

Use of the Quest Myocardial Protection System™ (MPS) for Modified Ultrafiltration During Pediatric Cardiac Surgery

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Abstract: Modified ultrafiltration generally is considered a standard of care for treating children undergoing cardiopulmonary bypass for congenital heart surgery. Different methods, incorporating a variety of devices and technologies, have been described.

The present report describes a technique of modified ultrafiltration using arterial-venous flow with the Quest Myocardial Protection System™ (MPS). **Keywords:** modified ultrafiltration, Quest MPS™. *JECT. 2005;37:219–221*

Since the initial description by Naik in 1991, modified ultrafiltration (MUF) has been studied and refined to the point that it generally is considered a standard of care for pediatric cardiopulmonary bypass (1). By pumping the patient's blood through an ultrafilter after cardiopulmonary bypass, it is possible to return a large portion of the residual blood in the bypass circuit while reducing plasma-free water, reducing the levels of some inflammatory mediators, and increasing the hematocrit and plasma protein concentrations (2). Multiple benefits, impacting numerous systems, have been shown from these effects. The increase in hematocrit and plasma protein concentration results in decreased transfusion requirements, both directly and via decreased blood loss in the first 24 hours (3,4). Hemodynamically, MUF results in increased systolic and diastolic pressures and increased cardiac index, whereas the systemic vascular resistance remains the same and both heart rate and pulmonary vascular resistance are decreased (2).

These hemodynamic effects are likely a result of increased myocardial contractility, decreased myocardial thickness, improved ventricular function, and improved diastolic compliance (2). Pulmonary function also improves, as measured by improved pulmonary compliance and arterial oxygenation, decreased pulmonary hypertension and intrapulmonary shunt fraction and decreased incidence of both pleural and pericardial effusions (2,5). The combined benefit of all effects, which originate from the improved cardiac function, decreased plasma-free water, increased plasma protein concentration, and decreased inflammatory mediator concentration, result in decreased hospital stay (6).

Despite the established benefits of MUF, the process incorporates additional risks. The extracorporealization of a significant portion of the patient's blood can lead to hypothermia, resulting in thermia-associated coagulopathies and/or hemodynamic instability (7). Methods to reduce the development of hypothermia secondary to MUF have been established, typically incorporating the use of the cardioplegia heat exchanger. A less frequent but more deleterious complication involves the potential to entrain air, either from the membrane oxygenator, the ultrafilter, or the cannulation site, into the MUF circuit. Any proposed method for MUF must incorporate mechanisms to finely control temperature and safeguard against the transmission of emboli to the patient.

A range of methods for performing MUF have been

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reported using a variety of access and infusion points, multiple circuit configurations, and an assortment of strategies. However, a consensus has not been reached regarding the optimal method, although most attempt to mediate the associated heat loss. The present report describes a MUF technique using the Myocardial Protection System™ (MPS; Quest, Allen, TX), with its microprocessor-controlled safety features, to optimize the process of MUF and limit secondary risk exposure.

DESCRIPTION

The MUF circuit uses an arterial–venous flow (ascending aorta to right atrium). Arterial blood is drawn from the arterial line by a twin roller pump at a site between the arterial line filter and the arterial cannula. The blood is pumped to a low-prime ultrafiltrator (COBE HF-700, COBE Cardiovascular, Arvada, CO) and into a side port of the MPS heat exchanger. The roller pump creates a driving force while warming, filtering, pressure monitoring, and air detection are provided by the MPS. As volume is removed by the ultrafilter, hemodynamics are maintained by infusing residual circuit blood through the aortic cannula.

Before the removal of the cross clamp, 5–10 minutes of retrograde warm blood is delivered to the heart using the MPS. To do so, the MPS is set on all blood with the

additives set on 0. The process is a component of the overall myocardial protection strategy but carries the additional benefit of prewarming the MUF line while removing the additives used for cardioplegia. At the termination of cardiopulmonary bypass, the cardioplegia line is removed from the infusion catheter(s) and connected to a vessel cannula (Medtronic, Minneapolis, MN). After flushing the cannula to remove residual air, it is placed into the right atrium.

A tubing clamp is applied to the arterial line distal to the arterial line filter and proximal to the “Y” connector (Figure 1). A clamp in this position allows the MUF circuit to draw blood from the patient’s aorta. MUF is initiated by slowly increasing the flow of the roller pump, which draws blood from the aorta, pumping it through the ultrafiltrator, into the additive cassette side port of the MPS, and into the patient’s right atrium. The centrifugal pump is maintained at sufficient RPMs to allow for infusion through the arterial line. The MUF flow is increased until a positive pressure of 70 mmHg is achieved, measured by a manometer located distal to the ultrafiltrator and proximal to the MPS. The MPS is set to deliver at 38°C, with the MPS flow is manually kept less than the roller pump. A flow of at least 10 mL·min⁻¹ on the MPS is required to open the safety valve. The flow of both pumps is then increased to achieve a positive pressure of 100 mmHg, as measured by the MPS. The MUF flow depends on the size

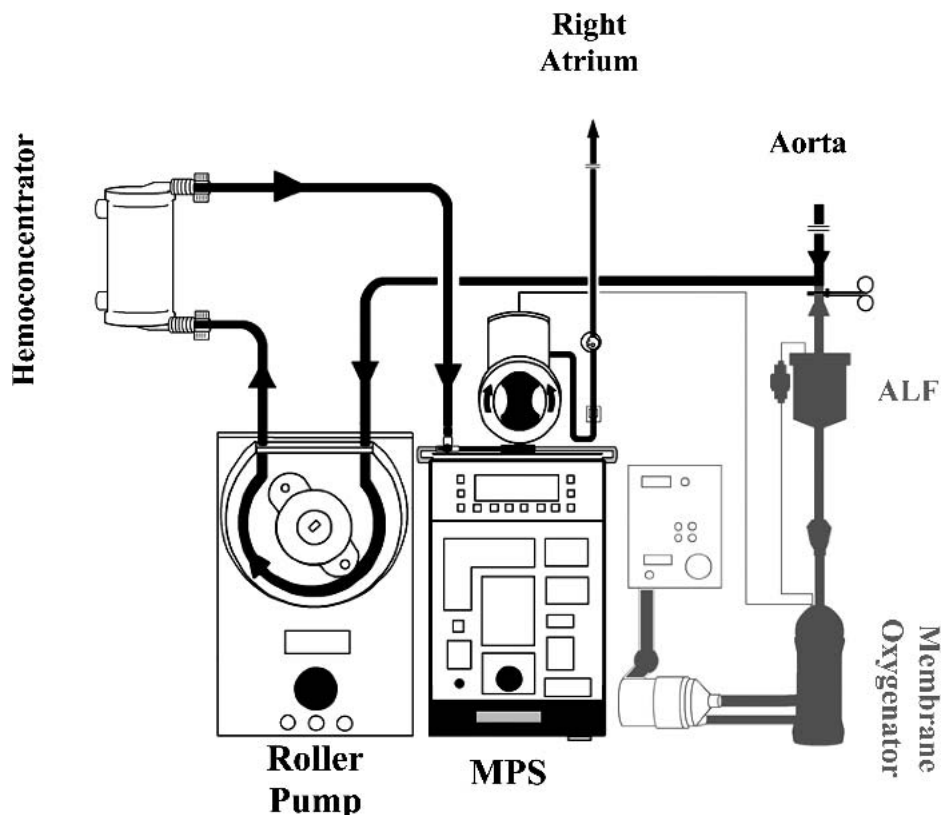


Figure 1: Modified ultrafiltration circuit. ALF, arterial line filter; MPS, myocardial protector system.

of the patient, with 50–150 mL·min⁻¹ typical. Suction usually is applied to the effluent line of the ultrafiltrator after MUF is initiated and stable. Vacuum is slowly increased and never exceeds 100 mmHg.

The patient's hemodynamic status is monitored continuously, and filling pressures are adjusted by either removal of plasma water by the hemoconcentrator or infusion via the arterial line in 20- to 50-mL boluses. Infusion is accomplished by briefly removing the tubing clamp located distal to the arterial line filter. The process is continued until the residual blood in the CPB circuit is reinfused. An additional 250 mL of 5% albumin is added, all shunts are turned off, and MUF is continued until either the ultrafiltrate volume or the additional reinfused volume exceeds the priming volume of the membrane oxygenators. MUF is discontinued and the aortic cannula is removed. The blood remaining in the arterial line is reinfused into the patient by reinitiating MUF.

DISCUSSION

The technique has been performed on 51 pediatric patients younger than 12 years of age. Average duration of MUF was 11.4 ± 3.0 min, with 22.5 ± 11.6 mL·min⁻¹ of plasma water removed from the patients. No complications related to MUF were encountered during any pro-

cedure. The modified technique provides a safe and convenient means of performing MUF in pediatric cardiac surgical patients using an existing device and its inherent safety features. The incorporation of the MPS allows precise regulation of the reinfused blood while offering multiple safeguards against air emboli transmission and overpressurization.

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