Air-Eliminating Characteristics of Five Cardiotomy Reservoirs

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Abstract

Five unfiltered cardiotomy reservoirs were bench-tested to determine their effectiveness at producing air-free blood. The test circuit closely resembled our clinical setup.

Pump blood with a hematocrit of 22 - 25% and ACT greater than 400 seconds was pumped through the test reservoirs at flows of .3, .5, .7, 1.0, and 1.3 liters per minute, and at reservoir levels of 0, 10, 20, 30, 40, 50, and 100 ml. Thirty-five separate runs were done on each of five reservoirs. Blood was filtered through a 20 micron filter before being recycled. The number of gaseous emboli emanating from the reservoirs was estimated using a Technique Labs bubble activity monitor. Gross air production and transmission were measured by aspiration of the accumulated air from a 20 micron cardiotomy filter.

The reservoirs were ranked at the 35 flow-level combinations as follows: lowest bubble count = 1, highest count = 5. The average ranks were: Intersept HRI 8900 - 10, 1.1; Harvey H500, 2.4; Shiley CARD, 2.7; Bentley BCR 3000, 4.1; and Dideco D 640, 4.7. Total air accumulated for all 35 runs for each reservoir was: Intersept HRI 8900 - 10, 10cc.; Bentley BCR 3000, 56 cc.; Harvey H 500, 544 cc.; Shiley CARD, 918 cc.; and Dideco D 640, 2036 cc. In both tests, the Intersept was the most effective and the Dideco proved the least effective.

Introduction

One of the purposes of a cardiotomy reservoir is to receive a mixture of blood and air, separate them, and allow the blood to be returned to the extracorporeal circuit. Casual observation of different brands of reservoirs seemed to indicate a vast difference in performance. A formal study was undertaken in an attempt to document and quantify this difference.

Materials & Methods

A test circuit, shown in Figure 1, was constructed to closely duplicate our clinical set-up. The tubing through the pumphead was ⅜-inch I.D. silicone rubber. The remainder of the tubing was polyvinyl chloride. The filter was an Intersept Model No. 1331,[a] 20 micron screen and dacron wool, located 21 inches below the test reservoir. The bubble activity monitor was a Concept TM 8.[b]

The following five unfiltered test reservoirs were chosen on the basis of their availability from hospital stock: the Bentley BCR 3000,[c] the Harvey H-500,[d] the Intersept HRI8900-10,[a] the Dideco D640,[e] and the Shiley CARD.[f]

Scavenged pump blood, with a hematocrit of 22-25% and ACT greater than 400 seconds, was used in the test circuit. The volume reservoir was raised and lowered to maintain the desired level in the test reservoir. Gross air production and trans-

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Presented at AMSECT's 21st International Conference, New Orleans, LA, April 9-11, 1983.

[a]Extracorporeal, King of Prussia, PA 19406
[b]Technique Laboratories, Haunts, England
[c]Bentley Labs Inc., Irvine, CA 92714
[d]C.R. Bard Inc., Santa Ana, CA 92705
[e]Electromedics Inc., Englewood, CA 80112
[f]Shiley Inc., Irvine, CA 92714

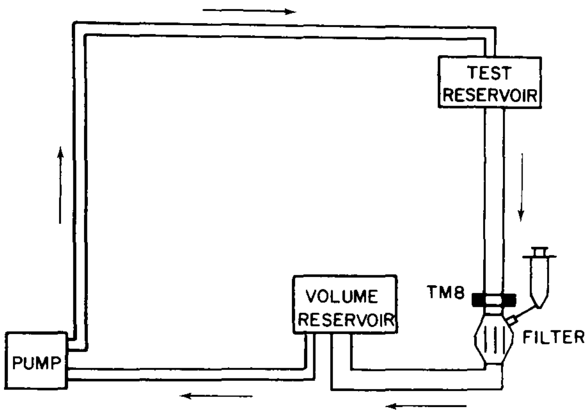

Figure 1: Cardiotomy reservoir test circuit

mission (vortexing) to the in-line cardiotomy filter were measured by aspirating the accumulated air via the purge port of the filter with a stopcock and appropriately sized syringes. Micro air production and transmission measurements were accomplished by placing the TM8 probe near the inlet of the cardiotomy filter with the sensitivity of the TM8 monitor set to count bubbles 50 microns in diameter and greater.

Blood was pumped through the test reservoirs at flow rates of .3, .5, .7, 1.0, and 1.3 liters per minute and at test reservoir levels of 100, 50, 40, 30, 20, 10, and 0 mls. Each test reservoir was run for ten minutes at each flow rate and each reservoir level. Micro bubble counts and gross air amounts were recorded.

Results

The bubble counts for each test reservoir at the 35 combinations of flow and level are reported in Figures 2-6. Bubble counts ranged from 9 counts per minute at 300 mls./min. flow and a reservoir level of 100 mls. to over 100,000 counts per minute at 1 liter/min. flow and a reservoir level of 0 mls. The amount of gross air for all 35 flow-level combinations for each reservoir is reported in Table 1. The range was from 10 mls. to 2036 mls. of total air collected at the filter. Bubble counts at representative high and low flows and levels are shown in Table 2.

To reduce this data, each reservoir was ranked at each of the 35 flow-level combinations as follows: lowest bubble count = 1; highest bubble count = 5. The number of times each reservoir had the lowest or highest bubble count is reported in Table 3. The best possible ranking would be 1.0 (lowest

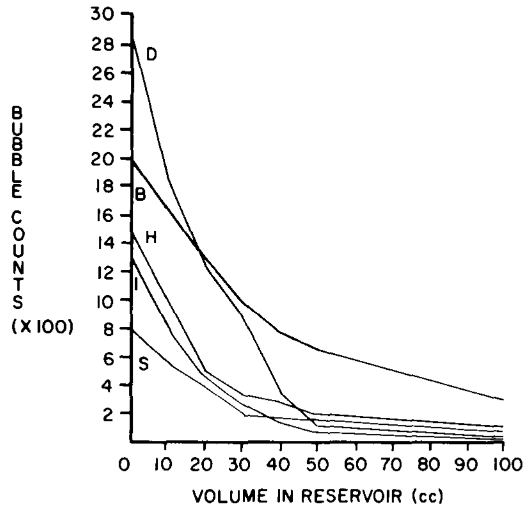

Figure 2: Bubble counts vs Volume at .3 LPM flow

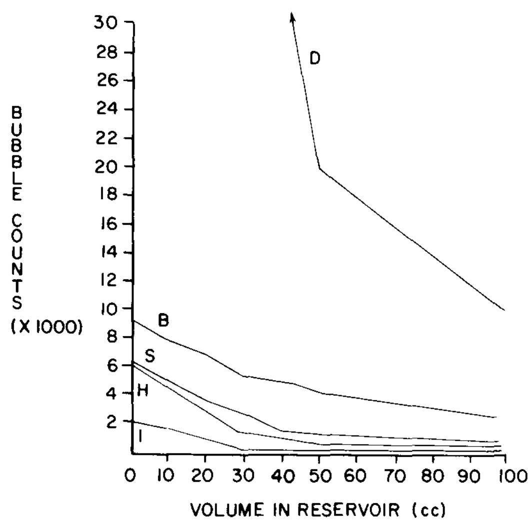

Figure 3: Bubble counts vs Volume at .5 LPM flow

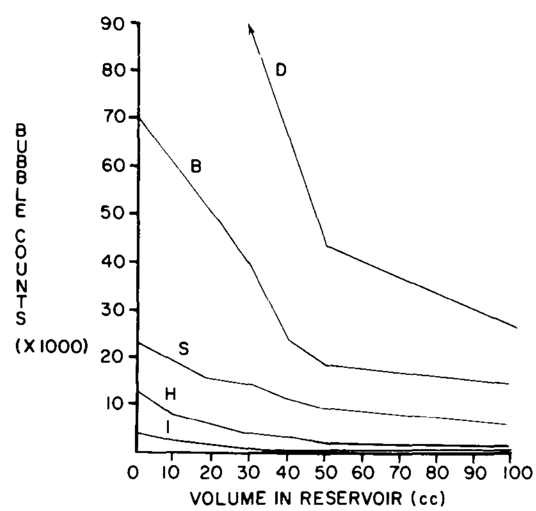

Figure 4: Bubble counts vs Volume at .7 LPM flow

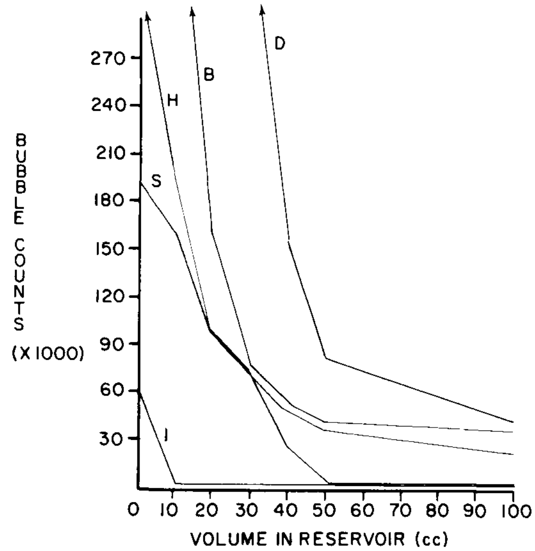

Figure 5: Bubble counts vs Volume at 1.0 LPM flow

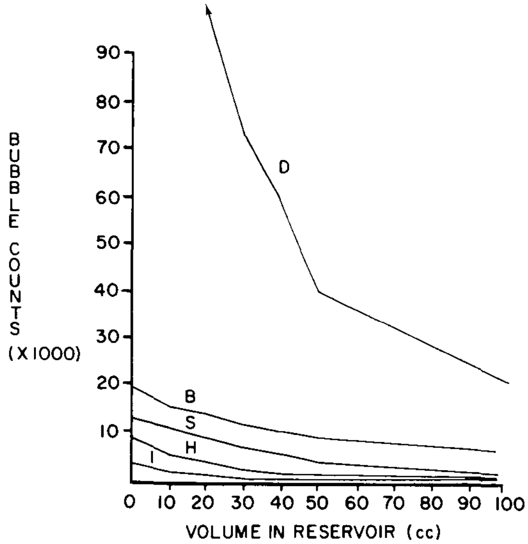

Figure 6: Bubble counts vs Volume at 1.3 LPM flow

count at every flow and level combination) and the worst possible 5.0 (highest count at every combination). The average rankings were: Intersept HRI 8900-10, 1.1; Harvey H500, 2.4; Shiley CARD 2.7; Bentley BCR 3000, 4.1; and Dideco D640, 4.7.

TABLE 1
Total Volume of Air Collected (ml)

Intersept HRI8900-10	10
Bentley BCR3000	58
Harvey H500	544
Shiley CARD	918
Dideco D640	2036

Discussion

Flow rate and level in the tested reservoirs markedly affected their performance. At low flow rates and high volumes all five reservoirs performed adequately. Differences in performance occur when levels are reduced or flow rates increased. The Intersept reservoir had the lowest bubble counts, ranking first in 31 of 35 runs, and was the most effective at preventing gross air vortexing.

The Dideco reservoir ranked last in 30 of 35 runs in the bubble count category and was also the least effective in the prevention of gross air vortexing.

Nitrogen has a very low solubility in blood, yet represents the largest component of air. Therefore, it is in the patient's best interests to use the reservoir which delivers blood as free from air emboli as possible.

TABLE 2
Bubble Counts per minute at Representative High and Low Flows and Levels

Reservoir Levels mls.	Flow Rate LPM	B	H	I	S	D
50	.3	642	156	78	124	84
0	.3	1986	1476	1320	806	2298
50	1.0	17742	1548	208	9240	43246
0	1.0	60222	12884	3682	22658	178284

B - Bentley, H - Harvey, I - Intersept, S - Shiley, D - Dideco

TABLE 3
Number of times each reservoir received the highest or lowest bubble counts per minute.

	B	H	I	S	D
No. of lowest counts	0	0	31	4	0
No. of highest counts	5	0	0	0	30

B - Bentley, H - Harvey, I - Intersept, S - Shiley, D - Dideco