Poster Presentation

In Vitro Comparison Tests of Five LV Vent Valves

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Abstract

Many surgical teams employ a sump pump to vent the left ventricle (LV). The problems associated with this technique are related to safety and convenience. If the flow is accidentally reversed in the LV vent line, air embolism accidents and subsequent litigation may be the result. If the cannula is occluded it is inconvenient to juggle pump speed to prevent the line from collapsing while maintaining gentle but adequate suction. We have in-vitro tested five commercially available L.V. Vent Valves (RLV-2100"B", LV-100, H-130, GLV and VRV-200"B"), which were designed to regulate suction in the LV vent line, prevent the flow of air towards the heart, and vent downstream pressure to the atmosphere. The valves were tested for suction at various flow rates and pressure heads. The results of pressure and suction tests (during flow and occluded line conditions) are tabulated. We found that the RLV-2100"B" offers the best combination of suction control and pressure relief.

Introduction and Objectives

During cardiopulmonary bypass procedures, the left ventricle (LV) has to be decompressed to keep the heart flaccid and cool. Safety valves have to be employed when using a sump pump to prevent accidental air embolism. According to a survey conducted by Kurusz, 36% of surgical teams insert a valve into the L.V. sump line to 1) control suction intensity, 2) prevent retrograde embolisation, 3) vent any line pressure to the atmosphere, 4) avoid collapsing the sump line. It has been reported by perfusionists that some valves 1), leak or spit blood, 2) are set to too high of a suction intensity and therefore have a tendency to suck air into the heart around the purse string suture,and 3) are noisy.

To compare and evaluate commercially available LV sump control valves for suction and pressure release capability, we have conducted in-vitro tests simulating clinical conditions.

Materials and Methods

Three each of the following valves were tested (in alphabetical order of manufacturer's name): 1. RLV-2100"B" (American Omni Medical, Inc.) 2. LV-100 (American Omni Medical, Inc.) 3. H-130 (C.R. Bard) 4. GLV (Gish Biomedical, Inc.) 5. VRV-200"B" (Healthdyne Cardiovascular, Inc.) These valves were subjected to the following in-vitro tests: a. Suction produced during normal flow conditions, b. Suction produced when the cannula is occluded and flow stops, and c. Pressure resistance test of the outlet valve.

The test medium was water. A calibrated roller pump was used to produce various flow rates. Suction measurements were taken with a U-Tube mercury manometer. In test a, the valve was placed 25cm. above the inlet reservoir to simulate the rise of the cannula over the chest. The pump discharged into a vented reservoir. For test b, the inflow cannula was occluded. For test c, a water-filled line was connected to the outlet to simulate the head pressure when the pump is stopped and blood fills the sump line.

Results

Figure 1 tabulates the suction intensity produced vs. flow rates, (since the valve is closed during normal flow, all valves produce essentially the same suction when the cannula is not occluded). Figure 2 shows the suction intensity at various pump rates when the cannula is occluded. That is the condition for which the valves were designed to provide convenience for the perfusionist i.e. the valve is supposed to reduce suction so that the sump line does not collapse. Figure 2-a shows various suction intensities attained vs. pump speeds. Figure 3 tabulates the height of water column achieved before the valve started leaking through the pressure relief opening.

Discussion

Several studies (Kurusz, Mandl, Mills, Stoney, Roe and Mortenson) have concluded that during left heart venting air embolism accidents can occur unless safety valves are employed. According to Kurusz, air embolism associated with venting was the third most common type of accident. An 18GA needle stuck into the sump line provides NO protection against air embolism when the pump is reversed or when the line is inserted into the pumphead backwards or if there is pressure in the downstream line for any reason. If the intracardiac cannula is occluded, it may be traumatic to wrench it away from the myocardium. Also the sump line may collapse. This necessitates juggling the pump speed. Therefore, many perfusionists use safety valves for convenience as well. However, if the suction relief valve is set too low, suction will be inadequate. If the setting is too high, there is a danger of sucking air into the heart around the purse string suture or, gases may be drawn out of

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Article available at https://ject.edpsciences.org or https://doi.org/10.1051/ject/199022S101

solution. When the pressure relief setting is too low, the valve may leak if it is placed low relative to the patient and/or if the pump is stopped. It is necessary therefore, to ensure that the valve provides just the right balance between low but adequate suction relief and protection against leakage. Some surgeons prefer to regulate LV sump suction from the sterile field. These surgeons use an adjustable valve.

Conclusions

Based on input from perfusionists and our criteria, our in-vitro tests have concluded that one, there is solid blood between the heart and the valve. It is therefore desirable to position the valve close to the heart to minimize priming volume in the sump line. This applies to all valves. Two, the LV-100, GLV, and VRV-200"B" valves may leak or spit blood. These valves must be positioned approximately level with the heart. Three, the H-130 valve produces an unnecessarily and dangerously high suction in the sump line, and four, the RLV-2100"B" valve does not leak and offers an optimum combination of low suction and pressure relief performance characteristics for safety and convenience. Suction performance varied substantially among the five valves types tested. Perfusionist are urged to compare them carefully to ensure safety of LV venting.

Figure 1

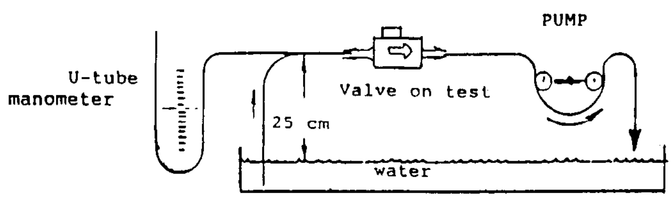


FIG. 1.

RESULTS OF TEST "A"

SUCTION RELIEF VALVE TEST DURING FLOW

VALVE CAT. NO.	PUMP SPEED (Flow Rate) L.P.M. 0.5	1.0	1.5	2.0
RLV-2100 "B"	14	15	18	23
LV-100*	10	11	13	16
H-130	14	15	20	23
GLV	14	16	18	20
VRV-200 "B"	14	15	16	20

* valve set to "max" suction. (At "min" setting, the valve produces negligible suction).

SUCTION RESULTS ARE SHOWN IN mm.Hg.

Figure 2

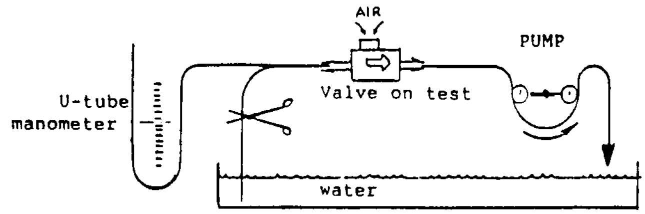


FIG. 2.

RESULTS OF TEST "B"

SUCTION RELIEF VALVE TEST WITH INLET OCCLUDED

VALVE CAT. NO.	PUMP SPEED "L.P.M." 0.5	1.0	1.5	2.0	2.5	3.0
RLV-2100 "B"	72	88	99	117	135	146
LV-100 @ "max"	216	313	357	377	396	403
H-130	277	237	239	245	264	260
GLV	84	86	90	99	107	108
VRV-200 "B"	148	152	154	155	157	159

SUCTION RESULTS ARE SHOWN IN mm. Hg.

Figure 2a

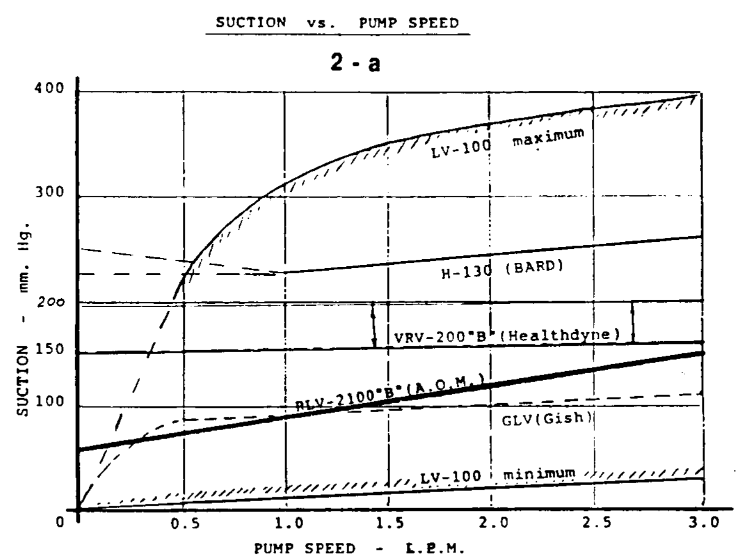
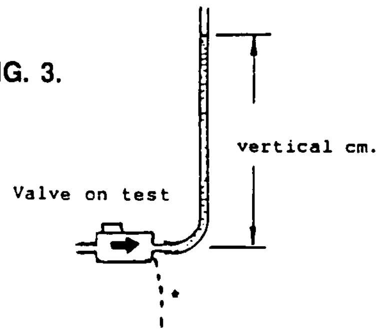


Figure 3

FIG. 3.



RESULTS OF TEST "C"
PRESSURE RELIEF VALVE TEST

VALVE CAT. NO.	PRESSURE HEAD approx. vertical centimeters (at which first drip occurs)
RLV-2100 "B"	275 + +
*LV-100	5
H-130	275 + +
*GLV	20
*VRV-200 "B"	9