

Can Vacuum Assisted Venous Drainage be Achieved using a Roller Pump in an Emergency? A Pilot Study using Neonatal Circuitry

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Abstract: There has been much advancement in perfusion technology over its 50 years of progression. One of these techniques is vacuum-assisted venous drainage (VAVD). Many perfusionists augment venous drainage using VAVD, typically from a wall vacuum source. This study explores alternates to providing VAVD if the wall vacuum fails. In two porcine laboratories, ~36 in. of 3/16-in. tubing was connected to a sucker return port and placed into the roller head next to the arterial pump. The vacuum was monitored with a DLP pressure monitoring system (Medtronic). This system was connected to small-bore tubing and attached to a stopcock on top of the reservoir. The vacuum was regulated using another stopcock connected to a non-filtered

luer lock port on top of the reservoir or by a segment of 3 × 0.25-in.-diameter tubing attached to the vent port with a c-clamp. Vacuum drainage was achieved, ranging from -18 mmHg to -71 mmHg by manipulating the stopcock or c-clamp. Changes in venous drainage were seen by volume fluctuations in the venous reservoir. The vacuum was adjusted to account for dramatic changes. Augmented venous drainage using a roller pump can be achieved successfully during cardiopulmonary bypass (CPB). This method of active drainage can be used in lieu of wall suction or during times of emergency if wall suction fails. **Keywords:** augmented venous drainage, vacuum, roller pump, neonatal circuitry. *JECT 2007;39:254-256*

Assisted drainage is used at many institutions practicing a “low prime” volume strategy. Using a “low volume” strategy can be achieved by reducing the diameter and length of tubing to minimize hemodilution during cardiac surgery when implementing CPB (1). Reducing the tubing diameter increases resistance to blood flow four-fold, resulting in a decrease in venous return.

Assisted venous drainage (AVD) can also enhance siphon drainage by way of increasing venous return into the reservoir (2). VAVD is used to overcome resistance created by an empty venous line, the tubing diameter/length, and the viscosity of blood. VAVD and other assisted drainage systems “enable the use of smaller venous lines and cannulas while being able to maintain adequate systemic flows” (3). The purpose of this study is to show that VAVD can be maintained using a roller pump in the event of vacuum failure from a wall source.

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MATERIALS AND METHODS

Research Compliance

This study was in compliance with the Institutional Animal Care and Use Committee protocol. Our porcine models used in the two studies received humane care in compliance with the “Guide for the Care and Use of Laboratory Animals”.

Equipment

The equipment used was a Sorin heart lung machine with a monitoring console (Stockert Instrumente GmbH, Munich, Germany), Capiiox RXE 05 and oxygenator/heat exchanger (Terumo Cardiovascular System, Ann Harbor, MI), 3/16-in. non-coated tubing (Medtronic, Minneapolis, MN), Capiiox Pediatric AF02 arterial line filter (Terumo Cardiovascular System), arterial filter holder (Terumo Cardiovascular System), bubble sensor (Terumo Cardiovascular System), and DLP pressure monitoring system (Medtronic).

VAVD

The pump used for VAVD was set to an occlusive setting. Three-sixteenth-inch tubing was connected to the auxiliary port and placed in a roller head next to the ar-

terial pump. A small segment of 0.25-in. tubing was placed on the vent port with a c-clamp to relieve excess negative pressure. The vacuum was also regulated using a stopcock connected to a non-filtered luer lock port on top of the reservoir. Negative pressure was measured from the venous reservoir using small-bore tubing where the other end of the tubing was connected to the DLP monitoring system.

RESULTS

In cases 1 and 2, the vacuum was regulated by way of a stopcock or a piece of 0.25-in. tubing using a c-clamp as shown in Figures 1 and 2. This was done while running the roller pump and adjusting the RPMs to reach a negative pressure, allowing for augmentation of venous return. The RPM was not recorded because of the time needed to maintain stability between inflow and outflow volume into and out of the reservoir. The negative pressure was monitored using a pressure monitor as seen in Figure 2.

In case 1 in Table 1, there were only two sets of data because CPB was terminated after the femoral artery was perforated. The data do show that VAVD was achieved. However, there were also difficulties in setting negative pressures with the stopcock or the c-clamp to maintain a constant (inflow and outflow) volume within the reservoir. The stopcock was set at ~15–35 degrees and/or the c-clamp was adjusted to regulate venous return.

Case 2 allowed more time to adjust the roller pump, stopcock, and c-clamp. VAVD using a roller pump was recorded at negative 18 to negative 60 mmHg, as seen in Table 2. If the negative pressure was less than negative 60 mmHg, the vacuum was adjusted. Although plasma free hemoglobin was not recorded, negative pressures were managed to prevent hemolysis and venous line chatter. This was done in an effort to simulate conducting bypass with a human patient.

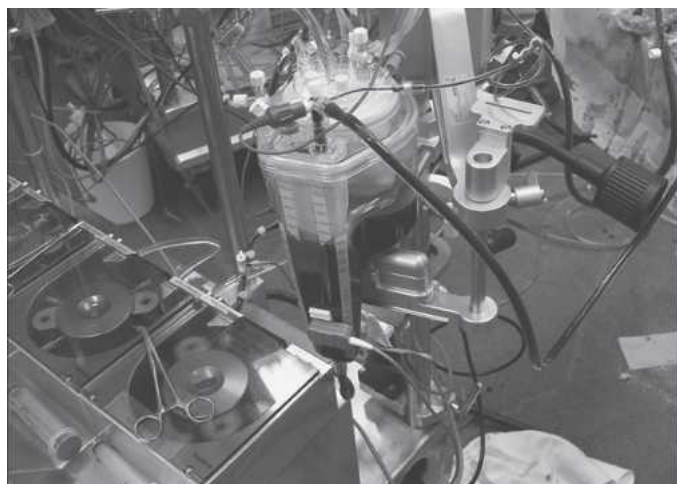


Figure 1. Vacuum roller pump.

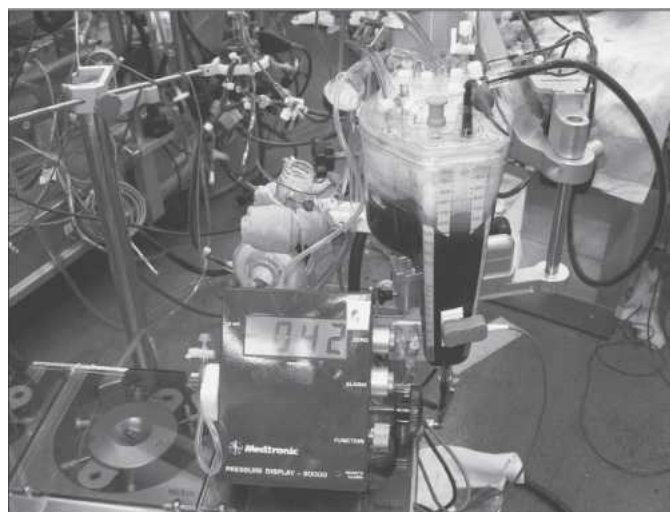


Figure 2. Vacuum roller pump with a DLP pressure monitoring system.

Table 1. Case 1—VAVD using a roller pump.

Time	Blood Flow (L)	Vacuum (mmHg)	Reservoir Level (mL)
1415 (initial)	0.67	-71	400
1430	0.67	-71	400
1431	Off bypass		

Table 2. Case 2—VAVD using a roller pump.

Time	Blood Flow (L)	Vacuum (mmHg)	Level (mL)
1315 (initial)			
1336	0.88	-50	600
1345	0.59	-18	500
1400	0.59	-60	700
1440	0.51	-35	600
1500	0.51	-38	600
1501	Off bypass		

The pressure monitoring system measured negative pressure instantaneously. For example, in Table 2, the negative pressure reading was negative 50 mmHg at 1336 and the reservoir volume was 600 mL. When the negative pressure decreased to negative 18 mmHg, the patient was being transfused with a volume in the reservoir, dropping the reservoir level to 500 mL. When the pressure increased to negative 60 mmHg, notice how the volume in the reservoir increased to 700 mL. When the pressure decreased to negative 35 and negative 38 mmHg, the patient again was being transfused, shown as a loss of volume in the reservoir.

DISCUSSION

The purpose of this study was to allow for maintenance of active venous drainage in the event of AVD failure. It is important to have a way to augment venous drainage

during an emergency such as electrical failure, because this can be a determinant between life and death of patients undergoing CPB. The importance behind having a back-up system stems from many institutions implementing a “low volume” strategy by minimizing the tubing diameter, tubing length, and cannula size. Techniques such as these can hinder venous return. With AVD, prime reduction methods are possible without excessive hemodilution of CPB patients.

The set-up proposed in this study can work in an emergency by way of handcranking with a pressure monitor that measures reservoir pressures. However, there were some difficulties maintaining a constant negative pressure. An addition that would improve this set-up would be to have a vacuum regulator connected to the reservoir to help regulate the negative pressure generated by the roller pump as shown in Figure 3.

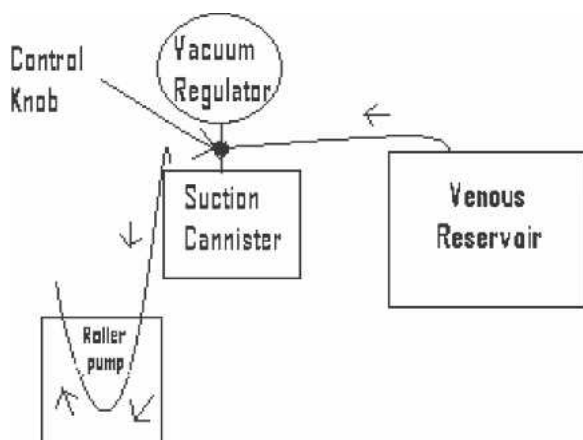


Figure 3. Regulating VAVD with a roller pump.

CONCLUSION

The technique described in this study can be lifesaving in the adult and pediatric population if the wall vacuum fails. Maintaining VAVD can minimize venous air locks that can occur when initiating CPB for congenital heart surgery caused by complex cannulation techniques (4). VAVD also allows for a smaller surgical footprint because it overcomes the resistance of smaller-diameter tubing and cannulas.

VAVD created with the use of a roller pump can be done emergently with equipment commonly used by perfusionists: a segment of sucker tubing, a stopcock, and/or a few inches of 0.25-in. tubing placed through a c-clamp. Because this is not a common way to implement VAVD, an emergency kit containing the necessary tools for this technique can be useful to sustain venous drainage. Emergency techniques have been established for many perfusion-related issues after CPB has been initiated. Being that many institutions are using AVD, the technique described in this study can be used if the wall vacuum fails.

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