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# The Use of a Hollow Fiber Membrane Oxygenator for Extended Extra-Corporeal Support

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## Abstract

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**There is a small percentage of patients, who having undergone cardiac surgery, are unable to be weaned from cardiopulmonary bypass. Some reports in the literature seem to indicate some success with extended extra-corporeal support. In an effort to reduce the amount of supplies needed and the resulting confusion of utilizing a completely different oxygenator, a hollow fiber membrane oxygenator was selected as the oxygenator of choice for an extended extra-corporeal support system.**

The hollow fiber membrane oxygenator for extended extra-corporeal support has been utilized on 5 patients in the past 12 months. Two patients were weaned from the system and all patients expired within 30 days. The hollow fiber membrane oxygenator performed adequately with respect to gas exchange and circulatory support. However, as extended extra-corporeal support approached 15 hours, there was evidence of plasma leakage across the membrane fibers. While there appeared to be no decrease in gas exchange, two hollow fiber membrane oxygenators were replaced because of the leakage.

We conclude that the hollow fiber membrane oxygenator for extended extra-corporeal support may not be adequate for support periods above 12 to 15 hours.

## Introduction

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The use of hollow fiber membrane oxygenators (HFMO) have gained increasing acceptance over the last several years for routine cardiac surgical procedures as well as extended surgical procedures. With

their increased use has come scattered reports of the units being used successfully for cases lasting over six hours. Concurrently with this development has been a renewed interest in extended extra-corporeal support (EECS) in certain categories of the patient population.

In an effort to reduce stocking and training requirements at a low volume cardiac surgical facility, the use of a HFMO was investigated to evaluate its usefulness for support periods over six hours. During a twelve month period five patients presented with a need for EECS. This report summarizes our experience during this evaluation.

## Materials and Methods

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The EECS system consisted of standard heartlung tubing,<sup>a</sup> a centrifugal pump,<sup>b</sup> and a hollow fiber membrane oxygenator.<sup>c</sup> The system was primed with 1000 ml of a balanced electrolyte.

Vascular access was from the patient's femoral vein to the centrifugal pump and then through the oxygenator. The return of oxygenated blood was directly from the oxygenator to a graft sewn end to side to the axillary artery. Two minutes prior to cannulation 7,000 units of sodium heparin was initiated as a bolus injection. After cannulation EECS flow was started and maximal flows were obtained. EECS flows were regulated to maintain venous saturation above 60%.

The oxygenator was ventilated with an FiO<sub>2</sub> ranging from 80 to 100% with a sweep of 1 liter of compressed air. Patient ventilator settings were regulated to achieve normal arterial blood gas results.

Activated clotting times (ACT) were performed initially and every 30 minutes of EECS time. ACTs were

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a TBG63, American Bentley, Irvine, CA 92714

b Model 600, Bio-Medicus, Inc., Minneapolis, MN 55344

c SK1380, J & J Cardiovascular, King of Prussia, PA 19406

maintained approximately 300 seconds, with the use of a heparin drip.

Laboratory tests included hemoglobin, hematocrit, electrolytes, creatine, BUN, glucose, platelets, protein, albumin, calcium, arterial blood gases, and oxygenator blood gases throughout the procedure. Electrocardiogram, arterial and pulmonary artery pressure and venous saturation were continuously monitored through indwelling catheters.

Patient body temperatures were maintained at 35°C. with the use of a heating blanket. All patients were kept paralyzed and sedated.

The first attempt at weaning the patient from the EECS system did not occur until after 12 hours of support. Except during weaning EECS flow was not allowed to drop below one liter per minute.

## Results

During the evaluation period, five patients were referred for EECS. One patient was two days post-C-Section who suffered a massive pulmonary embolus and respiratory arrest. Patient two was 48 hours post-emergency CABG who suffered respiratory failure. Patient three was 12 hours post-emergency CABG who suffered an acute MI with cardiac arrest. Patient four was 36 hours post-MVR secondary to drug use who was in a low output state. Patient five was a post-infarction VSD who could not be weaned from CPB.

Patient one was immediately placed on EECS and transferred to the cardiac cath lab for intrapulmonary streptokinase which only partially resolved the pulmonary embolus. EECS was terminated at 14 hours when EEG showed no brain wave activity.

Patients two through five were refractory to inotropic and counterpulsation therapy and were placed on EECS. Patient two was weaned from EECS at 12 hours in satisfactory condition. However he suffered a massive stroke 36 hours post weaning and expired two days later.

Patient three had two oxygenator changes during the EECS period. The first change occurred at 13 hours and was due to plasma leakage across the fibers and severe foaming.

Arterial blood gases during this period were satisfactory and did not contribute to the reasons for the change. The second oxygenator change occurred when it became evident that the patient could not be weaned and preparations were begun to transfer the patient on EECS to another facility for cardiac transplantation. During these arrangements the oxygenator was changed to a spiral coil membrane oxygenator.<sup>d</sup> Prior

to transfer the patient sustained spontaneous bleeding which could not be controlled and EECS was terminated after 38 hours.

Patient four sustained a low cardiac output state and was placed on EECS. He was supported for 21 hours and weaned in satisfactory condition. Two weeks post weaning he suffered a cardiac arrest from which he couldn't be resuscitated. Autopsy revealed massive myocardial bacterial infections thought to be secondary to his drug use.

Patient five had undergone a VSD repair and could not be weaned from bypass. The system was converted to EECS and the patient was supported for 10 hours. EECS was terminated when EEG revealed no evidence of cerebral activity.

## Discussion

The use of EECS has proved to be invaluable in neonates and infants.<sup>1-2</sup> There are other reports of its use in adults for ARDS,<sup>3-5</sup> post-operative cardiac failure,<sup>6-7</sup> severe asthma attacks<sup>8</sup> and for pulmonary lavage.<sup>9</sup> The increasing use of HFMO will lead to more reports of extended use of these devices. The Maxima was chosen for its compactness of design, reliability, and built-in heat exchanger. It can be rapidly assembled and primed in an EECS circuit.

The large fiber bundle, we believe, will allow the team to decrease heparin requirements in order to reduce the amount of bleeding which is a common problem with extended support.

All of the patients were adequately supported for up to 15 hours without the problem of oxygenator foaming due to plasma leakage across the fibers. However, two patients had oxygenators foam, but only one needed to be changed due to the severity of the foaming. The other system was continued in use until weaning was accomplished.

It is important to note that at no time was gas exchange compromised. It will take continued evaluation and refinement in order for these HFMOs to gain acceptance for long term use.

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*Steve Thompson, Tuscon, AZ: Question: Since you had a change out, can you describe how you changed the oxygenator and how the patient tolerated this?*

*Answer: We set up a second system on another Bio-pump and preprimed the oxygenator. When we were ready to make the change, we just popped the oxygenator into place and we were probably off bypass about 30 seconds and the patient tolerated it well.*