Technique

A Modification of the Sarns Conducer Heat Exchanger as a Low Prime Pediatric Cardioplegia System

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ABSTRACT

Cardioplegia delivery systems require significant modifications to accommodate the small pediatric patient. This new system employs the combination of a low prime heat exchanger, recirculation line systems and an open reservoir for use in both blood and crystalloid cardioplegia circuits. This modification is designed to minimize priming volume to approximately 50 ml, making it suitable for the very small patient. Simple tubing and reservoir variations can be made for the larger patient while still demonstrating excellent cooling, mixing and blood flow capability while safely delivering cardioplegia to the pediatric patient.

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INTRODUCTION

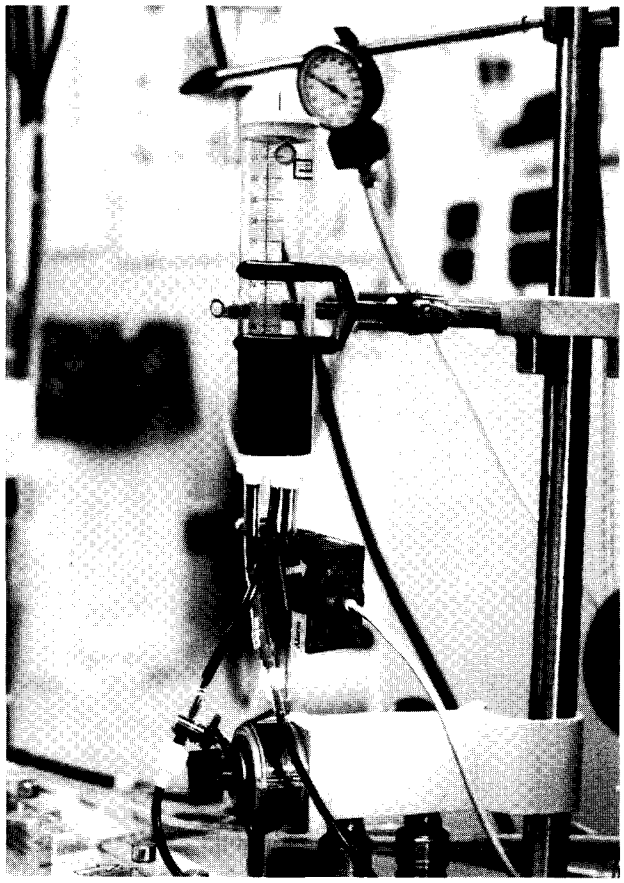
Pediatric myocardial preservation techniques continue to challenge many cardiac surgery teams. To further complicate myocardial protective strategies in pediatrics, the cardiac team must also consider the complexity of the heart lesion and/or repair, cyanotic versus acyanotic lesions, the decision to use crystalloid or blood cardioplegia, and lastly, the equipment and circuitry available. Even though much controversy exists concerning cardioplegia additives, most would agree that using a hypothermic solution in pediatric patients to lower myocardial temperature and oxygen demand is an excellent preservation strategy (1). Therefore, the small patient still presents a challenge for adapting the present cardioplegia systems while maintaining low priming volumes and heat exchanger efficiency.

MATERIALS AND METHODS

The purpose of this article is to describe the incorporation of the Sarns Conducer HX[a] in a new low prime cardioplegia recirculating system for pediatrics. The conducer's low prime and compact size enhance efficiency. Its thin, high tensile-strength stainless steel bellows are used to separate the countercurrent blood and water flows to maximize the temperature gradients at all points along the heat exchange area, and therefore require less energy to effect heat change. This new system was pursued after the discontinuation of the Cardio Metrics[b] C-NIP reservoir (2). The Sarns conducer requires a manufacturer custom order. The system consists of the conducer, recirculating table line, reservoir, a large-bore stopcock and polyvinyl chloride (PVC) tubing (Figure 1). The conducer comes with 1/4" inch connectors, a surface area of 0.258 m^2 and a priming volume of 7 ml. Efficiencies and pressure drops have been described by Hill, et al (3), as a one-pass system. Efficiency results were 85.2%, 80.3%, and 77.3% at 100 ml/min, 200 ml/min, and 300 ml/min, respectively. Pressure drops across the conducer with a hematocrit of 25% were calculated at 2 mmHg and 20 mmHg at 100 ml/min and 400 ml/min, respectivey. In addition, the pressure gradient has been tested at our institution across the conducer alone. Using outdated human blood at 37°C with a hematocrit of 36%, a pressure gradient of 29 mmHg at 1 L/min was measured, further demonstrating its safety for this type of system.

The Gish[c] table line (TL) is a two-way infusion/recirculation system already described by DiGregorio, et al (4). In this system, the TL is directly connected to the pump boot and reservoir with luer connections. The reservoirs are either modified burettes or various sizes of intravenous bags[d]. A large-bore stopcock is utilized to administer cardioplegia[c]. Other equipment needed to operate this custom system are as follows: a roller pump head, a water source for cooling or warming the cardioplegia, and a temperature probe of choice is also necessary.

Figure 1



SET-UP AND OPERATION

This system is easy to setup and operate. First, the Sarns conducer is removed from its commercially available custom pack and placed into its holder and water source. The reservoir is then placed in its appropriate holder. One end of the conducer is connected to the reservoir with the appropriate size tubing, while the other end is connected to the tubing boot (Figure 2). Depending on the size of the patient, tubing boot sizes vary. We utilize 1/8" for patients up to 6 kg body weight, 3/16" from 6 to 20 kg, and 1/4" over 20 kg. Once the tubing sizes are selected, appropriate connector modifications are undertaken proximally and distally to the roller head tubing. Alternatively, the conducer may be placed on the positive side of the roller head for larger patients where higher flows are expected. The Gish two-way infusion/recirculation line is connected to the system (Figure 2). The infusion female luer is attached to the the male luer on the roller head tubing. The recirculation male luer is then connected to the female luer of the reservoir. Pressure monitoring is achieved by connecting the female luer pressure line to a manometer and

a Sarns, 3M Health Care, Ann Arbor, MI 48103
b Cardio Metrics, Austin, TX 78754
c Gish Biomedical Inc., Santa Ana, CA 92705
d Abbott laboratories, North Chicago, IL 60064

primed retrograde as recommended by the manufacturer.

Desired amounts of crystalloid and/or blood cardioplegia are added to the system via a stopcock which is connected to the reservoir (Figure 2). The minimal prime of this custom recirculating system is approximately 50 ml when using a 1/8" boot at the lowest level in the reservoir. Safety devices such as bubble traps or alarm systems are easily adapted to the system. The Gish infusion/recirculation valve (Figure 3) is manipulated by the surgical team at the table. Like all recirculating systems, good communication is very important to avoid accidents.

SUMMARY

Based on our experience at Children's Medical Center of Dallas, the Sarns Conducer HX incorporated with a recirculating system is a safe and efficient system for delivering blood or crystalloid cardioplegia with minimal hemodilution. This system can easily be adapted to any size patient by changing the tubing size and reservoir.

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Figure 2

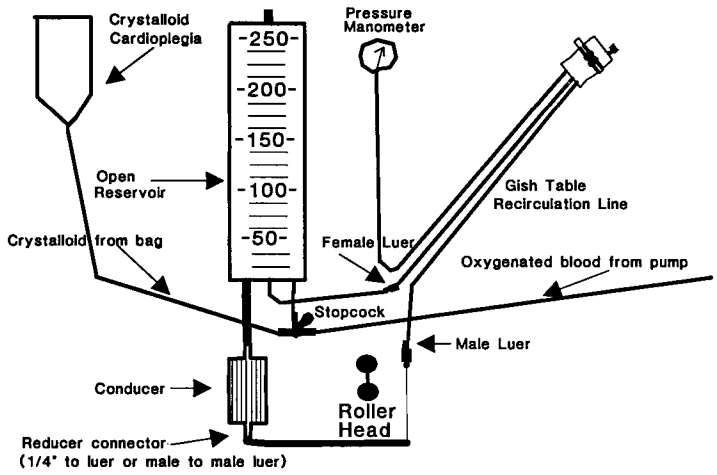

Figure 3
Infuse and Recirculation Valve