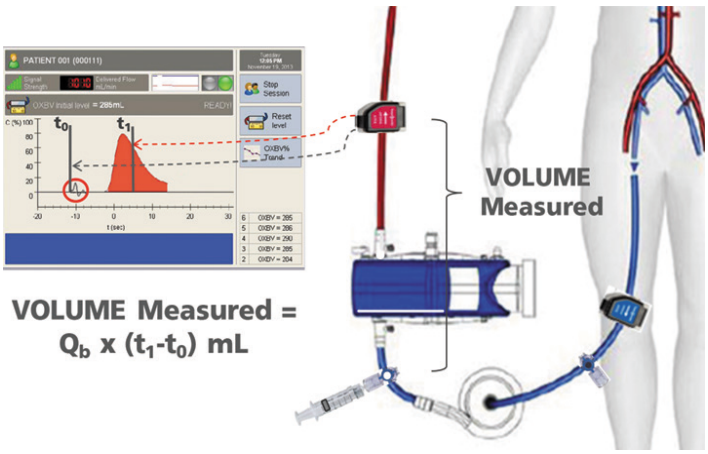
Detecting Oxygenator Clotting with the ELSA Monitor

Among the many problems facing ECMO team members, persistent clotting is among the most frustrating.

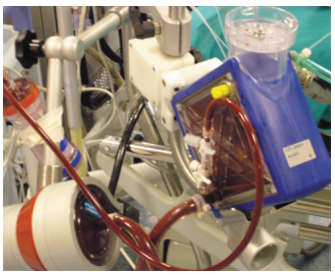
Clots within the ECMO circuit can have catastrophic consequences. Consequently, all circuits are run with low levels of Heparin to reduce the potential for clot formation while keeping bleeding at a minimum. Clot formation is traded for lower stroke risk. Full anticoagulation requires an Activated Clotting Time (ACT) of 400 to 480 seconds, but in ECMO cases ACT levels are maintained at 180 to 200 seconds, virtually assuring clot formation.

Each ECMO patient is different, requiring different flows, different circuit sizes/branches, and different patient blood chemistry. In some patients, a clot can begin forming within hours, in others, it might take days.

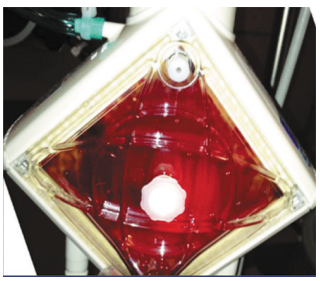
The most common method of measuring clot formation is monitoring the pressure proximal and distal to the oxygenator. The concept is that a clot resists the flow linearly with clot growth, and upstream pressure will increase. When room temp saline; (1 mL/kg from 5mL up to 20 mL), is injected near the inlet of the oxygenator, the ELSA Monitor measures oxygenator blood volume (OXBV) between the injection site and the arterial sensor and displays the result for each injection on a timeline. OXBV decreases as clot volume increases.



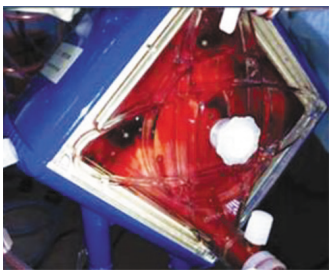
The arterial sensor senses the increase in flow during the injection, and marks the time. When the saline bolus passes the sensor, the saline bolus is plotted in red. The flow from the injection point to the center of the flow curve represents the total volume between the injection site and the sensor.



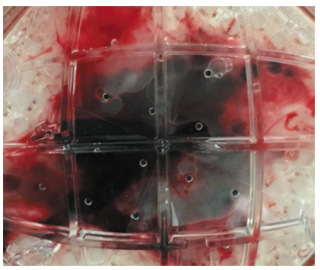
Shown is a Maquet Quadrox oxygenator in use. It is by far the most common type of ECMO oxygenator. Whatever the model, oxygenators all share the same tendency to clot. During a case, it is impossible to see through the flowing blood to identify the underlying amount of clot that has formed. Physicians and perfusionists are not taught about variance in clot formation and clots can differ.



Non-flaking soft clots evenly spread across the fibers shown here cause a high pressure gradient. This would tempt some teams to change out the oxygenator, even though it is still functioning well. That would not be a good move, as changing an oxygenator is risky (zero flow for a couple of minutes, and potential air embolism) as well as detrimental loss of RBCs, clotting factors, proteins, etc., in the oxygenator.



Shown in this oxygenator is a thin, soft layer of clot over most of the fibers with some fibers exposed so there is no pressure gradient change. Mixed density, some hard formations growing.



This pattern of clotting formation is the nightmare. There will be no pressure change upstream, since there are large open portions of fibers showing on the periphery. In the center a hard, well developed clot has formed which will continue to grow and shed thrombolic emboli. The team will have no indication since pressure and oxygenation are fine. These hard clot formations will grow and slough off, and eventually cause a stroke in VA patients, or pulmonary emboli in VV patients.

As a clot increases in volume, the blood volume decreases. To make oxygenator volume measurements (slightly) more accurate, an ELSA screen asks for the volume within the tubing between the injection site and the arterial sensor. ELSA will deduct the tubing volume from the total volume, isolating the volume of the oxygenator.

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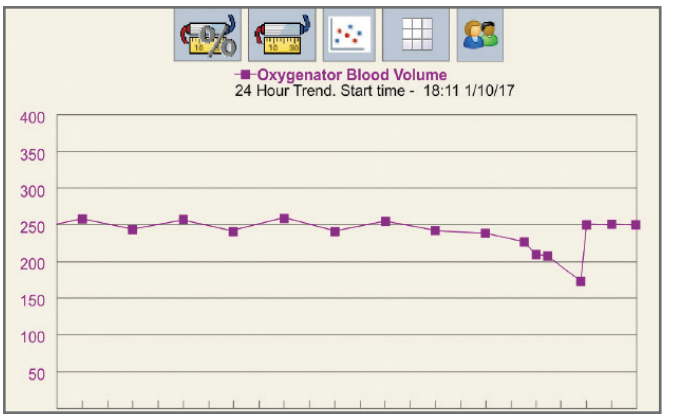
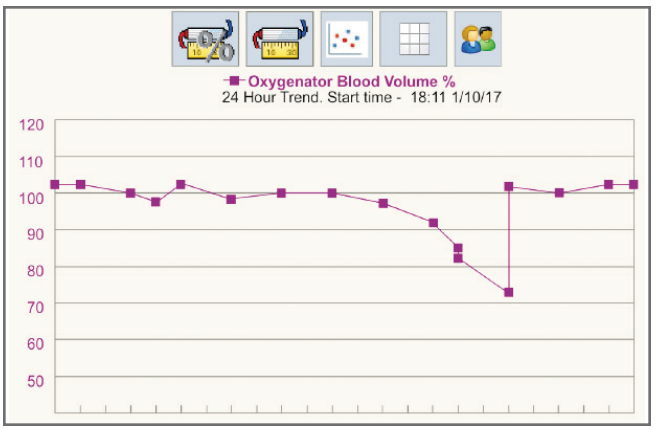
Detecting Oxygenator Clotting with the ELSA Monitor cont.

Trending is available in 4 hours, 24 hours, or total-case-time screens. The trended curves will help predict when an oxygenator change-out will be necessary. Such foreshadowing of clot formation in ECMO circuits can allow for device change outs, before clotting becomes a serious clinical risk.



Each injection is plotted. Here you can see where the volume decreased (as clot volume increased), and returns to baseline when the oxygenator is changed out.



Volume is also plotted as a percentage, if preferred.

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