State-of-the-art - Assisted circulation

How to replace an extracorporeal life support without interruption of the cardiopulmonary assistance

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Summary

The extracorporeal life support (ECLS) allows a maximum of a few weeks of cardio-respiratory assistance. Using standard ECLS, the circuit must be replaced after a few days or sometimes more frequently, in case of dysfunction. Classically, the replacement needs the interruption of the support inducing a temporarily hemodynamic instability. We report a simple technique, allowing this replacement without interruption of the assistance, based on the implantation of a new circuit in parallel. We describe the original modification, the complete procedure and our results. This method has been used in 34 ECLS replacements in 14 patients without any incident or thrombo-embolic events. This simple technique is safe, reliable, and avoids the hemodynamic instability induced by classical replacements.

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1. How to do it

The extracorporeal life support (ECLS) has become an interesting approach for heart or pulmonary failures, due to rapid initiation and good hemodynamic performances [1]. However, a classical circuit of ECLS must be regularly replaced. In case of rapid recovery, this replacement can be easily done, without serious problems. However, in case of a major hemodynamic instability, this replacement can induce some new complications and increase this instability. Actually, no ECLS circuit allows rapid replacements without interruption of cardiopulmonary support.

In our institution, we have modified a Medtronic circuit of ECLS (Santa Rosa, California) allowing an easy and rapid replacement without interruption of the assistance. This modification is based on two duplications of the tubing, placed before and after the oxygenator and the pump. These modifications can be easily performed by the surgeon, at the time of the implantation.

2. ECLS modification

The tubing is put on the surgical field. To duplicate the circuit on the arterial and the venous lines, four 30 cm segments of tubing are cut from the arterio-venous 'shunt' of the original circuit (Fig. 1a). A ‘Y’ connector is connected to each extremity of the circuit (Fig. 1b), allowing to connect two segments of tubing on each line (Fig. 1c). The final circuit presents duplicated areas on the arterial and the venous lines. The implantation of this circuit is performed as usual (Fig. 1d). During the cardio-respiratory support, the risk of thrombosis seems to not modify, probably due to the absence of clamp on this modified circuit.

3. ECLS replacement

The replacement of the circuit requires only four simple connectors and eight clamps. The new modified circuit must present a single duplicated arterio-venous shunt, performed as previously described (2 ‘Y’ connectors and two segments of tubing). Then, the duplicated area is clamped (4 clamps) and cut, at its middle (Fig. 2a). A simple connector is connected to each extremity (Fig. 2b). Then, one branch of the arterial and venous lines of the ancient circuit are clamped (before and after) and cut on their middles (Fig. 2c). They are purged and connected to the corresponding branch of the new circuit (Fig. 2d). The pump of the new circuit is now started, and clamps are removed allowing to clamp and to stop the old one. The same procedure is performed on the second branch of each line and recreates all conditions to perform the next replacement using the same technique (Fig. 2e). As demonstrated in Fig. 2 (arrows), the blood flow is never interrupted during the replacement.

4. Data from patients

To date, we have used this technique for 34 ECLS replacements in 14 patients without any complication. The mean age and the sex ratio were, respectively, 49 ± 24 and 1.9. The main time to achieve the replacement, after modifi-
Fig. 1. Modification of the original circuit of ECMO: (a) Preparation of the modified ECLS circuit. (b) ‘Y’ connectors’ connection to the circuit. (c) Modified circuit before clamping, section and connection to the cannulae. (d) Final aspect of the circuit after the implantation. (Triangles symbolise clamps, simple arrows represent the blood flow.)

cation of the circuit, was 6 min (2.49 replacements per patient, delay between each replacement: 2.1 days, and the total time under extracorporeal membrane oxygenation (ECMO): 73.5 days). Main indications of ECLS were cardiogenic shocks (primitive or following cardiac surgery) and respiratory distress (contusions, acute respiratory distress syndrome...). No thrombo-embolic events are related to our modification. And suppress 'and no factor VII been used'. As usual with a non-coated circuit, the anticoagulation (intravenous heparin), is adjusted to obtain an activated clotting time test (ACT) between 180 and 220 s. Due to the relative simplicity of this procedure and to the

Fig. 2. Complete procedure to replace the ECLS without interruption of cardiopulmonary support: (a) Preparation of the new circuit used for the ECLS replacement. (b) Section of the duplicated area of the circuit. (c) Section of the first branch of the old circuit between clamps without interruption of the cardiac support. (d) Connection of the first branch of the new circuit to the old one, clamp removed. (e) Similar aspect after the replacement than before.
absence of risk related to the duration of the procedure, no training is necessary. However, as usual, circuits must be clamped before the stop of the corresponding pump, to avoid a back flow through the arterial cannulae.

5. Discussion

The literature reports fatal complications during cardiopulmonary support [2], or during classical ECLS replacements [3]. Our technique allows rapid and safe iterative replacements of ECLS or ECMO circuits by surgeons, in intensive care unit. In our practice, we have used ECLS/ECMO to support some patients for more than three weeks. We have frequently used the Deltastream DP1 or DP2 pumps from Medtronic, known to be small but fragile. As a consequence, the manufacturer recommends the systematic replacement of this pump twice a week, explaining our 34 replacements. Moreover, one patient has required eight replacements, due to the precocious degradation of each pump, despite a massive anticoagulation (480,000 UI of heparin a day) without clinical efficacy (ACT: 129 s). The analysis of these pumps has shown many deposits of fibrin, explaining the rapid decrease of performance.

No additional inotropic drug was necessary and no hemodynamic variation was shown during each replacement, because of the homogenous repartition of the blood flow between each centrifugal pump. In stable conditions, the arterial blood pressure and the cardiac frequency are not modified during this procedure.

Previous descriptions report a higher thrombosis risk during low blood flow [4, 5] as in a clamped shunt. Using our technique, no part of the circuit is clamped during all the cardiopulmonary support. As a consequence, no specific survey is needed. The anticoagulation is classically monitored, especially just before the replacement, to be sure to have a sufficient anticoagulation to clamp all branches, without risk of thrombosis.

In conclusion, this safe and rapid modification allows easy ECLS replacements, even for conscious patients, without reinforcement of the cardiac support or the anaesthesia, due to the haemodynamic stability provided during the procedure.

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References