

【論文】

ローラポンプの繰り返し負荷による流路形状変化が 血流特性に及ぼす影響の検討

Evaluation of the Effects of the Changes in Flow Channel Deformation by Cyclic Loading on Blood Flow Characteristics in a Roller Pump Model

深谷碧(学生会員), 白石泰之(正会員)*, 山田昭博(非会員)*, 佐原玄太(非会員),

井上雄介(正会員)**, 山家智之(非会員)*

Aoi Fukaya, Yasuyuki Shiraishi*, Akihiro Yamada*, Genta Sahara, Yusuke Inoue** and Tomoyuki Yambe*

Abstract

Roller pumps are widely used as one of the cardiopulmonary bypasses during open-heart surgery. Hemolysis may cause acute kidney injury due to the changes in the tubing gap by the occlusion of roller pumps. In this study, we achieved the 3-D evaluation of the roller pump tubing gap for the first time by our originally developed visualization analysis. We examined the leak rate and the hemolysis under the 240-min circulatory support condition in a mock flow tester, and compared the tubing gap dimensions. As a result, the primary leak rate around 0.8 mL/min against 1 mH₂O afterload significantly decreased after 60-min circulation, and there was no leak rate detected for 10 minutes measurement afterwards. The 3-D tubing gaps indicated that the subsidiary opening width at the short-axis edge decreased by more flattening shapes. Moreover, plasma free hemoglobin levels showed a remarkable increase at 60-min after the pump start, although there was no discernible difference in the incremental ratio of hemolysis following 240-min support. Therefore, our findings suggest that the leak rate and hemolysis are to be considered by the primary occlusion settings as well as the time-varying gap deformation for longer use of roller pumps.

Key words

Cardiopulmonary bypass, Roller pump, Degree of occlusion, Hemolysis

1. はじめに

人工心肺装置を用いた心臓手術は年間 44,000 件以上実施されており、約 45%の施設は手術中の全身血液循環維持にローラポンプを使用する¹⁾。また、術野における出血の回収には2~3台

のローラポンプを用いる。人工心肺装置の準備時にはローラポンプのオクルージョンノブにてチューブの圧閉度を調整する。この圧閉度は血液損傷と深く関係し、過度圧閉や不完全圧閉はともに溶血を助長する²⁾。溶血時には、遊離ヘモグロビンが尿中に排泄

2020年12月16日 受付

2021年2月24日 掲載決定

東北大学大学院医工学研究科

〒980-8575 宮城県仙台市青葉区星陵町4-1

*東北大学加齢医学研究所

〒980-8575 宮城県仙台市青葉区星陵町4-1

**旭川医科大学先進医工学研究センター

〒078-8510 北海道旭川市緑が丘東2条1-1-1

Graduate School of Biomedical Engineering, Tohoku University, Seiryomachi 4-1, Aoba-ku Sendai, Miyagi, 980-8575, Japan

* Institute of Development, Aging and Cancer, Tohoku University, Seiryomachi 4-1, Aoba-ku Sendai, Miyagi, 980-8575, Japan

**Advanced Medical Engineering Research Center, Asahikawa Medical University, 1-1-1 Midorigaoka Higashi 2-jo, Asahikawa, Hokkaido, 078-8510, Japan