COstatus® Monitoring

- Cardiac Function
- Blood Volumes to Guide Fluid Therapy
- Shunt Identification & Quantification
- Use During Cardiac Support (ECMO, Impella, LVAD)

» Used on more than 700 neonatal, pediatric, & adult patients (0.6-115 kg)
» More than 100 publications (20 full papers)
» Hemodynamic parameters measured at various stages in single ventricle patients
» Largest pediatric single center hemodynamic study - 100 patients
» COstatus® was validated in the OR and multiple human & animal studies versus
  » Thermodilution PA Catheter
  » Direct Fick
  » Perivascular Flowsensors
Most Minimally Invasive, Universal Dilution Method

- Able to be used on patients of any age and any pathology including hypoplastic heart
- Minimally invasive - uses existing arterial & central venous catheters (no need to insert specialized catheter)
- Safe isotonic saline indicator
- No blood loss
- Quick 10 minute test

Neonatal Single Ventricle Patient 2.8 kg

*Courtesy: Dr. Ana Rodrigues & Prof. Manuel Sanchez, Hospital General Universitario Gregorio Marañón Madrid, Spain*

Adult Patient 108 kg

*Courtesy: Prof. Eremenko, Center for Surgery Moscow, Russia*

Transonic Systems Inc. is a global manufacturer of innovative biomedical measurement equipment. Founded in 1983, Transonic sells “gold standard” transit-time ultrasound flowmeters and monitors for surgical, hemodialysis, pediatric critical care, perfusion, interventional radiology and research applications. In addition, Transonic provides pressure and pressure volume systems, laser Doppler flowmeters and telemetry systems.
Schematic of AV Loop with connections to the patient’s existing arterial and CV catheters.

**ARterial Catheter**
- Radial
- Femoral
- Brachial
- Pedal etc.

**Central Venous Catheter**
- Jugular
- Subclavian
- Femoral

**AV Loop Priming Volume:**
- HCS3021: 5.3 mL
- Injection Volume: 0.5 - 1 mL/kg
- Maximum Injection Volume: 30 mL
- Pump Rate: 8-12 mL/min
- Measurement Time: 5 - 8 min
Hypo- and Hypervolemic Status Assessment in Pediatric and Neonatal Patients

TEDVI
Volume of Blood in the
- Heart at end of diastole

CBVI
Volume of Blood in the
- Heart
- Lungs
- Large Central Vessels

ACVI
Volume of Blood in the
- Heart
- Lungs
- Brain, Liver, Kidneys, etc.

*ACVI is close to total blood volume in infants

**Table of Values**

<table>
<thead>
<tr>
<th>Total End Diastolic Volume Index (TEDVI), mL/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypovolemic</td>
</tr>
<tr>
<td>1  2  3  4  5  6  7  8  9  10  11  12  13  14  15  16</td>
</tr>
<tr>
<td>Hypervolemic</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Central Blood Volume Index (CBVI), mL/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypovolemic</td>
</tr>
<tr>
<td>6  7  8  9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24  25  26  27  28  29  30</td>
</tr>
<tr>
<td>Hypervolemic</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Active Circulation Volume Index (ACVI), mL/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypovolemic</td>
</tr>
<tr>
<td>40  42  44  46  48  50  52  54  56  58  60  62  64  66  68  70  72  74  76  78  80  82  84  86  88  90  92</td>
</tr>
<tr>
<td>Hypervolemic</td>
</tr>
</tbody>
</table>

Transonic
THE MEASURE OF BETTER RESULTS.
Identifying and Quantifying Shunts with Qp/Qs

**Left to Right**

1. Possible L-R shunt Qp/Qs = 1.2 ± 0.2
2. Possible L-R shunt Qp/Qs = 3.1 ± 0.4
3. Possible L-R shunt Qp/Qs = 2.7 ± 0.4

**Right to Left**

1. Possible R-L shunt Qp/Qs = 0.84 ± 0.13
2. Possible R-L shunt Qp/Qs = 0.59 ± 0.10
3. Possible R-L shunt Qp/Qs = 0.72 ± 0.11

**Parameters**

- CO: Cardiac Output
- CI: Cardiac Index
- SV: Stroke Volume
- CIV: Central Venous Pressure
- TEE: Transesophageal Echocardiogram
- SVR: Systemic Vascular Resistance
- ACV: Atrial Contractility
- TEF: Total Elastance Fraction

**Values**

- **Left to Right**
  - CO: 0.73 L/min
  - CI: 3.35 L/min/m²
  - SV: 25 ml/m²
  - CIV: 18 mmHg
  - TEE: 13 mmHg
  - SVR: 860 dyne·sec/cm²
  - ACV: 68 mmHg
  - TEF: 48%

- **Right to Left**
  - CO: 1.97 L/min
  - CI: 2.14 L/min/m²
  - SV: 28 ml/m²
  - CIV: 11 mmHg
  - TEE: 12 mmHg
  - SVR: 2390 dyne·sec/cm²
  - ACV: 39 mmHg
  - TEF: 39%
Is a Residual Shunt Hemodynamically Significant?

Patient (3.5 kg) after VSD surgery

A post-op COstatus® measurement indicated a possible residual left-to-right shunt (Qp/Qs = 1.2) after shunt surgery.

Courtesy: Dr. Perez de Sá & Dr. Lindberg, Skåne University Hospital Lund, Sweden
Evaluating Patients with Single Ventricle Anatomy

Select Single Ventricle Patient on COstatus® Screen

Specify Single Ventricle Anatomy

Select Patient Anatomy

- Pre-stage 1 repair
- Post-stage 1 repair
- Bi-directional Glenn/Hemi-Fontan
- Fontan WITH fenestration
- Fontan with NO fenestration
Measurements Pre- and Post- Norwood Surgery

2.8 kg Patient

Pre-stage 1 Repair

<table>
<thead>
<tr>
<th></th>
<th>Pre-Repair</th>
<th>Post-Repair</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qp/Qs</td>
<td>2.5</td>
<td>1.8</td>
</tr>
<tr>
<td>SVRI</td>
<td>2710 (dy/s/cm²)*m²</td>
<td>1700 (dy/s/cm²)*m²</td>
</tr>
<tr>
<td>Qs</td>
<td>0.23 L/min</td>
<td>0.35 L/min</td>
</tr>
<tr>
<td>Cls</td>
<td>1.2 L/min/m²</td>
<td>1.8 L/min/m²</td>
</tr>
</tbody>
</table>

- CO and CI are total cardiac output and index
- Qs and Cls are systemic cardiac output and index
- Qp/Qs calculations are based on mathematical model

Courtesy: Dr. Ana Rodrigues & Prof. Manuel Sanchez,
Hospital General Universitario Gregorio Marañón Madrid, Spain
Heart Flow = Cardiac Output - Pump Flow
$\text{CO} = \text{total systemic flow from pump and heart}$

3.2 kg Patient

Total CO measured by COstatus®: 0.34 L/min
ECMO Pump Flow: 300 mL/min
Heart Flow = 340 mL/min - 300 mL/min = 40 mL/min

*Venous part of AV loop gets connected to the ECMO system (Between oxygenator and pump)
Bibliography: COstatus® References

PART I: CARDIAC OUTPUT

CARDIAC OUTPUT VALIDATIONS/COMPARISONS: CLINICAL STUDIES AND METHODOLOGY


Rajaopal SK, Costello M, “Validation of an Ultrasound Dilution Cardiac Output Measurement Technique in Critically Ill Children,” Pediatric Critical Care Colloquium, Pittsburgh, PA, May 15-17, 2010 [PICU, Vs. Metabolic Cart (indirect Fick)] Boston Childrens, USA. (Transonic Reference # CO8028V)


CARDIAC OUTPUT VALIDATIONS/COMPARISONS: ANIMAL MODELS


CARDIAC OUTPUT VALIDATIONS/COMPARISONS: ANIMAL MODELS CONT.


PART II: SHUNTS

SHUNT IDENTIFICATION: METHODOLOGY


Krivitski N, Kislukhin V, Thuramalla N, “Identification of Shunts based on the Shape of the Dilution Curve,” 3rd Congress of European Academy of Paediatric Societies (EAPS), Copenhagen, Denmark, Oct. 23-26 2010, Poster Presentation #121. (Transonic Reference # CO8042)

SHUNT IDENTIFICATION: PEDIATRIC AND NEONATAL CLINICAL STUDIES


Marr B, “Can Ultrasound Dilution (UD) Identify and Qualify the Type of Shunt in Neonates with Patent Ductus Arteriosus (PDA)?” Pediatric Critical Care Colloquium, Pittsburgh, PA, May 15-17, 2010. (Transonic Reference # CO8026A)


SHUNT IDENTIFICATION: PEDIATRIC AND NEONATAL ANIMAL MODELS


PART III: SINGLE VENTRICLE
SINGLE VENTRICLE: THEORY AND CLINICAL STUDIES


PART IV: BLOOD VOLUMES
BLOOD VOLUMES: PEDIATRIC AND NEONATAL CLINICAL STUDIES


Ostrowicki R et al, “Effect of Furosemide on Cardiac Index and Circulating Blood Volumes in Pediatric ICU Patients,” Pediatric Critical Care Colloquium, Pittsburgh, PA, May 15-17, 2010 (Transonic Reference # CO8027A)


Eremenko AA and Safarov PN, “Central blood volume index and total end-diastolic volume index as indicators of cardiac preload,”Abstract # 312, Critical Care Medicine, A83, Vol. 35 Supplement 12, Dec 2007. Poster Presentation at the SCCM 37th. Critical Care Congress, Feb 2-6, 2008, Hawaii, USA.


BLOOD VOLUMES: PEDIATRIC AND NEONATAL ANIMAL MODELS


Bandt C et al, “Effects of Norepinephrine on Dynamic versus Static Variables of Fluid Responsiveness during Hemorrhage and after Resuscitation in a Pediatric Model,” Poster Presentation: Pediatric Cardiac Int. Care Soc 2010, Dec 8-11 2010, Miami Beach, FL, USA. (Transonic Reference # CO8116A)
