ELSA Extracorporeal Life Support Assurance

- Optimize ECMO Therapy
- Detect Oxygenator Clotting
- Verify Delivered Blood Flow
Optimize ECMO Therapy
With Recirculation Percentage, Oxygenator Clot Detection, and Delivered Pump Flow Verification

OPTIMIZE ECMO THERAPY
With a single bolus of saline, the Transonic® ELSA Monitor detects and quantifies recirculation in VV ECMO single- and dual-cannula configurations.

The ELSA Monitor:
- Guides optimal catheter placement and treatment delivery by helping to:
  - Establish a maximum pump setting before recirculation occurs;
  - Use known values for flow and recirculation to minimize the length of ECMO runs;
- Identifies cannula migration through high recirculation rates.
- Identifies possible cardiac output failure during VV ECMO.

VERIFY DELIVERED BLOOD FLOW
Pump (delivered blood) flow errors and recirculation can compromise ECMO delivery of oxygenated blood. The Transonic® ELSA Monitor measures true delivered blood flow through ECMO tubing using “gold standard” transit-time ultrasound technology. By comparing actual delivered blood flow to the pump’s reading, any flow limiting cause such as incorrect cannula placement can be identified and corrected.

DETECT OXYGENATOR CLOTTING
Clots in the ECMO circuit pose one of the major complications of ECMO. The challenge is to keep the oxygenator from clotting while preventing bleeding in fragile patients.

With an injection of a small volume of saline, the ELSA Monitor measures oxygenator blood volume to identify early clot formation in the oxygenator of the ECMO circuit. Early detection of clot formation in ECMO circuits allows a wider window of opportunity to perform an oxygenator change-out.

Transonic Systems Inc., global manufacturer of biomedical flow measurement equipment, sells “gold standard” ultrasound transit-time flowmeters, hemodialysis, endovascular and laser Doppler perfusion monitors worldwide to surgeons, nephrologists, interventional radiologists, researchers and original equipment manufacturers (OEMs).
Predicting Oxygenator Clotting with the ELSA Monitor

Clots in the ECMO circuit are a common mechanical complication, causing patient complications, and oxygenator failure. The ELSA bedside Monitor uses dilution technique to measure Oxygenator Blood Volume. As clots form within the oxygenator, the circulating blood volume decreases.

The ELSA Monitor provides quantitative assessment of oxygenator clotting and thereby predicts its increased thrombotic risk to the patient, and diminished oxygenator performance.

% Oxygenator Blood Volumes –versus- ECMO time in hours

50% Clotted
**ELSA Recirculation & ECMO Cardiac Flow**

The ELSA Monitor measures Delivered Flow, Recirculation and ECMO Cardiac Flow (ECF). These measurements allow adjustment of Pump Flow and Catheter Placement to optimize ECMO therapy in VV ECMO patients.

- Delivered Flow (DLVFLW) is an actual measurement of blood flow in the ECMO lines (within the Monitor’s measurement accuracy).

- ECMO Cardiac Flow is the oxygenated blood flow delivered by the pump to the heart.

ECMO Cardiac Flow (ECF) = DLVFLW[1 – (% Recirculation Value/100)]

The higher the Recirculation, the lower the ECF

If increasing Pump Flow leads to increased Recirculation and no change or minimum change in ECF, the pump setting is not delivering the optimal flow.

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**ELSA Monitor screen showing 0% Recirculation where ECF = Flow**

**Art Flow = 640 mL/min**

**REC = 0% | ECF = 640 mL/min**

**ELSA Monitor screen showing 51% Recirculation where ECF = Flow**

**Art Flow = 640 mL/min**

**REC = 51% | ECF = 320 mL/min**

21% Recirculation, note that ECF is lower than the recorded flow
ELSA Theory of Operation

**DIFFERENTIAL TRANSIT-TIME ULTRASOUND**

HOW IT WORKS

A clip-on sensor transmits a beam of ultrasound through the blood line. Four transducers pass ultrasonic signals back and forth, alternately intersecting the flowing blood in upstream and downstream directions. The ELSA Monitor derives an accurate measure of the changes in the time it takes for the wave of ultrasound to travel from one pair of transducers to the other (“transit time”) resulting from the flow of blood in the vessel. The difference between the upstream and downstream transit times provides a measure of volume flow.

**ULTRASOUND INDICATOR DILUTION: HOW IT WORKS**

The velocity of ultrasound in blood (1560-1590 m/sec) is determined primarily by its blood protein concentration. The Transonic® ELSA Monitor and Flow/dilution Sensors measure ultrasound velocity. A bolus of isotonic saline (ultrasound velocity: 1533 m/sec) introduced into the blood stream dilutes the blood and reduces the ultrasound velocity. The sensor records this saline bolus as an indicator dilution curve.

**RECIRCULATION**

When a saline bolus is injected upstream from the arterial Flowsensor, the ELSA Monitor identifies the saline concentrations at both Flowsensors. The ratio of indicator concentrations equals recirculation (Fig. 3).

\[
\text{Rec} = \frac{S_v}{S_a} \times 100\%; \text{ where } S_v \text{ and } S_a \text{ are areas under arterial and venous dilution curves respectively.}
\]

**OXYGENATOR BLOOD VOLUME MEASUREMENT**

When a saline bolus is injected upstream from the oxygenator, the time that the indicator takes to travel through the oxygenator is proportional to its blood volume.

\[
\text{OXBV} = Q_b \times MTT; \text{ where } Q_b \text{ is blood flow through oxygenator and } MTT \text{ is mean transit time of indicator travel through oxygenator.}
\]

Percent change of OXBV% in time can be expressed: \( \text{OXBV\%} = \frac{\text{OXBV}_t}{\text{OXBV}_i} \times 100\%; \) where OXBV is the value of OXBV measured at any moment in the ECMO process. OXBV – initial OXBV measured at the beginning of ECMO process when oxygenator is free of clots.

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**Differential Transit-Time Ultrasound**

**ULTRASOUND INDICATOR DILUTION:**

**Recirculation**

**Oxygenator Blood Volume Measurement**

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**Fig. 1:** Schematic showing placement of Flow/dilution Sensors and site of saline bolus injection in VV ECMO circuit.

**Fig. 2:** Recirculation Results screen during VV ECMO.

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