Clinical Experience with 100 Shiley S-100 Oxygenators

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"The oxygenation of blood by gas dispersion is based upon the age-old knowledge that a huge gas-liquid interface can be created in a relatively small volume by bubbling the gas through the liquid. Gas exchange devices, in which this technique of exposing blood to oxygen prepotent, are grouped under the class of "bubble oxygenators", or a more familiar term "bubblers".[1]

Over the past 15 years a number of bubble oxygenators have been developed, each with its own distinct character and functional capabilities. Although all bubble oxygenators have the same basic principals of function, I would like to present the gas exchange capabilities and the heat exchange performance of the newest bubble oxygenator on the market, the Shiley S-100.

The design of the Shiley S-100 was (1) to eliminate water to blood seals with a one piece spiral coil venous side heat exchanger, (2) to eliminate as much error in assembly of the unit with as few seams as possible, therefore, also having fewer areas in which leaks will develop, and (3) to produce efficient, reliable gas transfer with a low gas to blood flow ratio. Efficiency in gas transfer is assured by a sparger plate, which produces a uniform bubble size, is combined with an open pore sponge to assure complete, but laminar, mixing of the bubbles with the venous blood.

DESCRIPTION

The unit is approximately 12 × 5½" by 16" high (Fig. 1). At the oxygen inlet section, which is located below the venous inlet port, there is a 175 pore sparger plate made from epoxy bonded glass beads*. A 10 pore per inch reticulated polyurethane sponge is located above the venous inlet. The blood-gas mixture flows vertically through this sponge where mixing occurs and then flows into the heat exchanger section. The heat exchanger is a seamless aluminum tube which is helically twisted and coiled. The grooves between the helical fins continue the laminar mixing process which provides an increased heat exchange surface area for the heating and cooling of the blood.[2] The coil is coated with polyurethane with a surface area of between 2,000 to 2,200 sq. cm. exposed to blood. The water goes in and out in a counter-current fashion. The heat exchanger has been tested by the manufacture at a pressure of 120 psi, but it is recommended that the water inlet pressure not exceed 60 psi.

As the blood-gas mixture passes through the heat exchange chamber, the major amount of gas transfer occurs. The blood-gas mixture flows across the top of the unit and gently downward into the defoamer along a Lexan flow guide tube which minimizes the vertical dropping of blood within the defoamer. The defoamer sponge is made of 20 pores per inch reticulated open cell Scottfoam which is black in color. The coating is Dow-Corning

Antifoam A. The defoamer sponge is covered with nylon tricot which has a normal 100 to 150 u (micron) mesh opening.

The blood-gas mixture has now reached the arterial reservoir, which is one solid injection molded piece except for the arterial and coronary outlets and arterial sample port. The reservoir is approximately 5″ in diameter with a total capacity of 4,000 ml.

MATERIALS AND METHODS

The oxygenator was used with our specific set-up for cardiopulmonary bypass. This system includes an arterial line** and cardiotomy filter***. Venting of the heart is through the left atrium. An in-line PO_2 analyzer**** was used for constant monitoring of arterial and venous PO_2's. Gases used were 100% O_2 and a mixture of 95% O_2 and 5% CO_2. A wall water source was used which has a flow of 15 liters/min. at a supply pressure of 45 psi.

Induction of anesthesia was with morphine sulfate, Valium and N_2O. Anesthesia was maintained with morphine sulfate and muscle relaxants.

The priming solution included 1,600 to 2,000 cc. of Plasmalyte 148 in water, 2 grams Solu-Medrol, 50 mg. beef lung heparin L:1000 units per cc., 25 grams albumin and sodium bicarbonate was used when necessary to adjust the pH. Hematocrits were maintained at 25% during bypass; deglyced blood was given as needed. Prior to cannulation, 30 mg. per kg. of beef lung heparin was administered. Reheparinization was done at one hour intervals with one-third the initial dose.

Blood flows were calculated at 2.4 liters/min.-M^2. Blood flow rates were regulated to maintain a mean pressure of 80 mm. Hg. Moderate hypothermia of 30° to 32°C was employed in all cases. On selected cases localized hypothermia was used. Hypothermia was induced with no more than a 12° gradient to eliminate premature fibrillation.

Arterial and venous blood gases were drawn approximately five minutes after the onset of bypass and every twenty minutes thereafter. Arterial blood gas samples were drawn from the arterial line of the patient, and venous blood gas samples were drawn simultaneously from the venous sampling port of the oxygenator.

Table 1

CLASSIFICATION OF PATIENTS UNDERGOING CARDIOPULMONARY BYPASS

DISEASE AND PROCEDURE	NUMBER OF PATIENTS
Coronary Artery Bypass	
Single	9
Double	23
Triple	36
X 4	16
X 5	4
Aortic Valve Replacement	2
Mitral Valve Replacement	2
Thoracic Aneurysm	1
Ventricular Aneurysm	1
Ventricular Aneurysm and Coronary Artery Bypass	4
Coronary Artery Bypass and Valve Replacement	1
Atrial-Septal Defect Repair	1
TOTAL: 100	100

Table 2

PATIENT CLINICAL DATA

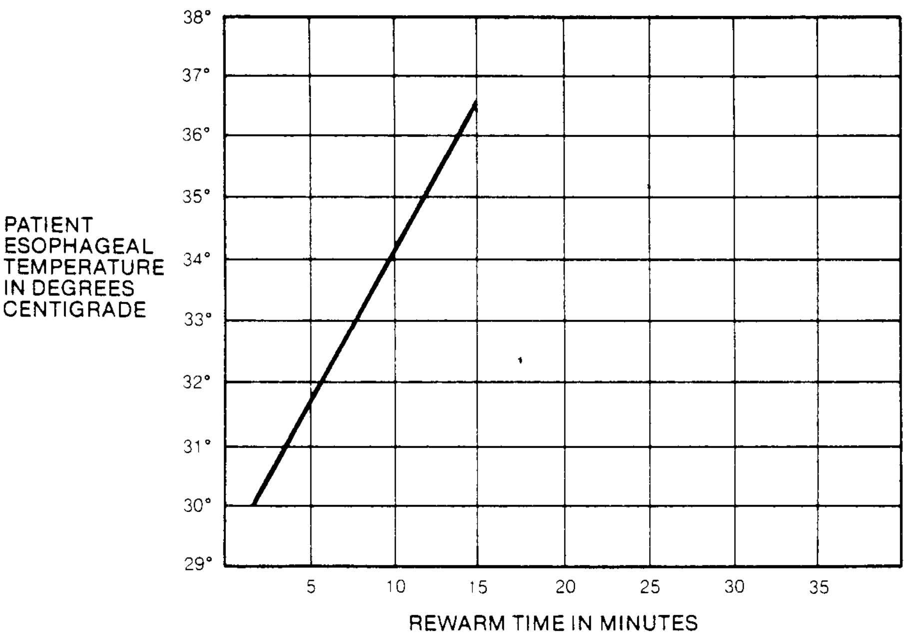
CLINICAL DATA	MINIMUM	MAXIMUM	AVERAGE
Patient Body Weight (KG.)	32	120	80.5
Blood Flow Rates (ML/MIN)	2500	7.000	4900
Oxygen Flow Rates (L/MIN)	1.2	4.2	2.5
Patient Age (Years)	32	81	55.5
Bypass Time	24 MIN	240 MIN	72 MIN

Table 3

CLINICAL BLOOD DATA

DATA	AVERAGE BEFORE BYPASS	AVERAGE DURING BYPASS	AVERAGE AFTER BYPASS
PO_2 (mmHg)	186.3	219	258.4
PCO_2 (mmHg)	40.4	40.7	39.8
PH	7.42	7.39	7.40
Base Excess (mEq/L)	+1	-.5	+2
Hematocrit ( )	47.7	25.5	35.4
Sodium (mEq/L)	140	139	140
Potassium (mEq/L)	4.3	4.0	3.9

Table 4



RESULTS

Cardiopulmonary bypass was performed on 100 patients (Table 1), ages ranging from 32 to 81 years, and weights ranging from 37.5 kg. to 120 kg. with average of 80.5 kg (Table 2). Flow rates ranged from 2,500 cc./min. to 7,000 cc./min. Bypass time was from 24 minutes to 240 minutes with an average of 72 minutes.

We found that to maintain PO_2's of 150mm Hg. to 200 mm. Hg. and PCO_2's of 35 to 45 mm. Hg., a 1.5:1 gas to blood flow ratio was needed to initiate bypass but that within three to five minutes this could be dropped to .5:1 (Table 3). As the rewarming period began, the CO_2 mixture was discontinued.

Average rewarming time from a temperature of 30°C to 37°C, depending upon the size of the patient, was 17 minutes. It took approximately 2.4 minutes to raise the temperature 1°C. The water temperature never exceeded 40°C (Table 4).

As previously stated by Hartley, et al.[3], it is recommended that finely calibrated gas meters be utilized with the Shiley S-100 to prevent excessive PO_2's and PCO_2's. We are not using finely calibrated gas flow meters and find we have no problem in obtaining excellent blood gas results.

COMMENTS

As you can see by the data presented from my clinical experience with the Shiley S-100, this unit produces excellent gas transfer and efficient heat exchange capabilities.

*Tegraglas 3-M

**Interspet — J & J

***Swank-Cobe Labs

****IBC

REFERENCES

1. Galletti, P. M., Brecher, G. A., Heart Lung Bypass (1) 61, 1962.
2. Bjork, V. O., Bergdall, L., Wussaw, C. Gas Flow in Relation to Blood Flow in Oxygenators (2) 81 Scand. J. Thor. Cardiovas. Surg., 1977.
3. Hartley, M. B., Pelley, W. B. A Comparative Study of Two Bubble Oxygenators (3) 6 1977.