
Clinical Evaluation of the Sarns 7800 LX Modular Centrifugal Pump

Charles F. Jerabek, BS, CCP, Howard G. Walton, BA, CCP

Providence Medical Center
Portland, OR

Key words: Pump, centrifugal, blood flow, Doppler

ABSTRACT

The Sarns 7800 LX Modular Centrifugal Pump is a second generation centrifugal pump using new Doppler technology for the measurement of flow. The *in vitro* portion of this evaluation compared the Sarns flowmeter and the Biomedicus electromagnetic flow probe to a known occlusive roller pump output under various pressure, temperature and hemoglobin levels encountered during routine cardiac surgery. No statistically significant ($p > .05$) difference was found when comparing either flowmeter with the roller pump, but the Bio-Medicus probe exhibited a positive correlation ($p = .026$) between increased temperature and the absolute value of roller pump output minus Biomedicus flow probe display. The *in vivo* portion of this study compared the Sarns centrifugal system to our current patient database in the areas of blood usage, overall mortality and morbidity, and D.I.C. panel test values. The Sarns was equal or superior in all areas recorded. Plasma free hemoglobin levels run one half hour post bypass averaged 56.3mg/dl with a range of 11-144. The new Sarns system was convenient to operate, interfaced easily with an IBM computer system and presented no problems during the evaluation.

INTRODUCTION

Centrifugal pumps have gained wide acceptance as an alternative to the traditional roller pump^{1,2} in cardiopulmonary bypass. In 1984 Sarns purchased the Centrimed centrifugal pump technology and, after several modifications, has released the latest generation of centrifugal blood pumps, the Sarns Delphin 7800 LX Modular Centrifugal System. This system has several improvements over the older Centrimed technology in areas such as control ergonomics, Doppler flow measurement and disposable bowl reliability. This study was undertaken with two goals in mind: the first was to measure the accuracy of the new Doppler flow probe under various conditions encountered during cardiac surgery and compare it to an electromagnetic flow probe. The second goal of this study was to evaluate the Sarns system *in vivo* on a sample of patients requiring cardiopulmonary support.

MATERIALS AND METHODS

The evaluation of flow probe accuracy was conducted using a dual pump/reservoir circuit shown in Figure 1. This was the circuit of choice for measuring flow values because of the

Address correspondence to: Charles F. Jerabek, Department of Surgery, Providence Medical Center, 4805 N. E. Glisan, Portland, OR 97213

inherent pulsatile nature of a simple roller pump circuit which would cause transient fluctuations in flow rate, causing errors in the values recorded by the distal flow probes. Errors in flow measurement have previously been encountered when using both electromagnetic³ and Doppler technology. It was decided that the variables of temperature, pressure and hemoglobin would be evaluated. Hemoglobin levels were adjusted to 15, 10 and 6 g by diluting outdated bank blood with Plasmalyte-A. Hemoglobin measurement was performed on a Radiometer ABL3^a blood gas machine. Temperature levels were adjusted to 20, 30 and 40°C using the heat exchanger of a Shiley M-2000^b oxygenator proximal to the flow probes. Temperature readings were obtained from the oxygenator's arterial probe site using a Yellow Springs 400^c thermistor probe. Line pressure was set at 10, 100 and 250 mmHg and adjusted by restricting the tubing orifice distal to both flow probes and the Sorenson strain gauge pressure transducer.

Controlled flow was produced by a Shiley Stockert roller pump calibrated at the flow rates of 1, 3, and 6 liters per minute. To assure that no belt slippage would skew the values, pump rpm was verified manually in addition to the pump's digital readout. No belt slippage was observed during the experiment. A Bio-Medicus^e centrifugal pump was used to supply the laminar non-pulsatile blood flow to the heat exchanger and flow probes. All analog output were sent through an Adalab^f analog to digital converter to an IBM computer and processed using the Providence Perfusion Software Package 4. Since fluid shifts in a two reservoir system could have adversely affected the accuracy of test data, a minimum of 30 seconds was spent between each sample to assure fluid level equilibrium. The Doppler probe was placed over Tygon^g S50HL Class VI 3/8 by 3/32 tubing using ultrasonic gel supplied by Sarns.^h

The pump circuit evaluated *in vivo* consisted of the Sarns centrifugal bowl, Sarns SMO oxygenator with collapsible bag, extracorporeal forty micron arterial filter, Tygon S50HL Class VI tubing, and a prime of 1400 cc Plasmalyte-A with 500cc Hespan. In 15 patients undergoing coronary artery revascularization, an initial heparin dose of 400u/kg was administered with subsequent minimum hourly doses of 1mg/kg to keep activated clotting times over 480 seconds. The patient

-
- a. Radiometer, Copenhagen, Denmark
 - b. and d. Shiley, Anaheim, CA
 - c. Yellow Springs
 - e. Bio-Medicus, Eden Prairie, MN
 - f. Adalab
 - g. Tygon
 - h. Sarns, Ann Arbor, MI

RESERVIOR 2

RESERVIOR 1

FIGURE 1

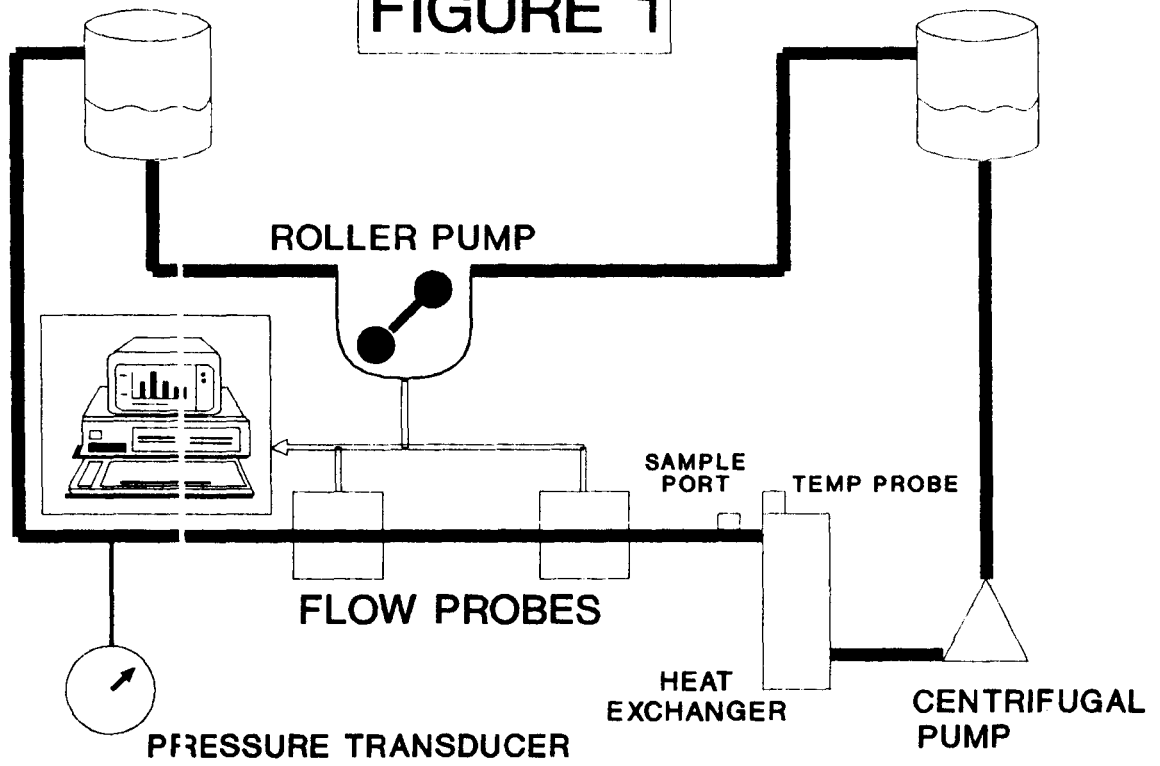


FIGURE 2

FLOW PROBE COMPARISON

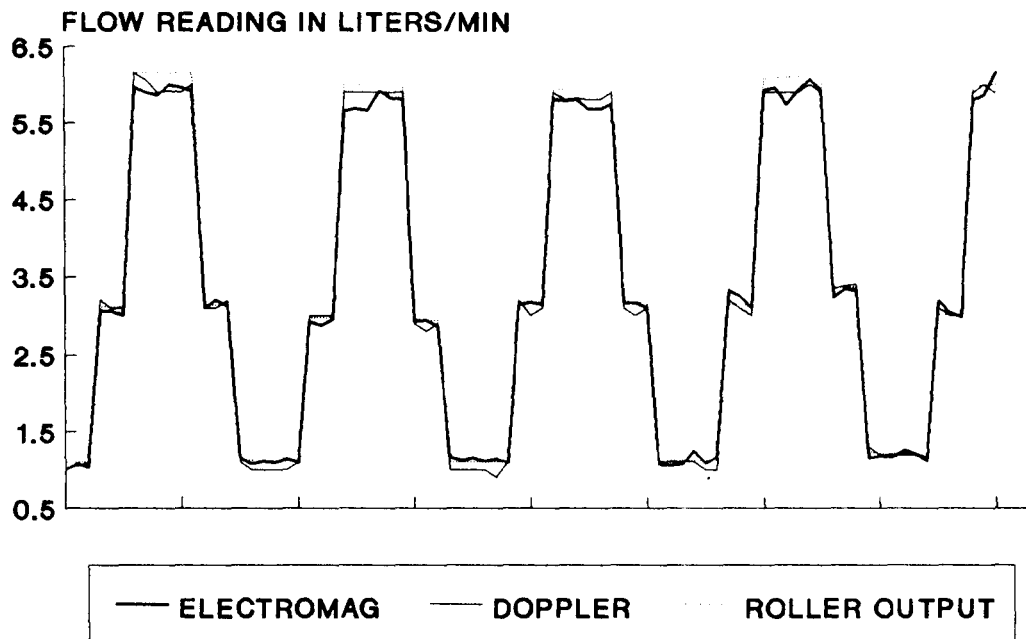


FIGURE 3

FLOW PROBE ERROR IN L/MIN

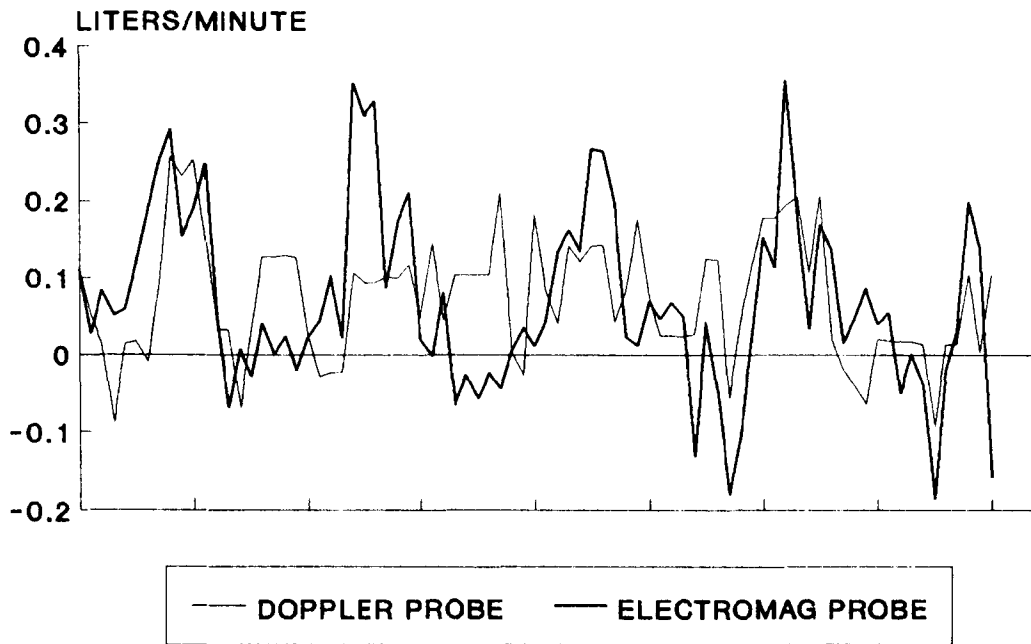
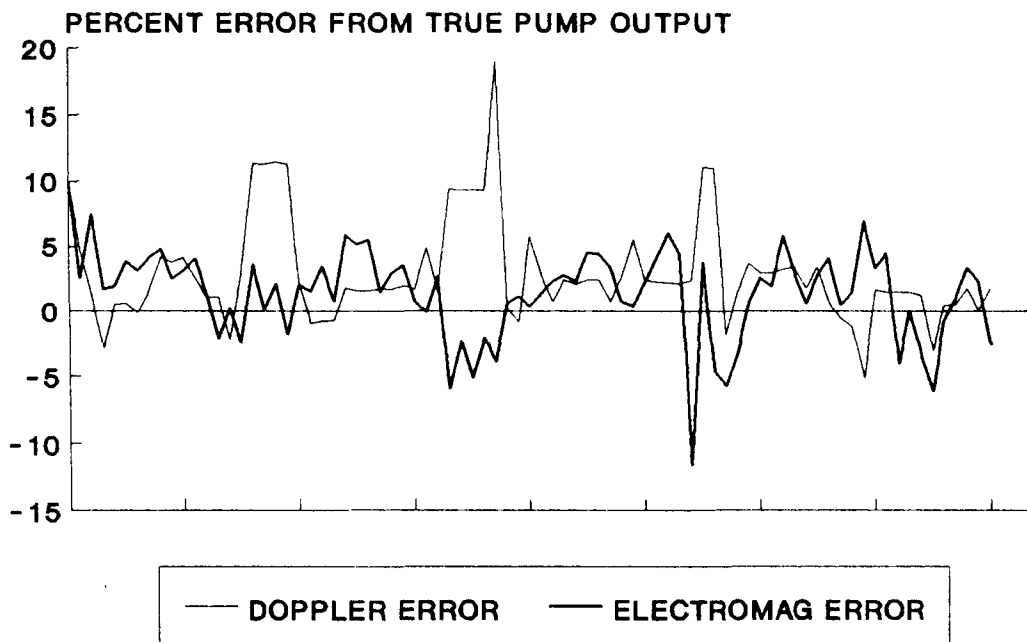


FIGURE 4

FLOW PROBE PERCENT ERROR



population is further described in Table 1. Patient morbidity was monitored post-operatively along with clinical laboratory testing which included plasma free hemoglobin levels and a disseminated intravascular coagulation panel drawn one half hour post bypass.

Statistical evaluation of the in vivo data was performed using the Dendrite Patient Analysis and Tracking System. The data from the flow probe evaluation were processed using the Kwikstat Shareware Statistical Package by Alan C. Elliot.

RESULTS

Neither flow probe showed any significant difference ($p < .05$) from true flow (roller pump). The electromagnetic probe showed a significant ($p = .026$) increase in percent error at higher temperatures.

Table 1 shows the post operative morbidity and blood usage figures from the fifteen patients studied. Table 2 lists the differences between the study group and the control. The patients in the control group were the remainder of our coronary artery revascularization patients from 1988. All the control cases were perfused with a membrane oxygenator, (85% roller pump, 15% Bio-Medicus pump) otherwise identical surgical, anesthesia, perfusion and techniques we employed. When the Sarns Delfin centrifugal system was used there was no difference in any of the parameters evaluated except for an increase in platelet usage. We attribute the difference in surgeons. One surgeon was more liberal with platelet usage than his peers and had a larger proportion of the cases in our sample.

DISCUSSION

The Sarns Delphin Centrifugal Pump System proved to be a reliable pump for this series of 15 patients. Staff perception of pump features has been positive. Several positive features of this pump are the alarm to alert for backflow at low RPM's, its light weight, easy cleaning characteristics, setup adaptability, sensitive secure control knob, and the dual pump engagement switches. On the negative side, however, the main power switch was inconveniently located and could be hit with a stray foot (although we were not able to turn off the system in this manner), the flow on LED was hard to see when mounted on a Shiley pump console, we had no trouble losing the pump drive motor cover which was not attached to the pump. Finally, at maximum flow with a resistance of 250 mmHg we were only able to reach 3120 rpm and a flow of 6.8 l/m due in part to safety features designed to prevent magnetic decoupling.

The Doppler flow probe was close to true flow under the varied conditions encountered during surgery. The flow values were equal to that of an electromagnetic probe. Since the Doppler flow sensor requires no disposables, we feel that it is a superior system. The reason for this improved accuracy is a process called digital signal processing. This processing digitalizes the waveform received from the Doppler signal, analyses it (a fast fourier transform) and reports an average velocity which is more accurate than the Doppler probe used on older Sarns systems.

Patient morbidity results are self explanatory. The values reported in Table 2 for character of operation, platelet

usage, fresh frozen plasma usage, cryoprecipitate usage, stroke incidence, CPK-MB evaluation, patient status reflect the percent of normal values observed. The statistical analysis of these variables, however, examined the whole spectrum of possible answers before delivering the p value. Our in-house comparison showed that the Sarns Delphin Centrifugal System when used with a collapsible bag and SMO oxygenator was a safe and effective system. Even though our control group had 15% of the patients perfused with a Biomedicus pump, we did not do a direct comparison since this group of patients was selected because of their acuity, skewing the statistical results in favor of the Sarns system. We saw no evidence of increased hemolysis during our bypass runs and our clinical data supports the research of Hoerr¹ that the blood handling properties of the Sarns bowl are clinically acceptable.

In conclusion, the results show that the Sarns Delphin Centrifugal System is an improved version of its predecessor, (the Sarns Centrimed) and a safe, effective choice for a primary pump head. The disposable bowl, when primed and run as specified in the instruction manual, operated without failure in our study and in over 20 subsequent cases. We are presently making plans to have the Sarns centrifugal bowl packaged in our pump packs preconnected to our lines decreasing both setup time and overall equipment cost.

REFERENCES

1. Hoerr HR et al.: In vitro comparison of the blood handling by the constrained vortex and twin roller blood pumps. *JECT*. 19(3):316-321. 1987
2. Massimino RJ, Martin J, Gough JD and Stearns GT.: An in vitro evaluation of the Bio-Medicus blood pump. *JECT*. 14(6):472-474, 1982
3. Wagoner PA.: The effects of hematocrit, amplifier input impedance and magnet excitation frequency on the accuracy of electromagnetic flowmeters. *JECT*. 17(2):56-64. 1985
4. Jerabek CF, Walton HG, Sugden EH.: An inexpensive real-time computer system for cardiac surgery. *AmSECT 26TH International Conference Proceedings*. 23-27, 1988
5. Dearing JP et al.: Clinical trails of a new low prime hollow fiber membrane oxygenator. *JECT*. 18(2):49-54. 1986.