Hemolysis of an Intravascular Lung Assist Device with Actuators

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1. Introduction

A vibrating intravascular lung assist device (VIVLAD) was undergoing additional engineering development and characterization.[1,2] The focus of these efforts was the VIVLAD that could supply as much as one-half basal O_2 consumption and CO_2 elimination rates while residing within the inferior and superior vena cavae after peripheral venous insertion. Our development efforts in an intravenous oxygenator have focused on increasing the efficiency of gas exchange (the gas exchange per membrane area) be using PL-128.255 Lead Zirconate Titanate (PZT) actuators and PVDF sensors within the fiber bundle to actively promote fluid mixing and augment gas exchange. Our vibrating intravascular lung assist device (VIVLAD) was demonstrated significant gas exchange enhancement with actuation. Despite the recent progress in gas exchange efficiencies, enormous investments are still necessary to establish an effective system covering the areas from blood donation to transfusion. Our aim was to evaluate membrane vibration dependence on hemolysis, and to provide verification data for developing a device.

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2. Results and Discussion

The blood is obtained from cattle (cows) having normal body temperature, no physical signs of disease, including diarrhea or rhinorrhea, and an acceptable range of hematological profiles. Before testing, the blood was examined to eliminate damaged samples. Mean free hemoglobin concentration before testing was 5.33±2.75 ㎎/dℓ, and the mean hematocrit was 28.1±3.0%. All of the blood were used within 6 hours of acquisition.

According to the established method in this laboratory, a mock circuit was assembled to measure hemolysis. Each circuit contained a pump, oxygenator, appropriate polyvinylchloride tubing, and connectors with stopcocks for blood sampling. The studies adhered to the recommended practice for assessment of hemolysis as described by the American Society of Testing and Materials (ASTM)[3]

The objective of this work was to investigate the effect of multiple mechanical forces in hemolysis by measuring O_2 transfer.

Figs 1, 2 show the NIHO in several modules. The NIHO obtained by the reduction of NIH when the module was connected to the test loop for NIH and when the module was disconnected from the test loop. It was indicated by two region in PZT actuator attached to each module, sinusoidal wave amplitude of DC 10 V with an excited frequency of 6 Hz(Fig. 1) and sinusoidal wave amplitude of DC 50 V with an excited frequency of 6 HZ (Fig. 2). It seemed that the NIHO value increased in accordance with the increments of flow rate and DC voltage.

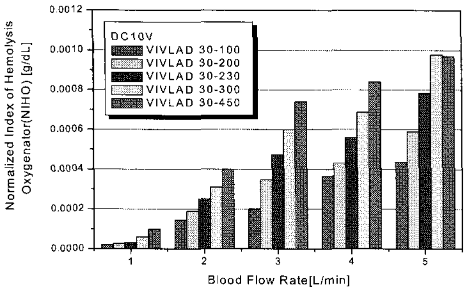

Fig. 1 The graph contrasts the results of hemolysis tests at excited DC 10V, 6Hz (NIHO : normalized index of hemolysis oxygenator).

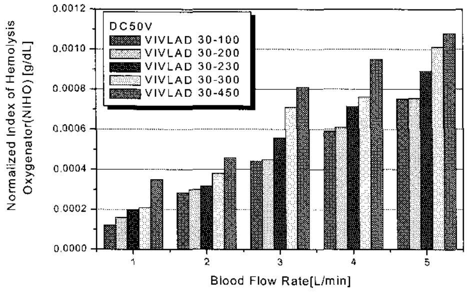

Fig. 2 The graph contrasts the results of hemolysis tests at exited DC 50V, 6Hz (NIHO : normalized index of hemolysis oxygenator).

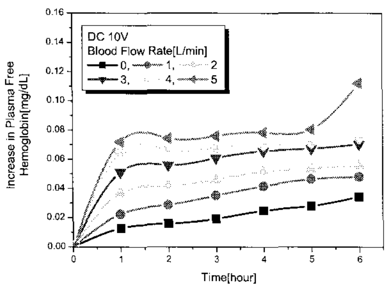

Fig. 3 The graph reveals an variety in plasma free hemoglobin as various blood flow rates with the passage of time at excited DC 10V, 6Hz.

Fig. 3 shows the change in the plasma free hemoglobin with each PZT actuator activated with a sinusoidal wave amplitude of DC 10 V. The change in plasma free hemoglobin was 0.112 g/dL after 6 hours with sinusoidal wave amplitude of DC 10 V and excited frequency of 6 Hz at the blood flow rate of 5 L/min in module VIVLAD 30-450. In this study, PZT materials were used as an exciting system to improve efficiency of O_2 transfer and blood compatibility of the new intravenous lung assist device.

Due to the instability of the exciting system which uses an electromagnetic force , it is required to have stable actuator in the magnetism circuit. Further work need to study the hemodynamic effects of the implantable device on cardiopulmonary circulation, the evaluation of fiber surface coatings to prevent plasma leakage and device failure, and the application of input voltage up to 100V can be dangerous and complicated for animal tests or clinical experiments.

3. Conclusion

A new intravenous lung assist device in this study demonstrated level of gas exchange performance with acceptable blood compatibility, implying the potential application as an implantable lung assist device for patients with lung disease.

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