height and weight. The recommended circuit is stated but the Perfusionist must make the final decision upon considering all the operation/patient facts.

For patients up to 20kg circuits are selected on a 3.0L/m$^2$/min flow.

For patients over 20kg circuits are selected on a 2.6L/m$^2$/min flow.

### a. Circuit Selection

| Oxygenator | Min Flow (LPM) | Max Flow (LPM) |
|---|---|---|
| Baby FX 5 | 0.1 | 1.5 |
| | | |

| | | |
|---|---|---|
| Maquet Paed | 0.2 | 2.8 |
| FX 15 R30 Adv | 0.5 | 5.0 |
| Adult FX 25 | 0.5 | 7.0 |

| Flow (LPM) | Pump Boot | Tubing Pack | AV Loop |
|---|---|---|---|
| 0.0 – 0.9 | 3/16 | Neonate/Paed | 3/16 – 1/4 |
| 0.9 - 1.2 | 1/4 | Neonate/Paed | 1/4 – 1/4 |
| 1.2 - 1.5 | 1/4 | Neonate/Paed | 1/4 - 3/8 |
| 1.5 – 3.4 | 3/8 | Paed | 1/4 - 3/8 |
| 3.4 - 7.0 | 3/8 or 1/2 | Child/Adult | 3/8-3/8 or 3/8-1/2 |

| | Flow on Bypass (l/min) | Prime Volume (ml) |
|---|---|---|
| Baby FX 3/16 – 1/4 | < 0.9 | 390 |
| Baby FX 1/4 – 1/4 | 0.9 – 1.2 | 440 |
| Baby FX 1/4 - 3/8 | 1.2 – 1.5 | 500 |
| Maquet Paed 1/4 – 3/8 | 1.5 – 2.8 | 750 |
| FX 15 (30) ¼ - 3/8 | 2.8 – 3.4 | 900 |

| | | |
|---|---|---|
| FX 15 (30) 3/8 – 3/8 | 3.4 – 5.0 | 1150 |
| FX 25 3/8 – 1/2 | 5.0 – 7.0 | 1500 |

## b. Cannula Selection

The prime calculation sheet will calculate a guide the Perfusionist as to which cannula to use. This is generated from the below charts.

Arterial Cannula

DLP

EOPA

NB: Criteria for maximum flow is a maximum pressure drop of 80mmHg

| SIZE | MAXIMUM FLOW (ml/min) |
|---|---|
| 6 Fr DLP | < 400 |
| 8 Fr DLP | <900 |
| 10 Fr DLP | 900 - 1260 |
| 12 Fr DLP | 1260 - 1800 |
| 14 Fr DLP | 1800 - 2500 |
| 16 Fr DLP | 2500 - 3400 |
| EOPA 18Fr | 2500 – 4250 |
| EOPA 20Fr | 4250 – 5000 |
| EOPA 22Fr | > 5000 |
| EOPA 24Fr | Rarely used |

Venous Cannula

NB: Criteria for maximum flow is a maximum pressure drop of 40mmHg

| BICAVAL | | FLOW ml/min |
|---|---|---|
| SVC (Fr) | IVC (Fr) | |
| 12 | 12 | 700 |
| 12 | 14 | 800 |
| 14 | 14 | 1100 |
| 14 | 16 | 1300 |
| 16 | 16 | 1500 |
| 16 | 18 | 1800 |
| 18 | 18 | 2100 |
| 18 | 20 | 2500 |
| 20 | 20 | 2800 |
| 20 | 24 | 3200 |
| 24 | 24 | 4000 |
| 24 | 28 | 5000 |
| 28 | 28 | 6000 |
| | | |
| **SINGLE VENOUS** | | |
| | 14 | 1.0 |
| | 16 | 1.5 |
| | 18 | 2.5 |
| | 20 | 3.0 |
| | 22 | 4.0 |
| | | |
| **TWO STAGE** | | |
| | 29/37 RMI | <3.5 |
| | 32/40 RMI | 3.5 – 5.0 |
| | 36/40 RMI | >5.0 |

## c. Peripheral ECMO Cannula

| ARTERIAL | | Pressure Drop Approx. 80mmhg |
|---|---|---|
| | Approx. Weight Range | MAX FLOW ml/min |
| Maquet 6 Fr | < 2 kg | < 400 |
| Maquet 8 Fr | 2 – 6.0 | 400 - 900 |
| Maquet 10 Fr | 6.0 – 10.0 | 900 - 1260 |
| Maquet 12 Fr | 10.0 – 15.0 | 1260 - 1800 |
| | | |
| **VENOUS** | | Pressure Drop Approx. 40mmHg |
| | Approx. Weight Range | MAX FLOW ml/min |
| Biomedicus 8 | < 2 kg | 0.45 |
| Biomedicus 10 | 2 – 4.8 kg | 0.75 |
| Biomedicus 12 | 4.8 – 6.5 kg | 1.25 |
| Biomedicus 14 | 6.6 – 8.2 kg | 1.75 |
| Biomedicus 15 | 8.2 – 10 kg | 1.25 |
| Biomedicus 17 | 10 – 15 kg | 1.75 |
| Biomedicus 19 | | 2.25 |
| Biomedicus 21 | | 3.0 |

| | | |
|---|---|---|
| Maquet multi-stag3 | 21 F | 3.2 L |
| Maquet multi-stage | 23 F | 4.2 L |
| Maquet mullti-stage | 25 F | ➢ 4.2 L |

### d. Circuit Assembly

The circuit is assembled in an aseptic manner in the Perfusion pump room.

All packaging is checked for integrity and sterility prior to assembly.

The setup is always left draped if not used immediately.

A dry circuit is viable for approximately 10 days. If a circuit is not used within 10 days it is discarded and recorded in the set up not used (SNU) spread sheet.

A clear primed circuit is viable for approximately 24 hours.

A blood primed circuit is viable for 4 hours after the addition of blood.

Co2 flushing occurs electively prior to priming to shorten the time it takes to de-bubble (reduces micro emboli) during the priming phase.

## 5. Prime Constituents

The prime constituents and volume are calculated in the perfusion prime sheet excel spread sheet upon entering the patient's most up to date height, weight, and current haematocrit.

National as well as international best practice guidelines for HCT levels indicate that lowest HCT when possible should not fall below 24% for all patients and no lower than 26% for neonates or cyanotic patients.

Predicted HCT on CPB is calculated via the Prime sheet. This can be further updated in Sorin Connect - in the prime section using the pre bypass patient gas result.

The prime consists of varying amounts of the following constituents.

Plasma-Lyte 148

20% Albumin (100ml per 500ml of Plasma-lyte 148)

Heparin (1000 iu/ml)

Sodium Bicarbonate 8.4%

Calcium Chloride 10%

Red Blood Cells (Leukocyte Depleted)

Tranexamic Acid is often added to the prime on instruction from the anaesthetist

## 6. Cardioplegia

<u>Solution</u>

Buckberg Blood Cardioplegia (4:1) is used.

Base (524 ml) solutions are premade by Biomed Limited Auckland.

**Induction** 15ml 50% Glucose (w/v 50mL 25g in 50mL) added to Base and 30mmol Potassium Chloride (10 mmol in 10 mL)

**Maintanence**: 15ml 50% Glucose (w/v 50mL 25g in 50mL) added to Base solution

All solutions are used within 24 hours after addition of glucose.

**Dose**

Cardioplegia is administered using the Sorin CSC-14 blood cardioplegia heat exchanged in a 4:1 blood: cardioplegia ratio.

| | |
|---|---|
| **Induction** | -30 ml/kg (minimum of 100ml total) induction dose |
| | -delivered at approx. 4 degrees Celsius |
| **Maintanence** | -15 ml/kg |
| | -delivered at approx. 4 degrees Celsius |

Alternatively (but rarely), del Nido prescribed by QCH Pharmacy may be used – 1:4 ratio at approximately 20 ml/kg for induction and 10 ml/kg for subsequent doses.

Cardioplegia is given at approximately 20 – 50-minute intervals at the request of the surgeon. Please notify the surgeon at 20 minutes ischemia and then every 10 minutes after that unless the surgeon has stated otherwise.

Cardioplegia flow rates are patient dependent. Up to 10kg, approximately 5 - 10ml/kg/min will achieve the desired aortic root pressure of 60-120mmHg. An initial short sharp burst of cardioplegia may be required to close the aortic valve. The Perfusionist constantly monitors the cardioplegia line pressure and ECG during administration.

Cardioplegia can also be delivered via direct coronary Ostia. Flow rates are usually between 20 – 80ml/min with a cardioplegia line pressure of no greater than 120mmHg.

Retrograde cardioplegia into the coronary sinus may be given. This is usually given at a flow rate of 100-300ml with a delivery pressure of no more than 40mmHg as measured in the cannula. The flow rate differs with patient size. When delivery pressure is unavailable, CP line pressure can be used as a guide.

# 7. Cell Saver Protocol

Cell saver is to be used for all bypass cases. At the end of bypass cases, residual blood in the CPB circuit will be washed with cell saver.

For non-bypass cases, cell saver can be used at the discretion of the surgeon depending on procedure and expected bleeding.

Cell saver wash solution is Plasma-Lyte 148. Anticoagulant solution is Plasma-Lyte 148 with 30,000 units of Heparin and 15ml of Sodium Bicarbonate 8.4%.

# 8. Zero Balance Ultrafiltration (ZBUF)

Zero balance ultrafiltration is utilised in every case, unless discussed otherwise. This is achieved by filtration using the DHF 02 or DHF 06.

Volume is replaced using HVR (hemofiltration volume replacement). The addition of HVR is titrated according to the volume removed. Filtrate removal is dependent on several factors including patient size and volume. Typically, it can be 50ml/kg/hr.

HVR consists of 1L Plasma-lyte 148, with 15ml 8.4% Sodium Bicarbonate and 2ml 10% Calcium Chloride.

Filtration may be active (use of suction at a maximum of -200mmHg) or passive depending on patient requirement.

All volume added and removed is recorded with accuracy in Sorin Connect to keep an accurate fluid balance total.

# 9. Modified Ultrafiltration (MUF)

MUF is utilised in every cardiopulmonary bypass case.

MUF is performed by un-slaving the cardioplegia pump from the main arterial pump head. The Heather Cooler unit CP temperature is set to warm (approximately 37-38 degrees) and the crystalloid cardioplegia line clamped.

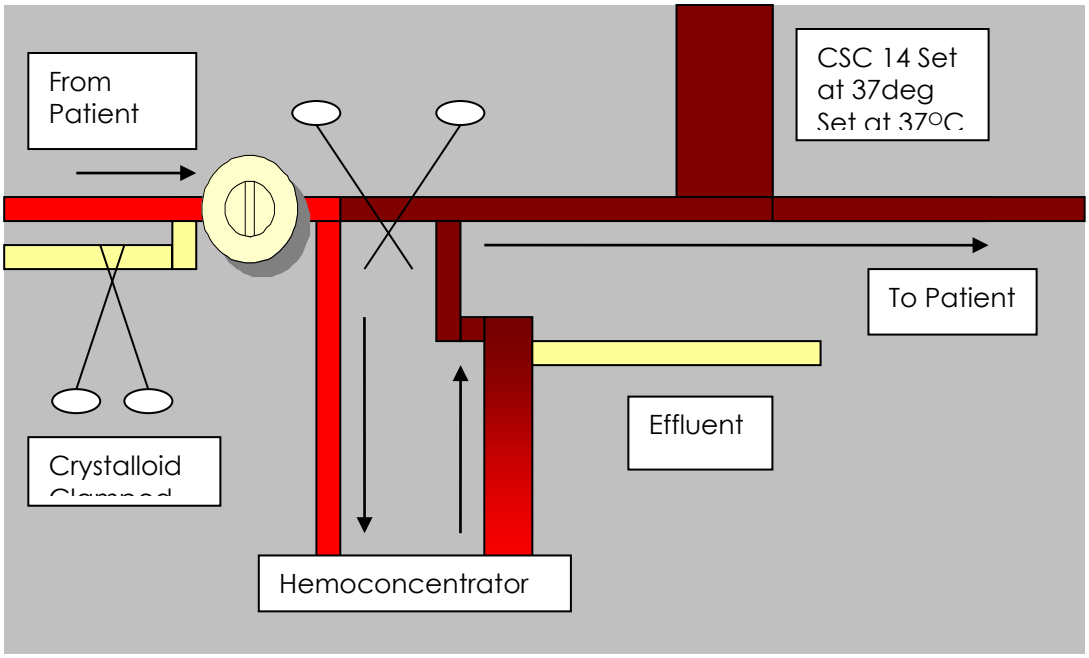
MUF is achieved by drawing volume from the patient via the aortic cannula at a slow rate of approx. 5-10ml/kg/min into the cardioplegia circuit, where it is directed through the hemoconcentrator. The concentrated volume is returned to the patient by the cardioplegia delivery line attached to the venous cannula (or directly into the RA via a cardioplegia delivery needle or coronary Ostia cannula). Filtrate is extracted at approximately 7ml/kg/min, with the aim of extracting approximately 100ml/kg by the end of MUF for patients under 5kg and varying amounts for larger patients. The anaesthetist may be delivering clotting products at the same time – each case should be assessed individually, and best/safe practice utilised during this time.

MUF is carried out for an average of 10-12 minutes or until all circuit volume is concentrated or until consensus that patient state is optimal and remaining volume can be utilised for further filling or bagged off and processed in cell saver. Special attention is paid to cardioplegia line pressure to ensure that it is always positive. This is done by attaching a third pressure transducer line to the arterial pressure line via a three-way connector. A pump stop occurs on the MUF circuit when the pressure becomes less than -7mmHg.

Volume can be returned to the patient via the arterial pump during the MUF procedure if so required.

Total MUF time and volume removed is dependent on many factors and the above times and volumes are to be used as an indication only.

Schematic MUF Circuit Diagram




## 10. ACT Management

Activated coagulation time (ACT) is monitored using the Haemochron Junior Signature.

ACT must be monitored regularly throughout the bypass – a guide of every 30 minutes is recommended but may need to be more often depending on the circumstances

A minimum ACT of 400 seconds is required for Aortic Cannulation. ACTs are maintained above 420 seconds during CPB.

Adequate ACTs are maintained by heparin boluses as necessary during cardiopulmonary bypass.

After 2 hours of CPB an extra heparin bolus may be considered at a dose of 50 iu/kg.

NB: in some circumstances extra heparin may be required just before weaning to ensure adequate anticoagulation for at least 15 minutes of MUF

Low range cartridges (0 -399 seconds) are used for the pre bypass and post protamine ACTs.

High range (400 – 1005 seconds) cartridges are used to monitor ACTs post heparin administration and during CPB.

## 11. pH Stat/Alpha Stat

pH stat (@) is utilised for patients who are cooled to 30 degrees and below. The aim is to maintain a pCO2 of 40mmHg at patient blood temperature as measured on the arterial outlet of the oxygenator.

pH stat is initialised once the arterial blood temperature reaches 30 degrees and continued until rewarming. Conversion back to alpha stat once arterial blood temperature is 30 degrees.

pH stat is achieved by the addition of $CO_2$ via the Stockert electronic gas blender to obtain a pCO2 of 40mmHg.

$pCO_2$ is continuously monitored via the CDI 500 (switched to the pH stat/@ mode). The amount of $CO_2$ added is adjusted to maintain a patient $pCO_2$ of 40mmHg at a temperature corrected value, starting with 5% of total gas flow.

If circulatory arrest will be utilised, a period of hyperoxemia (FiO2 at 100%) for the 5 mins prior to the pump being turned off can be considered.

## 12. Rewarming Protocol

Patient temperature monitoring sites are nasopharyngeal (core) and skin (peripheral).

Many cases are maintained at 'normothermia' or approximately 36 degrees Celsius.

'Rewarming' is carried out at a 0.3 degree per minute increase in arterial blood temperature. The gradient between the water temperature and arterial blood temperature is approximately 3 degrees.

The patient warmer (Bair Hugger) is turned on to approximately 38 degrees once the rewarm command has been given from the surgeon depending on what temperature the patient is currently at. The Bair Hugger if set to its maximum temperature must be closely monitored in order to not overheat the patient.

The patient is warmed to a circuit arterial temperature of 36.5 degrees and considered warm when the arterial and venous temperatures are stable at approximately 36 degrees.

## 13. Data Management System – Sorin Connect

All cases are recorded electronically using the Sorin Connect online data management system.

The Sorin Connect records manually and electronically entered data;

Manual Inputs:

Patient details – name, DOB, UR number, height, weight, clinical details

Surgical team

Perfusion equipment – oxygenator, circuit, serial numbers, cannula

Circuit Prime – constituents and volumes

Fluid inputs and outputs

Drug additions

Cerebral Oxygenation Values, Kidney Saturation values

Automatic Inputs:

Circuit parameters - line pressures, temperatures, alarms, Gas & Blood flows, Bypass and cross clamp time

Adjustable Circuit Parameters – FiO2, sweep, heater/cooler settings

Patient parameters - pressures and temperatures

ACT values

A printed bypass report is placed in the patient's notes and a copy of the bypass report is scanned into the patient's electronic record (Health Track).

An electronic version is kept on the Mainframe Sorin computer in the pumproom which is routinely backed up.

The pump checklist is filed in the pumproom.

## 14. Standard Chain of Events

Perfusion checklist is completed.

A Pump circuit is primed in the Operating Theatre.

A cell saver is connected.

Patient is heparinised.

The AV loop is divided at the table. The arterial side is kept at a positive pressure just above that of the patient mean pressure.

A Pre-CPB ACT sample is taken. Once ACT is > 400 seconds, it is safe to cannulate and use the cardiotomy suckers.

The aorta is cannulated with an appropriately sized cannula. The aortic cannula is connected to the arterial side of the AV loop. This is ALWAYS checked by slightly turning the arterial pump and confirming that the arterial line pressure is appropriate. It should not be excessively high and should reflect the patients mean arterial pressure.

Sweep and FiO2 are now set in accordance with patient requirements, initially gas flow: blood flow ratio of approximately 0.8:1. NB: with cyanotic patients the FiO2 is left at room air to prevent or reduce oxygen free radical damage.

One or both venous cannula are positioned and CPB is commenced. Pump flow is increased slowly towards the calculated full flow. If venous return is adequate, full flow is achieved. All circuit and patient parameters are observed during commencement of CPB, including arterial line pressure, patient saturations (arterial, venous and cerebral) and mean pressures. The Perfusionist must inform the anaesthetist when/if full flow is achieved before ventilator is switched off.

If not already in place, a second venous cannula is introduced, and full flow is achieved. The perfusionist may now begin to cool the patient after ductus ligation (if required) upon consultation with the surgeon. Ensure that the patient warmer (Bair Hugger) is switched off at this time. If normothermia is used then Bair Hugger may remain on.

ZBUF is initiated once there is adequate volume in the venous reservoir (normally when full flow is achieved), and both the circuit and patient are stable. The hemofilter shunt is opened and suction is adjusted as necessary to produce appropriate filtrate removal. HVR is titrated in a controlled fashion (via a burette) to match the hemofiltrate volume.

A blood gas and ACT are taken from the circuit within the first ten minutes of CPB. The CDI500 is calibrated using this blood gas sample by pressing the store and recall buttons. Blood gasses are required to be checked regularly, on average every 20-45 minutes – as the CDI 550 does not measure many important values of interest during CPB e.g. lactate, glucose, sodium, chloride. Any unusual blood gas results **must be** discussed with the anaesthetist at the earliest opportunity and if appropriate also the cardiac surgeon.

Cardioplegia is flushed up to the table (cold) when requested by the surgeon, ensuring that there is adequate blood/cardioplegia mixed to the tip of the line.

Flows are often reduced to 25% at the discretion of the surgeon, as the cross clamp is placed on the aorta. Cardioplegia is administered into the aortic root and at the same time full flow is resumed.

Surgeon is notified at 20-minute cardioplegia intervals and every 10 minutes thereafter unless otherwise stated.

Warming is commenced at instructions from the surgeon. Upon warming, flows are increased; FiO2 is increased in line with increased oxygen consumption to maintain a PO2 of approximately 100 – 250mmHg and a venous saturation of 65 – 75%. Cerebral saturations are constantly monitored to ensure adequate cerebral oxygen demand. The patient warmer is also turned on at this time.

Flows are reduced at discretion of surgeon and the cross clamp is removed.

A final blood gas is taken once the patient is warm, and an ACT is run to ensure adequate heparinisation for MUF. Final blood gas to be viewed by anaesthesia and where appropriate reported to surgeon.

Upon instruction from the surgeon the perfusionist will wean from bypass communicating with both surgeon and anaesthetist.

Pre-wean checks include:

Ventilation On

Blood Gas and electrolytes optimal for weaning

Ensure there is adequate volume in reservoir for weaning - add volume to reservoir if required (do not come off bypass with volume on the low level/low level alarm warning as this will prevent optimal filling. The heart requires optimal filling at this time for successful and safe weaning.

The level sensor and bubble sensor are to always remain on during bypass including weaning from bypass.

Patient parameters optimal for weaning (temperature, pressure, rhythm, saturations)

MUF circuit ready (crystalloid line clamped, 3-way tap at recirculation port off, temperature set at 38 degrees, suction clamped and delivery line open to table)

Once MUF has ended surgeon will remove the venous cannula prior to protamine starting.

At this time the perfusionist may 'drain the MUF line' into a blood collection bag or 50 ml syringe but must leave residual volume in the reservoir and be prepared to transfuse volume via the arterial line up until the arterial cannula is removed. Do not bag off residual bypass blood into the blood collection bag until the protamine is finished and the arterial cannula is removed. Extra attention may be required at this time due to possible protamine reactions and/or bleeding that would require volume to be given by the perfusionist.

Once the arterial cannula is removed continue to bag off all residual bypass volume, chasing it through with Plasma-Lyte 148 to flush remaining red cells – at his time the scrub staff can 'dip the suckers' to remove remaining blood cells from the lumens of the suckers and vent back to the bypass reservoir and process via the cell saver. The last step is to flush the remaining volume up the arterial line to the cell saver once the surgeon or fellow has an opportunity.

Assistant Perfusionist Duties: point of care testing (TEG, ABG, etc.), ensure all supplies are stocked, setup and run cell saver pre, intra and post CPB to process pump blood. Preference is for the second/assistant perfusionist to be in theatre during 'going on' and 'coming off' bypass as well during opening the sternum for redo cases and whenever assistance is required by primary perfusionist. Patient safety is everybody's responsibility – this includes the assistant being aware of what is happening in the case and being prepared to take over/give a break if necessary. They are an important second set of eyes and hands for the duration of the case.

# 15. Emergency Procedures

## a. Pump Boot Change out

<u>Change out Box Contents;</u>

| | |
|---|---|
| 1/4" pump boot (x1) | Sterile Scissors (x2) |
| 3/8" pump boot (x1) | Alcohol Swabs |
| 1/4" Connector (x4) | Clamps (x4) |
| 3/8 – 3/8 Connector (x4) | Blades |
| Sterile Scissors (x2) | Cable ties |

(1) Immediately inform the surgeon and call for assistance.

(2) Get the change out box from the perfusion trolley and select the appropriately sized pump boot and connectors.

(3) When the surgeon is ready, come off bypass.

(4) Clamp venous to isolate patient and clamp immediately below reservoir outlet.

(5) Turn all shunts OFF.

(6) Move clamp from recirculation line to the arterial line.

(7) Move clamp from ALF bypass to proximal to the AFL to isolate the ALF

(8) Double-clamp between reservoir and raceway, and the raceway and oxygenator. Leave a sufficient length of tubing to attach a connector.

(9) Alcohol swab between all clamps

(10) Cut between each set of clamps using sterile scissors.

(11) Remove damaged section of pump boot from pump raceway.

(12) Using aseptic technique, insert connectors on remaining sections of tubing (i.e. still attached to reservoir and oxygenator)

(13) Attach new pump boot onto reservoir connector, SLOWLY open clamp to prime new section of boot. Clamp distal end of new boot

(14) Load tubing into raceway and attach new pump boot onto remaining connector.

(15) Remove clamps from the pump boot

(16) Turn bubble alarm OFF!

(17) Open oxygenator integral fine bore recirculation line

(18) Recirculate at a minimum of 1.5Lpm to de-air the circuit

(19) Turn bubble alarm back ON while recirculating (if it's quiet then it's happy too!)

(20) Move the ALF clamp back onto the ALF bypass line.

(21) Move clamp off of arterial line back onto circuit recirculation line.

(22) Put cable ties on new connections (4 in total)

(23) Inform the surgeon that you are ready to go back onto bypass

(24) Open all shunts

(25) Leave the oxygenator recirculation shunt open for a few minutes (compensate for this with your flows).

(26) Turn oxy integral shunt off and continue as normal

## b. Oxygenator Change out

(1) Make sure oxygenator change out box is available in the perfusion cart in theatre as part of the pre-bypass checklist.

(2) If time allows, get help and have all necessary supplies gathered.

- New Oxygenator
- Matching size connectors (1/4-1/4, 3/8-3/8 etc.) along with a sterile section of appropriate sized tubing
- 4 clamps
- sterile scissors
- alcohol swabs
- cable ties

(3) Inform surgeon of problem. A specific plan may be determined depending on point in procedure.

(4) Clamp venous line to isolate patient.

(5) Turn all shunts OFF.

(6) Take clamp from recirculation line and transfer it to the arterial line.

(7) Take clamp from ALF filter bypass and isolate ALF from circuit.

(8) Turn Bubble alarm off and remove tubing from Bubble detector.

(9) Remove failing Oxygenator recirculation line from top of venous reservoir.

(10) Remove gas line from gas inlet of failing Oxygenator, in addition to water lines if time permits.

(11) Double clamp as close to inlet and outlet of failing Oxygenator as possible.

(12) Alcohol swab between all clamps.

(13) Cut between clamps as close to failing Oxygenator as possible using sterile scissors.

(14) Disconnect failing Oxygenator from bottom of venous reservoir and connect replacement Oxygenator in its place

(15) Using sterile technique, attach cut inlet and outlet ends onto new Oxygenator.

(16) Attach gas line to new Oxygenator in addition to water lines if time permits.

(17) Attach new Oxygenator's recirculation line to top of venous reservoir and ensure it is **OPEN**.

(18) Remove all remaining clamps.

(19) Recirculate until happy no air remaining in circuit or Oxygenator.

(20) Replace arterial line back in bubble detector and turn bubble alarm back **ON!**

(21) Move clamp from ALF back onto the ALF bypass line.

(22) Move clamp off of arterial line back onto circuit recirculation line.

(23) Back onto bypass

(24) Shunts open

(25) Oxygenator recirculation shunt should still be open. Close if all looks well and Oxygenator seems to be "air free".

# 16. Prime Spread sheet and prime contents

Prime contents are as follows:

Plasma-Lyte 148 (Baxter AHB2534) 1000 mL bags

Sodium Bicarbonate 8.4% Injection 8.4g in 100 mL

Heparin – Heparin sodium injection (porcine mucous) 5000 IU in 5mL

Calcium Chloride 10% Injection 1g in 10mL

Albumex 20 – Human Albumin 20% (200 g/L)

If required Donor Packed Red Blood Cells less than 10 days old may be used

Additional prime additions that may be requested by anaesthesia:

Tranexamic Acid (routinely requested for prime)

FFP when required (for example - known Heparin resistance)

Other drugs that may be requested to be given during bypass by anaesthesia and prepared by anaesthesia: Magnesium, Fentanyl, Pancuronium, Rocuronium, Potassium Chloride, Metaraminol, Phenylephrine Isofluorane

**PRIME SHEET**

| | | | |
|---|---|---|---|
| **Name:** | | | |
| **Height** | 53 | cm | |
| **Weight** | 3.5 | kg | |
| **Patient Hct** | 40 | % Hct | |
| **Required Hct** | 28 | % Hct | |
| **PLT:** | | | |
| < 1year old | 85 | ml/kg | |
| RBC | 55 | % Hct | |
| **Enter required Index** | 3 | | |

| | # |
|---|---|
| **BSA =** | 0.22 $m^2$ |
| **BMI =** | 12.46 |

**Flows**

| | |
|---|---|
| 2.4 $L/m^2/min$ | 0.52 L/min |
| 2.6 $L/m^2/min$ | 0.57 L/min |
| 2.8 $L/m^2/min$ | 0.61 L/min |
| 3.0 $L/m^2/min$ | 0.65 L/min |
| 3.5 $L/m^2/min$ | 0.76 L/min |

| | |
|---|---|
| **Full Flow** | **0.65 L/min** |

| | |
|---|---|
| **Set:** | **Neo (0 - 900 ml/min)** |
| **Oxygenator:** | **Baby FX** |
| **AV Line:** | **3/16 - 1/4** |
| **Pump boot:** | **1/4** |

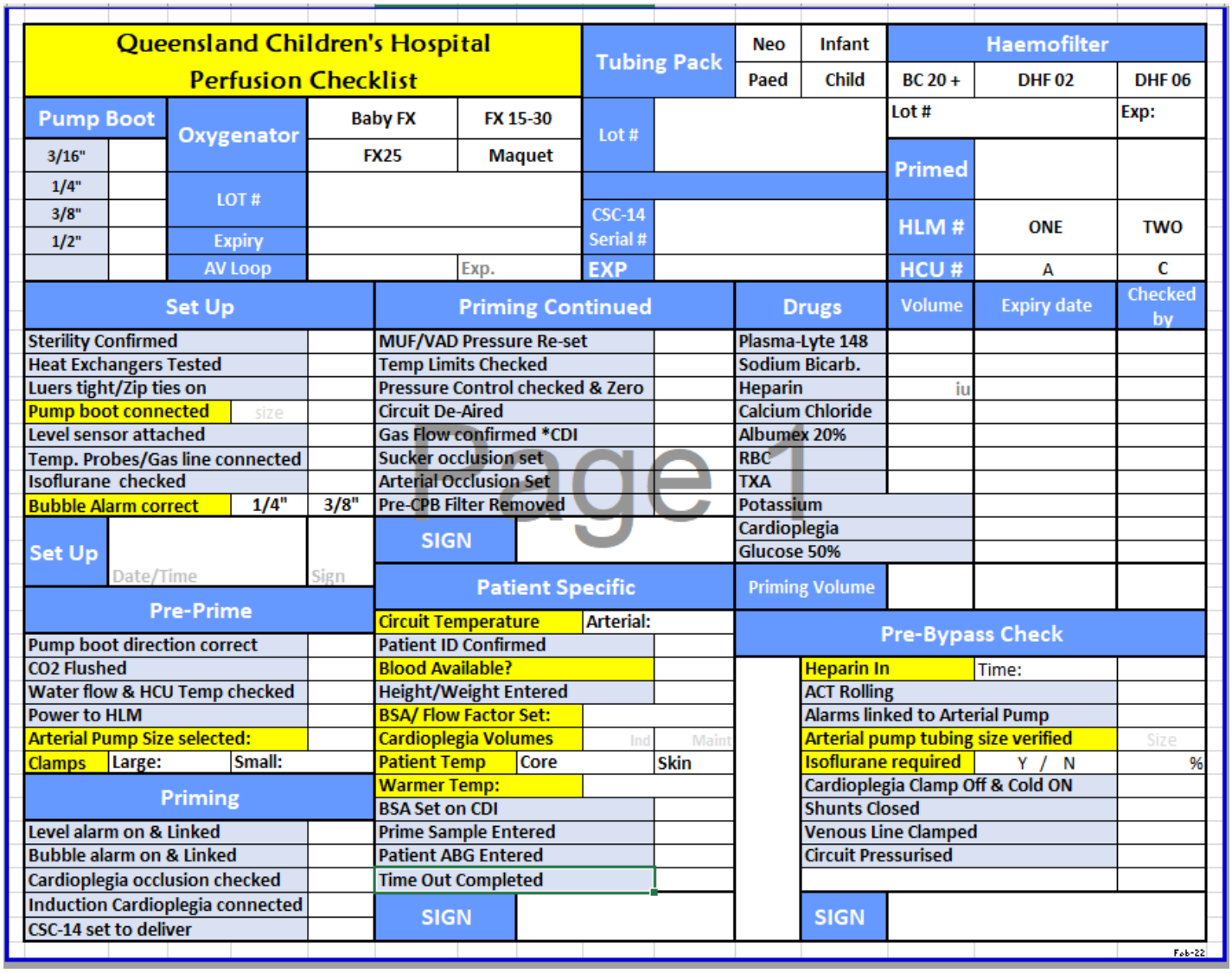
| | |
|---|---|
| **Arterial Cannula:** | **DLP 8F (<900 ml/min)** |
| **Perc.Ped.+ Int. kit Art Cann** | **Med 10F (0.51- 0.9 ml/min)** |
| **Perc.Ped.+ Int. kit Ven Can** | **Med 12F (0.61 - 1.3 L/min)** |
| **Jug / Fem Art cannula.32cn** | **MED 15F (<2.0 L/min)** |
| **Jug/Fem Ven cannula.32cn** | **MED 15F (<1.9 L/min)** |
| **LONG Fem. VEN cannula** | **MED 15F (<=1.4 L/min)** |
| **SVC:** | **10Fr (<400ml/min) or 12 Fr (<700ml/min)** |
| **IVC:** | **14 Fr (< 800ml/min)** |
| **Cardioplegia pack:** | **Paed** |
| **Haemoconcentrator:** | **BC20+** |

| | |
|---|---|
| **Volume of blood required** | **144 ml** |
| Albumex 20% | **78.0** ml |
| Sodium bicarbonate | **25** ml |
| Heparin | **577** iu |
| Calcium (0.7 mg/ml) | **0.8** ml |
| Plasmalyte | **142** ml |
| **Total Prime Volume** | **390 ml** |

| **Buckburg Cardioplegia Doses** | |
|---|---|
| Induction (30ml/kg) | **105 ml** |
| Maint/Reperf (15ml/kg) | **53 ml** |

| | |
|---|---|
| *Expected* Hct % if no blood | 17 |
| HCT % of prime should be | ## |

# 17. Pump Checklist



| Queensland Children's Hospital Perfusion Checklist | | | | Tubing Pack | Neo | Infant | Haemofilter | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Paed | Child | BC 20 + | DHF 02 | DHF 06 |
| Pump Boot | | Oxygenator | Baby FX | FX 15-30 | Lot # | | Lot # | | Exp: |
| 3/16" | | | FX25 | Maquet | | | Primed | | |
| 1/4" | | LOT # | | | | | | | |
| 3/8" | | | | | CSC-14 Serial # | | HLM # | ONE | TWO |
| 1/2" | | Expiry | | | | | | | |
| | | AV Loop | | Exp. | EXP | | HCU # | A | C |

| Set Up | | | Priming Continued | | | Drugs | Volume | Expiry date | Checked by |
|---|---|---|---|---|---|---|---|---|---|
| Sterility Confirmed | | | MUF/VAD Pressure Re-set | | | Plasma-Lyte 148 | | | |
| Heat Exchangers Tested | | | Temp Limits Checked | | | Sodium Bicarb. | | | |
| Luers tight/Zip ties on | | | Pressure Control checked & Zero | | | Heparin | iu | | |
| Pump boot connected | size | | Circuit De-Aired | | | Calcium Chloride | | | |
| Level sensor attached | | | Gas Flow confirmed *CDI | | | Albumex 20% | | | |
| Temp. Probes/Gas line connected | | | Sucker occlusion set | | | RBC | | | |
| Isoflurane checked | | | Arterial Occlusion Set | | | TXA | | | |
| Bubble Alarm correct | 1/4" | 3/8" | Pre-CPB Filter Removed | | | Potassium | | | |
| Set Up | Date/Time | Sign | SIGN | | | Cardioplegia | | | |
| | | | | | | Glucose 50% | | | |
| Pre-Prime | | | Patient Specific | | | Priming Volume | | | |
| Pump boot direction correct | | | Circuit Temperature | Arterial: | | | | | |
| CO2 Flushed | | | Patient ID Confirmed | | | Pre-Bypass Check | | | |
| Water flow & HCU Temp checked | | | Blood Available? | | | Heparin In | Time: | | |
| Power to HLM | | | Height/Weight Entered | | | ACT Rolling | | | |
| Arterial Pump Size selected: | | | BSA/ Flow Factor Set: | | | Alarms linked to Arterial Pump | | | |
| Clamps | Large: | Small: | Cardioplegia Volumes | Ind | Maint | Arterial pump tubing size verified | | Size | |
| Priming | | | Patient Temp | Core | Skin | Isoflurane required | Y / N | % | |
| Level alarm on & Linked | | | Warmer Temp: | | | Cardioplegia Clamp Off & Cold ON | | | |
| Bubble alarm on & Linked | | | BSA Set on CDI | | | Shunts Closed | | | |
| Cardioplegia occlusion checked | | | Prime Sample Entered | | | Venous Line Clamped | | | |
| Induction Cardioplegia connected | | | Patient ABG Entered | | | Circuit Pressurised | | | |
| CSC-14 set to deliver | | | Time Out Completed | | | | | | |
| | | | SIGN | | | SIGN | | | |

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# 18. Cannulae Flow Chart

**Central cannulae**

| Medt. DLP Straight Art. | | Flow *ml* |
|---|---|---|
| 1/4" conn. | 06 Fr | < 500 |
| | 08 Fr | < 750 |
| | 10 Fr | 750 - 1100 |
| | 12 Fr | 1100 - 1800 |
| | 14 Fr | 1800 - 2500 |
| | 16 Fr | 2500 - 3400 |

| Medt. DLP-Metal Tip Ven. | | Flow *ml* |
|---|---|---|
| 1/4" conn. | 12 F | 0 - 800 |
| | 14 F | 800 - 1600 |
| | 16 F | 1600 - 2000 |
| 3/8" conn. | 18 F | 2000 - 2800 |
| | 20 F | 2800 - 3400 |
| | 22 F | 3400 - 4600 |
| | 24 F | 4600 - 5500 |
| | 28 F | > 5500 |

| Edwards 2 Stage ven. | | Flow *ml* |
|---|---|---|
| 3/8" conn. | 29 / 37 F | < 3500 |
| 1/2" conn. | 32 / 40 F | > 5000 |
| | 36 / 46 F | < 5000 |

| Medt Biomed ** cut-down ** | | Flow *ml* |
|---|---|---|
| | 08F short | 0 - 500 |
| | 10F short | 0 - 750 |
| | 12F short | 750 - 1250 |
| | 14F short | 1250 - 1750 |

| Shunt size (mm) | | Cannula |
|---|---|---|
| 3.0 | Gortx | 8 F |
| 4.0 | Gortx | 10 F |
| 4.0 | Gortx | 12 F |
| 5.0 | Gortx | 14 F |
| 6.0 | Vasc/Bost | 16 F |
| 6.0 | Vasc/Bost | 18 F |
| 8.0 | Vasc/Bost | EOPA 20F |
| 8.0 | Vasc/Bost | 21 F |

**Perc. Paed. Cannulae**

**Arterial Cannulae**

| Medt Paed. Art. x 23 cm | | Flow *ml* |
|---|---|---|
| 1/4 " Conn. | 8 F | < 500 |
| | 10 F | < 900 |
| | 12 F | < 1600 |
| | 14 F | < 2300 |

| Edwards Art. x 24 cm | | Flow *ml* |
|---|---|---|
| 3/8" conn. | 16 Fr | 2500 - 3400 |

| Medt. EOPA x 31 cm | | Flow *ml* |
|---|---|---|
| 3/8" conn. | 18 Fr | 2500 - 4250 |
| | 20 Fr | 4250 - 5000 |
| | 22 Fr | > 5000 |
| | 24 Fr | > 6000 |

**Venous Cannulae**

| Medt Paed. Ven. x 23 cm | | Flow *ml* |
|---|---|---|
| 1/4 " Conn. | 8 F | < 400 |
| | 10 F | < 600 |
| | 12 F | < 1300 |
| | 14 F | < 1850 |

| Medt. Fem Ven. x 65-70 cm | | Flow *ml* |
|---|---|---|
| 3/8" conn. | 15 F | < 1400 |
| | 17 F | < 1900 |
| | 19 F | < 2700 |

| Maquet HLS x 55 cm | | Flow *ml* |
|---|---|---|
| 3/8" conn. | 21F | 3200 |
| | 23F | 4200 |
| | 25F | >4200 |

**Fem. Art./Jug. Ven. Cannulae ** Can be used as either ****

| Medt. x 32 cm | | Flow (Art.) *ml* | | Flow (Ven.) *ml* |
|---|---|---|---|---|
| 3/8" conn. | 17 F | < 2700 | | < 2400 |
| | 19 F | < 3500 | | < 3200 |
| | 21 F | < 4500 | | < 4000 |
| | 23 F | < 5500 | | < 5000 |

**Bi-Caval Dual Lumen Venous**

| AVALON | | | Flow *ml* |
|---|---|---|---|
| 1/4" conn. | 13 Fr | | 220 - 750 |
| | 16 Fr | | 470 - 1250 |
| | 19 Fr | | 630 - 1750 |
| 3/8" conn. | 23 Fr (15-20 kg) | | > 2200 |
| | 27 Fr (20-65 kg) | | > 3300 |

# 19. ECMO Setup and Prime

There is always a clear primed wet ¼" ECMO Circuit available in PICU and a dry Cardiohelp 3/8 " circuit

Please refer to ECLS Protocol for more information

# 20. ECMO Transport (In House)

Check that oxygen and air cylinders are full and have the appropriate connections available.

Remove all unnecessary equipment from the circuit. This includes counter-current haemodialysis solution.

Turn off the heater (it does not run on battery and will alarm).

ALWAYS turn off/clamp the haemofilter shunt for the actual transport.

Ensure the yellow vent cap is firmly in place on the oxygenator