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Continuous Ultrasonic Transit-Time Blood Flow and Arterial Blood Pressure Monitoring in Freely Moving Sprague-Dawley Rats via Implantable Telemetry

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BACKGROUND: Simultaneous blood flow and pressure measurements provide a more comprehensive hemodynamic assessment in cardiovascular studies. However, current cardiac output (CO) measurements, by flow probes or imaging, require either anesthesia or a tethered setup, which result in limitations due to anesthesia effects and/or monitoring time.

OBJECTIVE: The objective of this study was to use an implantable telemetry device (EndoGear (EG), Transonic Systems Inc., Ithaca, NY) to measure continuous CO (real-time ascending aortic blood flow), and mean arterial pressure (MAP) in conscious, freely moving rats and to verify the ability of the system to capture well-known circadian oscillations in major cardiovascular parameters.

METHODS: All procedures were approved by the Institutional Animal Care and Use Committee of Wayne State University and complied with the NIH Guide for the Care and Use of Laboratory Animals. Male Sprague-Dawley rats were implanted with EG transmitters to continuously monitor CO, MAP, temperature, and activity for 5 weeks. An ultrasonic transit-time flow probe was placed around the ascending aorta via a right lateral thoracotomy (4^{th} intercostal space). The pressure catheter was inserted into the iliac artery and advanced (approximately 2.5 cm) into the abdominal aorta, while the transmitter was implanted intraperitoneally via a midline laparotomy approach. The inductive power receiver associated with the implant was positioned in an abdominal subcutaneous pocket. After surgery, rats received thermal support, prophylactic analgesics, and antibiotics, as well as fluid supplementation. Body weight, food and fluid intake were monitored daily for the first 10 days and then bi-weekly until the end of the study. Animal checks and necessary handling were conducted at specific times to minimize circadian disturbances.

RESULTS: Changes in MAP, heart rate (HR, captured from pressure and flow traces), CO, stoke volume (SV, calculated as CO/HR), and temperature revealed, as expected, a clear circadian pattern characterized by lower values during the light phase. MAP decreased by ~5%, from 96.9 ± 0.15 to 92.1 ± 0.19 mmHg ($p<0.05$). HR decreased by ~10%, from 369 ± 3 to 329 ± 6 bpm ($p<0.05$). CO decreased by ~14%, from 91.6 ± 1.79 to 78.4 ± 1.89 ml/min ($p<0.05$). SV decreased by ~7%, from 245 ± 3.5 to 238 ± 1.4 µl ($p<0.05$). The decreases in temperature and activity during the light phase were subtle yet significant.

CONCLUSIONS: The telemetry device was able to effectively measure continuous changes in CO and MAP. Preservation of the circadian rhythm indicates favorable post-operative outcome after extensive surgery and complex chronic implantation in rats.

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