VERIFICATION OF THE EFFECT OF PULSATILE FLOW FROM A BLOOD PUMP ON THROMBUS FORMATION IN A MEMBRANE OXYGENATOR

Tatsuki Fujiwara (1), Hironobu Sakurai (1), Wataru Hijikata (2), Daiki Toda (2), Hiro Kato (2), Katsuhiro Ohuchi (3), Orolzod Bumerdene (1), Tomoyuki Fujita (1)

1. Department of Cardiovascular Surgery, Tokyo Medical and Dental University (TMDU), Japan
2. Department of Mechanical Engineering, Tokyo Institute of Technology, Japan
3. Department of Clinical Engineering, Faculty of Medical Science, Juntendo University, Japan

Introduction

Thrombus formation in the ECMO circuit can cause embolism and impaired gas exchange in the oxygenator. Anticoagulant for the prevention of thrombus formation in the circuits carry the risk of bleeding complications. We have studied the effect of controlling the driving conditions of centrifugal blood pumps to inhibit thrombus formation in the circuit. In this study, we modified a commercially available centrifugal pump control device and verified the effect of the generated pulsatile flow on thrombus formation in the oxygenator in acute animal experiments.

Methods

Eight pigs were used in this study. One pig was fitted with two venous–arterial ECMO circuits (one by jugular vein and carotid artery, one by femoral vein and artery) under general anesthesia, and the thrombi formed in each oxygenator were compared [1]. The MERA HCF-MP23H was used as the centrifugal pump and the MERA NHP Excelung NSH-R as the oxygenator (SENKO Medical Instrument Mfg. Co., Ltd., Tokyo, Japan). To create a pulsatile flow, a motor speed control system was installed in the driver of the centrifugal pump. The driving conditions for each circuit were set to steady and pulsatile flow, and the average flow rate was matched at 2 L / min. Under the pulsating flow conditions, the pump speed was controlled so that the pattern was a steady flow plus a half-wave rectified waveform (sinusoidal waveform with the negative portion set to zero). Heparin was administered only during cannulation, and protamine was administered when the circulation stabilized, and no anticoagulants were used during extracorporeal circulation. Thrombus formation in the oxygenator was assessed using indocyanine green (ICG) fluorescence imaging every hour, with constant observation by the naked eye during circulation [2]. After the circulation was stopped, the blood was replaced with saline solution for observation, and the oxygenator was cut to observe internal thrombus formation.

Results

Intraoperative sacking occurred in two of the eight cases, so the final evaluation could not be performed in these cases. In 6 cases, pulsatile flow could be created by controlling the centrifugal pump speed in a stable manner. In the thrombus evaluation after cessation of circulation, there was a tendency for less thrombus formation in the pulsatile flow circuit than in the steady flow circuit in all six pigs.

Figure and Tables

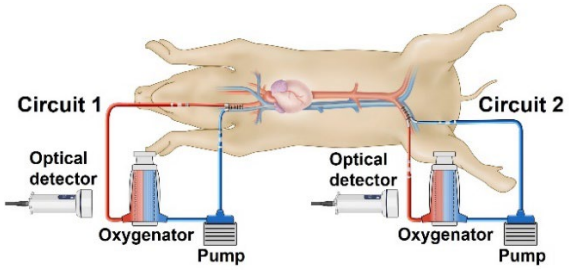

Figure 1: Two venous–arterial ECMO circuits were installed in the cervical and femoral regions of the same animal. The oxygenators are observed with both the naked eye and Indocyanine green (ICG) fluorescence imaging during circulation

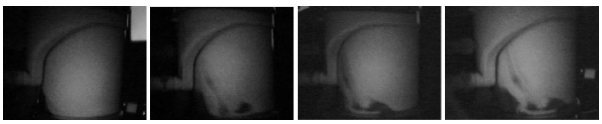

Figure 2: ICG fluorescence imaging shows changes in thrombi formation within the oxygenators

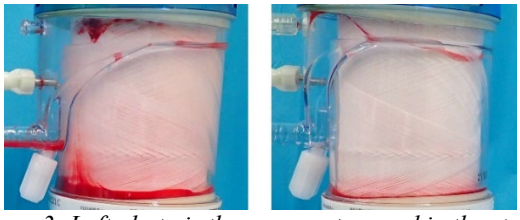

Figure 3: Left photo is the oxygenator used in the steady flow conditions. Right photo is the oxygenator used in the pulsatile flow conditions

Discussion

This technology improves the anti-thrombogenicity of ECMO circuits by controlling pump speed and creating pulsatile flow. We believe that the originality of this technology is that it can be introduced into existing commercially available ECMO devices without new product development.

References

1. Sakurai H et al, Artif Organs, 47:77-87, 2023
2. Sakurai H et al, Artif Organs, 45:1173-1182, 2021