

Comparison of the Agger with the Intersept Arterial Line Filter at Removing Gaseous Microemboli

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INTRODUCTION

A prototype arterial line filter developed by Bellco, Mirandola, Italy, and the Johnson and Johnson Intersept filter were compared for their effectiveness at reducing gaseous microemboli. The Intersept filter was used as a standard of comparison because of its reported efficiency.¹⁻⁴

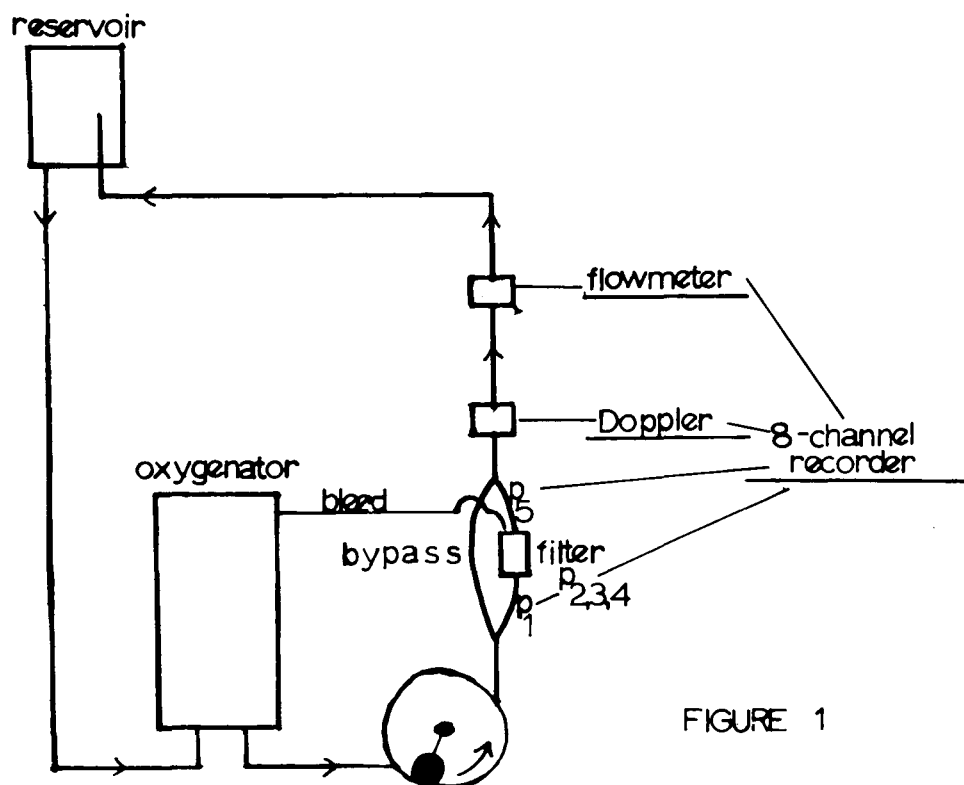


FIGURE 1

Figure 1. The extracorporeal circuit used in the study.

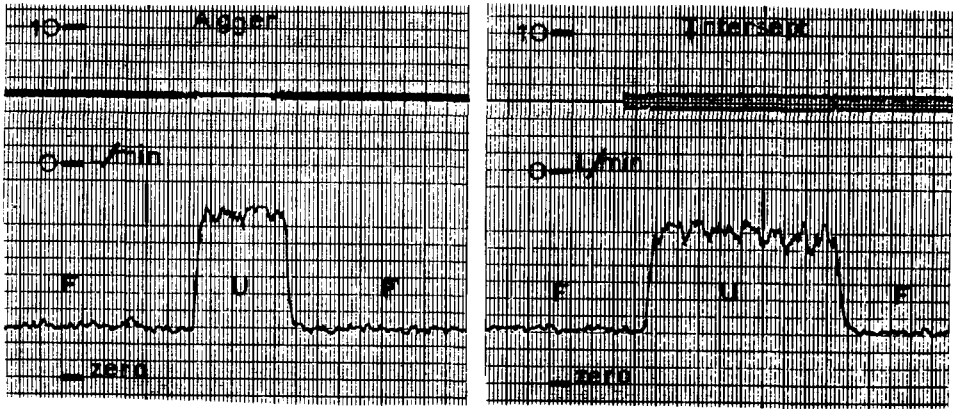


Figure 2. The effectiveness of the filters are demonstrated. Fluid flow is the upper and frequency shift the lower channel. F denotes filtered flow and U unfiltered flow. Note that the filtered levels are the same for both filters. Flow is 5 L/min.

MATERIALS AND METHODS

An extracorporeal circuit was designed to test the effectiveness of the arterial filters (Fig. 1). The circuit was primed with 3 L of Lactated Ringers solution maintained at 37°C. A Harvey H-1000 bubble oxygenator and a Travenol reservoir were used in the circuit. The oxygenator served as a source of microbubble formation. Gas to blood flow ratios were purposely made high to generate gaseous microemboli. A Doppler ultrasonic probe and a Biotronex flow probe were incorporated distal to the arterial filter. These measured frequency shifts caused by emboli and flow respectively. Pressures were

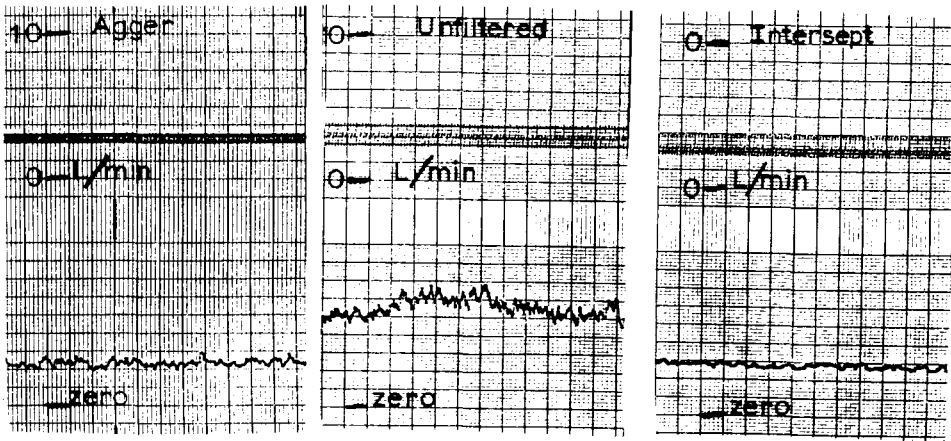


Figure 3. The effectiveness of both filters at preventing increases in emboli is shown when the gas flow in the oxygenator is increased from 6 to 12 L/min. The middle tracing shows this effect when the flow is unfiltered.

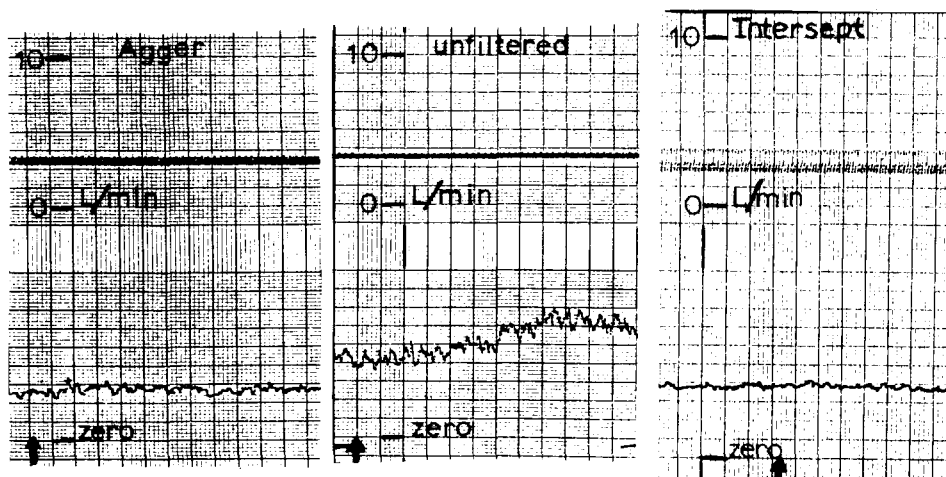


Figure 4. The effectiveness of both filters at reducing microemboli created by striking the oxygenator is shown (arrows). The middle tracing shows a shower of microemboli created when the flow is not filtered. Note that the flow is constant.

measured in the Agger filter proximal (P_1) and distal (P_2) and in all three ports of the filter ($P_{3,4,5}$). Fluid flows were either 3 or 5 L/min while the gas flows were either 6 or 12 L/min of 100% oxygen. All parameters were recorded on a Sanborn 7700 8-channel monitoring and recording system.

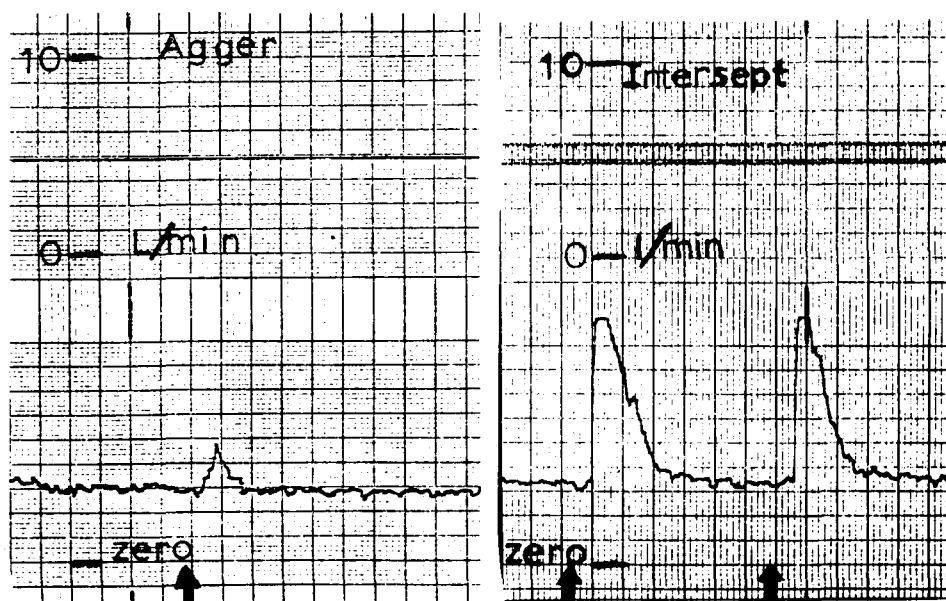


Figure 5. A shower of microemboli occurs when either filter is struck (arrows).

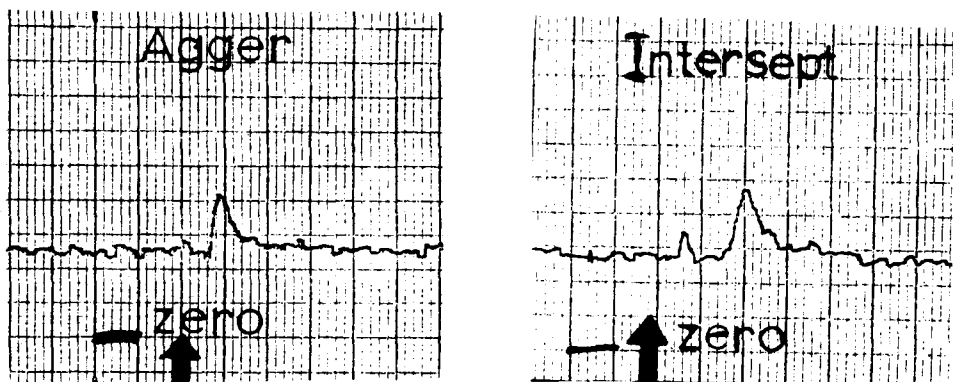


Figure 6. A shower of emboli is produced in both filters when a small volume of air is injected proximal to the filter. The arrows signify the time of injection.

Measurement of embolic activity was made with a Parks Model 806 Doppler flowmeter according to a previously described technique.⁵ The effect of filtration was compared by recording frequency shifts to unfiltered flow by clamping flow to the filter and diverting the flow through the filter bypass line. Fluid flow was monitored to insure constant flow since Doppler measurement is affected by changes in flow. The filter bleed ports were kept open during all measurements.

Changes in frequency shifts were recorded under the following conditions for each filter:

- 1) Flows at 3 L/min at 6 and 12 L/min oxygen flows,
- 2) Flows at 5 L/min at 6 and 12 L/min oxygen flows,
- 3) Rapping the side of the oxygenator to produce embolic showers at various flows,
- 4) Rapping the filter to produce embolic showers,
- 5) Injecting boluses of air proximal to the filters,
- 6) Draining the oxygenator reservoir and pumping large volumes of air.

The Intersept filter was primed, debubbled, and used according to that manufacturer's instructions. The Agger filter was primed simply by flowing through the filter after the filter bypass line was primed and after keeping all priming ports open.

RESULTS

Both filters comparatively reduced gaseous emboli at either 3 or 5 L/min flows (Fig. 2). Both filters effectively reduced embolic showers caused by increasing gas flows from 6 to 12 L/min (Fig. 3), or rapping the oxygenator (Fig. 4). Both filters produced a shower of microemboli when struck sharply (Fig. 5). Both filters allowed a shower of microemboli to occur following injection of air proximal to the filter (Fig. 6). The ranges of air required to shift the frequency were 0.125 to 3 cc in the Agger and 10 to 20 cc in the Intersept.

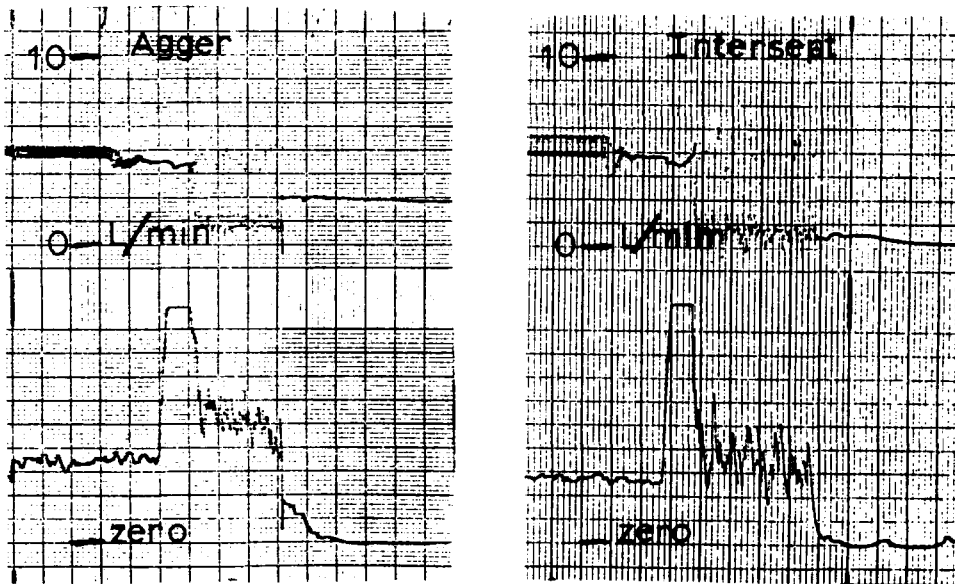


Figure 7. Neither filter prevented gross air from being pumped across the filter when the arterial reservoir of the oxygenator was depleted. Note the drop in flow when gross air passed the electromagnetic flow probe.

Both filters allowed large volumes of air to pass when air was pumped after depleting the oxygenator arterial reservoir (Fig. 7).

A 5 mm pressure gradient was measured at 3 L/min flow across the filter (Fig. 8). There was a drop in pressure at the top of the filter where the ports are located. This is due to the hydrostatic pressure of fluid in the filter.

DISCUSSION

Although the system used to monitor embolic activity is qualitative and not quantitative, the sensitivity of ultrasound at detecting embolic activity in extracorporeal circuits has been demonstrated with the use of microspheres.⁶

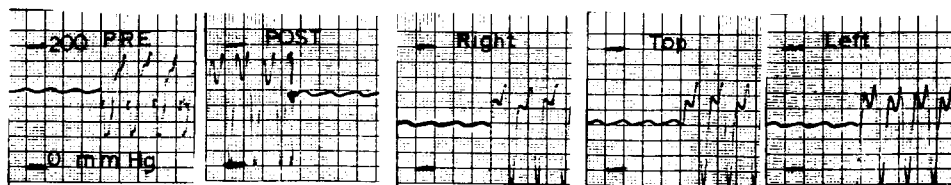


Figure 8. A small pressure gradient across the filter was observed at 3 L/min. A lower pressure exists in the priming/debubbling ports as a result of a lower hydrostatic pressure. Both phasic and mean pressures were recorded.

The Agger filter was most easily and simply primed and debubbled. This is a major advantage of this filter. This is probably because of its three priming/debubbling ports. However, these ports present a problem with most hard shell bubble oxygenators since there are not enough Luer-Lok ports on the oxygenator to accommodate the three filter bleed lines. A manifold could easily handle this plumbing problem.

There wasn't a large pressure drop at 3 L/min. A lower pressure near the top of the filter should help any microbubbles more effectively float toward the priming/debubbling ports.

The Agger filter appears to be quite comparable to the Intersept arterial filter regarding the effectiveness of gaseous microemboli removal. Neither filter, however, was effective in preventing gross air from being pumped through the filter.

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