PRZECIWPŁYTKOWY EFEKT DZIAŁANIA DONORÓW NITROKSYLU (HNO) W MODELU PRZYZYCIOWEJ ZAKRZEPICY U MYSZY

ANTIPLATELET EFFECT OF NITROXYL (HNO) DONORS IN INTRAVITAL IN A MODEL OF REAL-TIME INTRAVITAL THROMBOSIS IN MICE

KAROL KRAMKOWSKI[1] | TOMASZ PRZYGODZKI[2] | WERONIKA ZARĘBA[1] | JOANNA KIRMUĆ[1] | KLAUDIA SIKORSKA[1] | URSZULA POWIERZA[1] | PAWEŁ OSIENNIK[1] | MARTA IWANICKA[1] | KAROLINA SZYSZKA[1] | ELZBIETA BOŁTROMIUK[1] | TOMASZ MISZTAL[1] | TOMASZ RUSAK[1] | CEZARY WATALA[2] | JAKUB PIETA[3] | ADAM SIKORA[4]

1 Department of Physical Chemistry, Medical Universtiy of Bialystok
2 Department of Haemostasis and Haemostatic Disorders, Medical University of Lodz
3 Interdepartmental Institute of Radiation Technology, Lodz University of Technology
4 Interdepartmental Institute of Radiation Technology, Lodz University of Technology

Background HNO (nitroxyl, azanone) is gaseous endogenic moiety reported to possess cardiovascular and antiplatelet effects. Most of HNO donors are water insoluble or show clinically unacceptable kinetics of HNO release. We have synthetized new, water-soluble donors of HNO based on Piloty`s Acid (PA) moiety para-substituted with carboxyl group (for water solubility) and with Br- or methyl--ortho-substituents (regulating HNO release, pH=7.4, 37?C) with T1/2 of 2.1 or 42.0minutes, respectively.

The aim of study to show antiplatelet activity of newly-synthetized HNO donors: 2-Br-4-COOH-PA (Br-PA) and 2-methyl-4-COOH-PA (CH3-PA) under in vivo conditions in various time points after intravenous administration in doses of 30lmol/kg each. Inactivated Br-PA or CH3-PA or vehicle (Phosphate Buffered 0,9% Saline, PBS, 2 ml/kg) were used as control.

Methods Laser-induced thrombosis with real-time fluorescent visualization in mesenteric vein of anesthetized Green Fluorescent Protein (GFP) mice (C57BL6--based) were used. Accumulation of GFP platelets represented thrombus volume/area. Additionally, in Br-PA experiment, AnnexinV/Alexa647 (2lg/g, intravenously) was injected to visualize platelet-exposed phosphatidylserine. Thrombus area and/or annexin fluorescence intensity were quantified with ImageJ software. Thrombi area plotted against time were used to calculate area under the curve (AUC).

Results Both of tested substances decreased platelet accumulation and platelet accumulation/activation in area of thrombotic laser-induced injury versus VEH or inactivated Br-PA or CH3-PA in accordance to kinetics of HNO release (Table1). The effect of short-lasting moiety was more pronounced after 15/35minutes, while the effects of long-lasting donor were developed 50/65minutes after administration.

Conclusion For the first time we have shown intravitally antiplatelet and antithrombotic effect of water-soluble PA-based HNO donors. It involves decrease in

thrombus volume/area and inhibition of platelet phosphatidylserine expression in the area of thrombosis. The experiment shows that water-soluble HNO donors are promising precursors for pharmacological platelet inhibition.

Research founded by Polish National Science Centre grant OPUS 2021/43/B/NZ7/01903 and Medical University of Bialystok grants

B.SUB.23.359 and B.SUB.24.305 and B.SUB.25.300.

Table 1. Antiplatelet effects of 2-F-4-COOH-PA (F-PA) and 2-Br-4-COOH-PA (Br-PA) t-Student's or Mann--Whitney (when data deviated from normal distribution) tests were used to evaluate the significance of differences between tested substances and vehicle. Data are presented as mean±SEM; α=5%; *$p<0.05$; **$p<0.01$ after 15 or 65 minutes, respectively, n=6-12. AUC, area under the curve.

Time after iv administration (min.)	Thrombus volume/area AUC (Green fluorescence, megapixels in region of interest)	Platelet activation AUC (red fluorescence, intensity of flurescence, arbitrary units)
VEH (PBS, 2 ml/kg)		
15th minutes	18.44±2.27	10.66±1.09
65th minutes	17.99±3.1	No data
Br-PA, 30 μmol/kg		
5th minutes	12.95±1.94	5.84±1.71
35th minutes	8.14±2.23**	4.98±2.15**
50th minutes	9.19±2.39*	6.13±1.88*
65th minutes	9.54±1.05**	8.91±1.24**
Inactivated Br-PA, 30 μmol/kg		
5th minute	18.34±2.79	13.06±2.12
15th minute	15.42±3.98*	10.65±1.52*
35th minute	13.53±4.28*	9.19±1.8*
65th minute	12.91±1.91*	10.13±1.35*
Inactivated CH3-PA, 30 μmol/kg		
65th minute	16.10±4.41	No data

KOSZT ENERGETYCZNY WZROSTU ŚREDNIEGO CIŚNIENIA TĘTNICZEGO PODCZAS ĆWICZEŃ STATYCZNYCH MOŻE ZALEŻEĆ OD SPOSOBU, W JAKI CIŚNIENIE TO WZRASTA

THE ENERGY COST OF INCREASING MEAN ARTERIAL PRESSURE DURING STATIC EXERCISE MAY DEPEND ON THE WAY IN WHICH THIS PRESSURE INCREASES

WIKTOR NIEWIADOMSKI[1] | ANNA GĄSIOROWSKA-BIEŃ[1] | ANNA STĘPNIEWSKA[1] | GRAŻYNA NIEWIADOMSKA[1] | MAREK ŻYLIŃSKI[2, 3] | GERARD CYBULSKI[3]

1 Mossakowski Medical Research Institute, Polish Academy of Sciences
2 Department of Electrical and Electronic Engineering, Imperial College London, South Kensington Campus
3 Institute of Metrology and Biomedical Engineering, Faculty of Mechatronics, Warsaw University of Technology

Mean arterial pressure (MAP) depends on cardiac output (CO) and total peripheral resistance (TPR) according to the formula MAP = CO x TPR; CO is a product of heart rate (HR) and stroke volume (SV), i.e. CO = HR x SV. Mechanical energy (E) dissipated by resistance vessels is given by the formula E = MAP x CO = HR2 x SV2 x TPR. MAP changes in proportion to changes in HR, SV and TPR, while E changes more with changes in HR and SV than with changes in TPR.

Thus, the same increase in MAP can cause different increases in E depending on how HR, SV and TPR change. During static handgrip, we observed that in some subjects the increase in MAP was achieved by a reduction in CO due to a decrease in SV and a simultaneous increase in TPR, causing a smaller increase in E than in MAP, whereas in others the reverse was true and E increased more than MAP. The relationship between total mechanical work of the heart and E is complex, E being the lowest estimate of this work, i.e. true work of the heart must always be greater than E. Minimising E may be important in subjects in whom handgrip elicits a marked increase in MAP and in those with weak heart muscle.

AZANON (NITROXYL, HNO) WYKAZUJE DZIAŁANIE PRZECIWZAKRZEPOWE W SZCZURZYM MODELU ZAKRZEPICY TĘTNICZEJ

AZANONE (NITROXYL, HNO) EXERTS ANTITHROMBOTIC EFFECTS IN RAT MODEL OF ARTERIAL THROMBOSIS

WERONIKA ZARĘBA[1] | JOANNA KIRMUĆ[1] | KLAUDIA SIKORSKA[1] | URSZULA POWIERZA[1] | PAWEŁ OSIENNIK[1] | MARTA IWANICKA[1] | KAROLINA SZYSZKA[1] | ELŻBIETA BOŁTROMIUK[1] | TOMASZ MISZTAL[1] | TOMASZ RUSAK[1] | JAKUB PIĘTA[2] | ADAM SIKORA[2] | KAROL KRAMKOWSKI[3]

1 Zakład Chemii Fizycznej, Uniwersytet Medyczny w Białymstoku
2 Międzyresortowy Instytut Techniki Radiacyjnej, Politechnika Łódzka
3 Department of Physical Chemistry, Medical Universtiy of Bialystok

Background Cardiovascular diseases, including thromboembolism, account for the highest percentage of deaths worldwide. Therefore, the search for new, more effective antiplatelet drugs is essential. New HNO-releasing derivatives of Piloty's acid show beneficial effects on the circulatory system and may be a therapeutic option for thrombotic complications of various civilization diseases.The aim of this study was to evaluate the antithrombotic properties of novel water-soluble HNO donors. These are Piloty's acid derivatives ortho-substituted by fluorine or bromine atoms and para-substituted by a carboxyl group (to improve their water solubility): 2-F-4-COOH-PA (F-PA) and 2-Br-4-COOH-PA (Br-PA). These donors release HNO in aqueous solutions at pH=7.4 and 37°C, with T1/2=33.0 or 2.1min, respectively. **Methods** We used method of electrically-induced thrombosis in Wistar rat carotid artery with ex vivo evaluation of collagen-induced platelet aggregation in whole blood (impedance method). Classical coaguology parameters (PT, aPTT, TT, Fibrinogen level) and blood cell count were also evaluated. F-PA, Br-PA (1, 3, 10, 30 ľmol/kg), acetylsalicylic acid (ASA, 150mg/kg), sodium nitrite (15 ľmol/kg, an inorganic NO donor) and PBS buffer (VEH, 2ml/kg) were administered iv 10min before the stimulation (1mA, 10min). After 50min of thrombosis progression clot was extracted and weighed after 24 hours. Results: F-PA and Br-PA decreased arterial thrombus weight in a dose-dependent manner and in some groups decreased aggregation. Antithrombotic effect is of similar potency to ASA and nitrite (Table 1). No statistically significant changes were observed in blood cell count and coaguology parameters.In conclusion, for the first time we have shown antithrombotic effect of water soluble Piloty`s acid-based HNO donors. It involves platelet inhibition, but not blood coagulation cascade inhibition. Further research into other such derivatives and their mechanisms of action is fully warranted to create advances in area of drug candidates for thromboembolism treatment.

Research founded by Polish National Science Centre grant 2021/43/B/NZ7/01903.

Table 2. Antithrombotic and antiplatelet effects
*t-Student's or Mann–Whitney (when no normal distribution) tests were used to evaluate the significance of differences between tested substances and vehicle. Data are presented as mean±SEM; *p<0.01 vs VEH; n=7–12.

	Arterial thrombus weight (mg)	Whole blood platelet aggregation amplitude at the time of aggregation curve (% of control)
VEH	0.93±0.05	100±1.1
ASA 150 mg/kg	0.67±0.11**	31.6±3.2**
Sodium nitrite 15 µmol/kg	0.68±0.09	–
F-PA 1 µmol/kg	0.43±0.09**	2.1±0.9**
F-PA 3 µmol/kg	0.73±0.05**	–
F-PA 10 µmol/kg	0.75±0.07**	4.7±1.1**
Br-PA 1 µmol/kg	0.79±0.09	30.7±3.6
Br-PA 3 µmol/kg	0.63±0.07**	2.1±0.7**
Br-PA 10 µmol/kg	–	–

MECHANIZM WZROSTU CIŚNIENIA TĘTNICZEGO KRWI PODCZAS WYSIŁKU: OD INAKTYWACJI BARORECEPTORÓW DO AKTYWNIE UTRZYMYWANEGO POZIOMU NASTAWCZEGO

MECHANISM OF ARTERIAL PRESSURE RISE DURING EXERCISE: FROM BAROREFLEX INACTIVATION TO ACTIVELY MAINTAINED SET LEVEL

WIKTOR NIEWIADOMSKI[1] | ANNA GĄSIOROWSKA-BIEŃ[1] | ANNA STĘPNIEWSKA[1] | MAREK ŻYLIŃSKI[2, 3] | GERARD CYBULSKI[3] | GRAŻYNA NIEWIADOMSKA[1]

1 Mossakowski Medical Research Institute, Polish Academy of Sciences
2 Department of Electrical and Electronic Engineering, Imperial College London,
3 Institute of Metrology and Biomedical Engineering, Faculty of Mechatronics, Warsaw University of Technology

The baroreflex tries to maintain arterial pressure at a constant level by continuously regulating the activity of the autonomic nervous system. However, during exercise, arterial pressure increases. Since, by definition, the baroreflex would not allow such an increase, it has been hypothesised that the baroreflex is switched off during exercise. However, as it has been experimentally demonstrated that the baroreflex remains intact during exercise, the concept of baroreflex resetting has gradually been adopted. It was also shown that the occurrence of two phenomena during exercise: central command and exercise pressor reflex, is essential to alter autonomic activity resulting in an increase in arterial pressure. It has been suggested that the intensity of the autonomic response determines the magnitude of the increase in arterial pressure. This view is incompatible with the concept of baroreflex resetting. Two phenomena observed during static exercise: replacement and correction, i.e. when one mode of autonomic activity can replace or oppose the other, support the crucial role of baroreceptor resetting as the cause of the increase in arterial pressure during exercise.

PRZECIWPŁYTKOWE DZIAŁANIE NOWYCH NOWYCH DONORÓW HNO - BADANIA *IN VITRO* NA KRWI WIEPRZOWEJ

ANTIPLATELET EFFECTS OF NEW HNO DONORS - AN IN VITRO STUDY ON PORCINE BLOOD.

KLAUDIA SIKORSKA[1] | WERONIKA ZARĘBA[1] | JOANNA KIRMUĆ[1] | URSZULA POWIERZA[1] | PAWEŁ OSIENNIK[1] | MARTA IWANICKA[1] | KAROLINA SZYSZKA[1] | ELŻBIETA BOŁTROMIUK[1] | TOMASZ MISZTAL[1] | TOMASZ RUSAK[1] | JAKUB PIĘTA[2] | ADAM SIKORA[2] | KAROL KRAMKOWSKI[3]

1 Zakład Chemii Fizycznej, Uniwersytet Medyczny w Białymstoku
2 Międzyresortowy Instytut Techniki Radiacyjnej, Politechnika Łódzka
3 Department of Physical Chemistry, Medical Universtiy of Bialystok

Background HNO is mostly known for its beneficial cardiovascular properties. Moreover it is reported to exert in vivo antithrombotic effects which are suggested to be platelet dependent (Smulik-Izydorczyk, 2019).

The aim of the study was to evaluate the in vitro antiplatelet effects of a HNO donor (DMSO-soluble 2-bromo-N-hydroxybenzenesulfonamide, 2-Br-Piloty`s Acid, 2-Br-PA) compared to acetylsalicylic acid (ASA), noted antiplatelet drug.

Methods We employed combined methods of simultaneous measurement of collagen-stimulated (3.75 ľg/ml) platelet aggregation and ATP-secretion labelled with luciferase (50 ľl/ml) from platelet dense granules in the same sample of porcine platelet rich plasma (PRP) using Chrono-log lumi-aggregometer. **Results** 2-Br-PA at concentrations of 0.3 μM, 1 μM, 3 μM, 10 μM, 30 μM and 100 μM, respectively, decreased platelet aggregation into 50.15+-1.80; 40,31+-2,95***; 39.15+-3.18***; 34.54+-1.55***; 25.77+-1.97***; 9.39+-1,56*** vs VEH (100 ľM DMSO, 54.62+-2.19) [% of max. response] and, simultaneously, decreased platelet ATP secretion into 1.10+-0.12*; 0.65+-0.16***; 0.61+-0.12***; 0.54+-0.16***; 0.35+-0.09***; 0.14+-0.04*** vs VEH=1.69+-0.11 [nmol].In the same experiment, ASA decreased aggregation into 47.60+-9,47; 41.00+-9.69; 38.40+-9.55; 28.44+-6.67*; 9.90+-1.68*** vs VEH (0.9%NaCl, 52.67+-6,45) [% of max. response] and decreased platelet ATP secretion into 1.15+-0.25; 0.72+-0.19**;

0.67+-0.19***; 0.50+-0.18***; 0.32+-0,12*** vs VEH=1.69+-0.17 [nmol]. t-Student`s test was used, data are shown as Mean+-SEM, *p<0.05, **p<0.01, ***p<0.001 vs VEH, n=12.

Conclusion In our hands, both, 2-Br-PA and ASA inhibit platelet aggregation and secretion in PRP in vitro in concentration-dependent manner. Moreover, the inhibitory effect of 2-Br-PA was observed at concentrations lower than ASA, which may suggest a stronger antiplatelet effect of 2-Br-PA compared to ASA.

Research founded by Polish National Science Centre grant OPUS 2021/43/B/NZ7/01903.

WPŁYW PUNKTÓW ZMIAN W MUZYCE NA FIZJOLOGIĘ CZŁOWIEKA: W KIERUNKU SPERSONALIZOWANYCH INTERWENCJI MUZYCZNYCH W KARDIOLOGII

MUSIC-PHYSIOLOGY ASSOCIATIONS VIA CHANGE POINT CONNECTIVITY GRAPHS: TOWARDS PERSONALISED MUSIC INTERVENTIONS IN CARDIOLOGY

MATEUSZ SOLIŃSKI[1] | VANESSA POPE[1] | PIER LAMBIASE[2] | ELAINE CHEW[1]

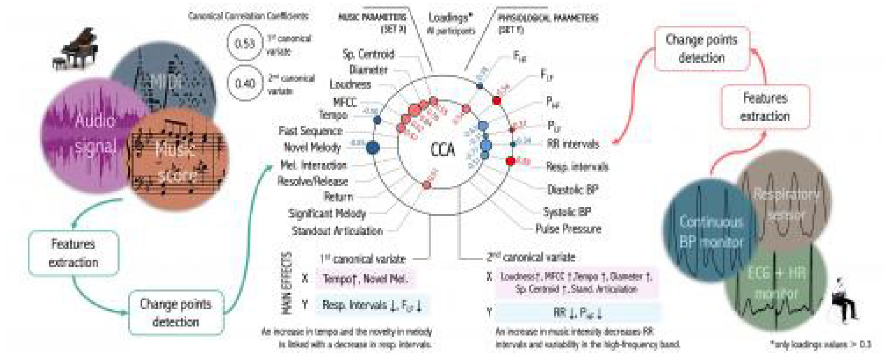
1 Department of Engineering and School of Biomedical Engineering & Imaging Sciences King`s College London
2 Barts Heart Centre, Barts Health NHS Trust

Identifying how the body responds to changes in music is key to understanding how expressive structures influence physiology. Neurological studies have investigated the brain's role in processing acoustic boundaries, yet little is known about peripheral physiological responses. This gap limits the use of music-based interventions in cardiovascular therapies. Our study links changes in expressive music features with physiological signals to examine physiological responses to music.

Musical and physiological data were collected from 80 listeners during a 5-minute baseline and while listening to a playlist of 9 classical pieces (approx. 40 min). A total of 984 musical change points were identified, either automatically from acoustic signals (derived from audio and MIDI recordings) or manually annotated by two experts. Using canonical correlation analysis, musical change points were linked with physiological change points detected in time series extracted from ECG (RR intervals and spectral HRV parameters), continuous BP signals, and respiratory intervals. The links were visualised by change point connectivity graphs specifically developed for this study.

The results show distinctive music-physiology association patterns in cardio-respiratory signals. In the general population, the first two canonical variates were selected for the analysis with canonical correlation coefficients 0.53 and 0.40. The most prominent associations, related to the highest loadings values, were observed between respiratory intervals and both Novel Melody and tempo changes (first variate) and between acoustic parameters (i.a. loudness and MFCC) and RR intervals and HRV power spectrum in a high-frequency band (second variate). In subgroup analysis, baseline autonomic nervous system activity is found to be a main determinant of music-physiology association patterns, showing that physiological starting points play a key role in determining response to expressive music structures. Other distinguishing factors include raised blood pressure (>140/90 mmHg) and musicianship level.

Change point connectivity graphs enable the selection of music structures for targeted physiological effects. They also highlight the role of baseline autonomic profiles in shaping music-physiology associations. This research lays the groundwork for creating personalised music interventions for cardiovascular theranostics, integrating therapeutic and diagnostic approaches in cardiology.



Canonical Correlation Coefficients
0.53
0.40
MUSIC PARAMETERS (SET X)
Loadings*
All participants
PHYSIOLOGICAL PARAMETERS (SET Y)
MIDI
Audio signal
Music score
Sp. Centroid
Diameter
Loudness
MFCC
Tempo
Fast Sequence
Novel Melody
Mel. Interaction
Resolve/Release
Return
Significant Melody
Standout Articulation
CCA
RR intervals
Resp. intervals
Diastolic BP
Systolic BP
Pulse Pressure
Change points detection
Features extraction
Continuous BP monitor
Respiratory sensor
ECG + HR monitor
MAIN EFFECTS
X
Y
Tempo↑, Novel Mel.
2nd canonical variate
RR ↓
An increase in tempo and the novelty in melody is linked with a decrease in resp. intervals.
An increase in music intensity decreases RR intervals and variability in the high-frequency band.
*only loadings values > 0.3

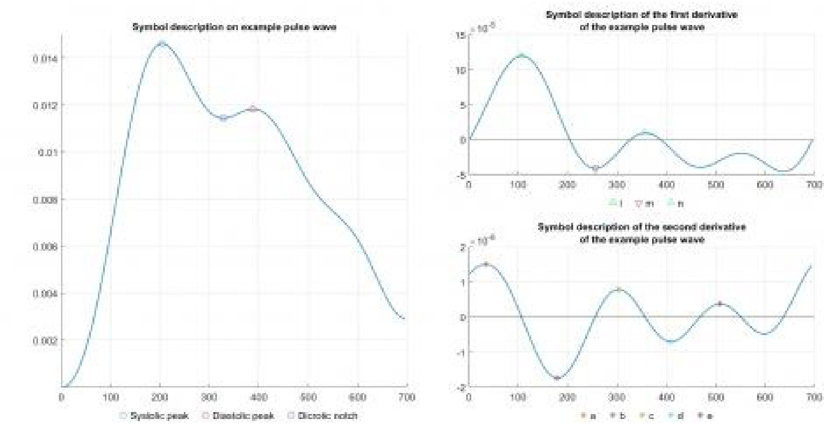
ZMIANY PODOKRESÓW SKURCZU PODCZAS TESTU POCHYLENIOWEGO U MŁODYCH KOBIET

SYSTOLIC TIME INTERVALS MODIFICATIONS DURING TILT TEST IN YOUNG WOMEN

MILENA CHOŁUJ[1] | BARTOSZ ŚMIGIELSKI[1] | GERARD CYBULSKI[2]

1 Politechnika Warszawska
2 Institute of Metrology and Biomedical Engineering, Faculty of Mechatronics, Warsaw University of Technology

Changes in body position affect the circulatory system, which can be monitored using non-invasive impedance cardiography (ICG) combined with simultaneous ECG measurement. The aim of this study was to identify new systolic time intervals that change during postural transition. The study involved five young women (23-26 yrs), in whom measurements were taken in both supine and tilted (60o) positions. Two systolic time intervals, pre-ejection period (PEP) and left ventricular ejection time (LVET) were analysed. Additionally, two periods, describing the electromechanical coupling and its compliment/adjunction to whole cardiac cycle, were introduced. They describe the time between R and C (symbolized as RC) and C and next R (denoted as CR), where R is from QRS in ECG and C is a maximum of first derivative in ICG signal. Those parameters were automatically determined using the authors` own program. The preliminary results showed significant changes in all analysed parameters, suggesting their potential usefulness in the diagnosis of hemodynamic regulation.



SPEKTROSKOPIA DIELEKTRYCZNA KLATKI PIERSIOWEJ

DIELECTRIC SPECTROSCOPY FOR THORACIC TISSUE ANALYSIS

MACIEJ ŚLOT[1] | KAMILA SAMOLEJ[1, 2]

1 WFIS, Uniwersytet Łódzki
2 Klinika Kardiologii i Wad Wrodzonych Dorosłych ICZMP

Spektroskopia dielektryczna to metoda pomiarowa polegająca na analizie transmisji oraz odbicia sygnału mikrofalowego od badanego obiektu. Pozwala ona na bezinwazyjną i szybką (w ułamku sekundy) estymację parametrów dielektrycznych próbki. Dotychczas znalazła zastosowanie w wielu obszarach inżynierskich – od budownictwa (m.in. pomiar wilgotności ścian) po rolnictwo (np. kontrola świeżości owoców). Badanie przenikalności dielektrycznej płynu przesiękowego (konkurs grantowy Inkubator Innowacyjności 4.0) opracowano pierwszy prototyp czujnika kardiologicznego RuFuS (Radio Frequency Spectroscopy). Urządzenie, bazując na spektroskopii dielektrycznej, ma docelowo umożliwić ocenę ilości płynu gromadzącego się w pęcherzykach płucnych pacjentów z niewydolnością serca.

Zastój płucny pozostaje jedną z głównych przyczyn hospitalizacji w przypadkach niewyrównanej niewydolności serca. Polega on na gromadzeniu się płynu przesiękowego w pęcherzykach płucnych, co zaburza wymianę gazową. Aby opracować bardziej spersonalizowane terapie, konieczne jest stworzenie nowatorskich narzędzi diagnostycznych, pozwalających na efektywniejsze i precyzyjniejsze dawkowanie leków moczopędnych. Istnieją co prawda techniki służące do pomiaru ilości płynu w płucach (zarówno bezpośrednio, jak i pośrednio), jednak w codziennej praktyce brakuje szybkiego, niezawodnego i całkowicie nieinwazyjnego rozwiązania do pomiaru przesięku.

Pierwsze testy prototypu RuFuS wykazały, że u pacjentów z zastojem płucnym, potwierdzonym badaniem RTG, absorpcja promieniowania radiowego jest istotnie wyższa w porównaniu z grupą kontrolną. Urządzenie zostało objęte ochroną patentową (nr Pat. 24598, Urząd Patentowy RP), co otwiera drogę do dalszych prac rozwojowych i możliwego wdrożenia w praktyce klinicznej.

CZY POMIAR RYTMU SERCA MOŻE BYĆ STOSOWANY DO WYZNACZANIA PROGÓW MLECZANOWYCH?

CAN THE HEART RATE MEASUREMENT BE USED TO DETERMINE LACTATE THRESHOLDS?

IZABELA GHAFOUR[1] | MONIKA PETELCZYC[1]

Faculty of Physics, Warsaw University of Technology

Trzy Strefową klasyfikację intensywności wysiłku wprowadził A. Mader już w 1976 roku. Trzy strefy rozdzielane są przez progi mleczanowe: tlenowy i beztlenowy. Pierwszy reprezentuje przejście z procesów tlenowych metabolizmu glukozy (opisanych cyklem Krebsa) na metabolizm mieszany tlenowo-beztlenowy. Po drugim progu dominują procesy beztlenowe (opisane cyklem Corich).

Fizjologia sportu nie jest zgodna w definicji oraz sposobie wyznaczania progów mleczanowych. Najczęściej określane są one jako konkretna wartość stężenia mleczanów we krwi, standardowo 2 mmol/L i 4 mmol/L, wyznaczane w trakcie próby wysiłkowej o rosnącym obciążeniu. Te wartości progów zostały przyjęte dla wysiłku w formie biegu lub jazdy na rowerze. Alternatywnie, progi mleczanowe definiowane są także jako punkty zmiany krzywych kinetyki stężeń mleczanów. Niestety sam pomiar wiąże się z wielokrotnym poborem krwi z palca bądź płatka ucha, co wymaga przerwy w wysiłku i kadry laboratoryjnej.

Progi wyznaczane z rytmu serca są alternatywą dla inwazyjności i ograniczonej dostępności do profesjonalnych badań, a dodatkowo nie wymagają przerw w wysiłku. Z drugiej jednak strony brakuje ujednoliconej metodyki ich detekcji. Większość metod zaproponowanych w literaturze jest wrażliwa na czas trwania próby wysiłkowej, zazwyczaj wymagają również dodatkowego oprogramowania. Dlatego praktyczne wykorzystanie progów tętna jako wskaźników progów mleczanowych cieszy się umiarkowanym zainteresowaniem. Niniejsza praca jest poświęcona przeglądowi i ocenie stosowanych metod detekcji progów tętna. Porównanie z progami mleczanowymi wyznaczanymi z badań krwi zostało przeprowadzone na rejestracjach pochodzących z prób wysiłkowych przeprowadzonych u osób zdrowych i aktywnych fizycznie (47 badanych, miejsce badań - Instytut Nauk o Sporcie, Uniwersytet Rostocki, Niemcy).

REKONSTRUKCJA ZAŁAMKA T PRZY UŻYCIU ALGORYTMU PHYSECG

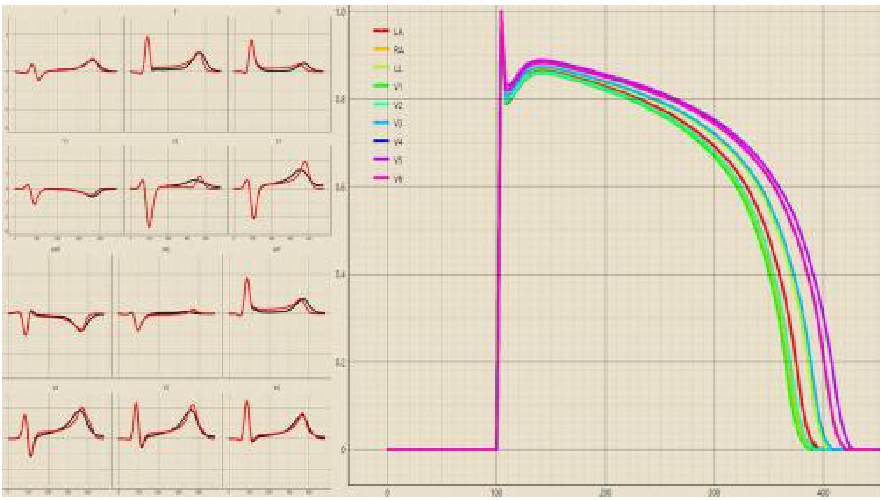
T WAVE RECONSTRUCTION USING PHYSECG ALGORITHM

SEBASTIAN WILDOWICZ[1] | TOMASZ GRADOWSKI[1] | IGOR OLCZAK[1] | TEODOR BUCHNER[1]

Wydział Fizyki, Politechnika Warszawska

The PhysECG method may be considered a reduced solution to the inverse problem of ECG imaging, which reconstructs the epicardial potentials and enables a good qualitative assessment of pathological changes. The foundations of the model are based on a molecular approach to biopotential propagation. It allows us to reformulate the assumptions of the computational procedure, which is fast and robust, with excellent convergence. During PhysECG research we presented a physically motivated projection of the 12 lead electrocardiogram based on a deep learning model that allows the separation between left and right ventricular activity. However, the model itself was limited to reconstructing only the QRS complex. Now we expand its possibilities to recreate the T wave.

Reconstruction of the QRS complexes views the heart activity as a composition of two distinct processes: the passage of the electric activation wavefront and the response of the cardiomyocyte. Assuming cardiomyocyte potential as theoretically given, we were able to recreate said activation wavefront potential seen by the electrodes. Using calculated activation functions, we move forward to recreate the T wave, where we assume that each electrode sees a different cardiomyocyte response. With this as an input, it is possible to reveal cardiomyocyte potential for each given electrode. Updated PhysECG algorithm allows in vitro tracking and monitoring of the heterogeneity of potential propagation. It is a window of opportunity to shorten and ease the diagnostic process in clinical applications. Further study will explore known disorders using the presented method to validate its usefulness in field conditions.



WPŁYW CZĘSTOŚCI ODDECHOWEJ NA NIEMIAROWOŚĆ ODDECHOWĄ

THE IMPACT OF RESPIRATORY RATE ON RESPIRATORY SINUS ARRHYTHMIA

MONIKA PETELCZYC[1] | JULIA POTOCKA[2]

1 Faculty of Physics, Warsaw University of Technology
2 Wydział Fizyki, Politechnika Warszawska

Niemiarowość oddechowa (Respiratory Sinus Arrhythmia, RSA) to fizjologiczna zmienność rytmu serca wynikająca z synchronizacji z cyklem oddechowym. Analiza tego zjawiska jest wykorzystywana w ocenie zdrowia układu krążeniowo-oddechowego oraz funkcjonowania autonomicznego układu nerwowego. RSA stanowi również cenny wskaźnik zdolności adaptacyjnych organizmu. Celem badań było opracowanie skutecznego protokołu eksperymentalnego oraz analiza działania wybranych metod oceny RSA na podstawie sygnałów EKG.

W ramach badań przeprowadzono pomiary EKG oraz równoczesną rejestrację oddechu na niewielkiej grupie osób różnych płci. Pomiary wykonywane były w warunkach oddechu kontrolowanego o różnych częstotliwościach (10, 15 i 20 oddechów/min) oraz oddechu swobodnego. Analizę przeprowadzono z wykorzystaniem metody BPRSA (Bivariate Phase-Rectified Signal Averaging) oraz tradycyjnej metody peak-to-valley, co umożliwiło ocenę wpływu częstości oddechu na skalę zjawiska RSA. Uzyskane wyniki wskazują, że najwyższe wartości RSA występowały dla częstości oddechowych zbliżonych do naturalnego rytmu oddychania, szczególniedla 10 oddechów/min, gdzie średnie wartości RSA wyniosły 27,1 +- 11,1 ms (BPRSA) oraz 78,9 +- 21,8 ms (peak-to-valley). Przy wyższych częstościach oddechu wartości RSA istotnie malały (dla 20 oddechów/min: 9,1 +- 5,9 ms i 37,2 +- 3,9 ms), co jest zgodne z wcześniejszymi badaniami wskazującymi na osłabienie wpływu oddychania na zmienność rytmu serca przy szybszym oddechu.

Zaobserwowano również znaczenie stylu życia dla wartości RSA - osoby aktywne fizycznie wykazywały istotnie wyższe wartości, natomiast u osób prowadzących siedzący tryb życia oraz palaczy były one znacząco niższe.

Uzyskane wyniki potwierdzają skuteczność metody BPRSA w analizie niemiarowości oddechowej oraz podkreślają kluczową rolę częstości oddechu w regulacji RSA. Sugerują także możliwość wykorzystania RSA jako wskaźnika kondycji autonomicznej i zdrowia układu krążeniowo-oddechowego.

CARDIOVASCULAR AUTONOMIC DYSREGULATION IN PARKINSON'S DISEASE IS RELATED TO THE ASSUMED ORIGIN OF PATHOLOGICAL PROCESS

CARDIOVASCULAR AUTONOMIC DYSREGULATION IN PARKINSON'S DISEASE IS RELATED TO THE ASSUMED ORIGIN OF PATHOLOGICAL PROCESS

MICHAL JAVORKA[1] | JANA CERNANOVA KROHOVA[1] | JANA OLEKSAKOVA[2] | BARBORA CZIPPELOVA[1] | MILAN GROFIK[2] | LUCIA BABALOVA[2] | EGON KURCA[2]

1 Dept of Physiology, Jessenius Faculty of Medicine, Comenius University
2 Biomedical Center Martin, Jessenius Faculty of Medicine in Martin, Comenius University in Bratislava

Parkinson`s disease (PD) is a chronic progressive neurodegenerative disease characterized by various motor and non-motor symptoms including those resulting from autonomic nervous system dysregulation. Stemming from the recently introduced concept of PD pathogenesis - SOC (alpha-Synuclein Origin site and Connectome) model, neurodegenerative process can originate not only in the brain (brain first subtype), but also in the peripheral nervous system (body first subtype). In accordance with the pathogenesis of the second subtype, autonomic dysregulation is expected to be more expressed there. This study aims to assess a relation between expected subtype of PD and severity of cardiovascular autonomic dysregulation in patients with very early stage of PD (< 6 months after first motor signs occurrence). It is expected that the results of this study could contribute to SOC model validation on the phenotype level.

We examined 19 patients with PD and 19 healthy controls. PD patients were classified into assumed brain first and body first subtypes based on the motor signs symmetry, presence of obstipation and olfactory impairment. We assessed a wide spectrum of measures reflecting various cardiovascular autonomic control characteristics (including cardiac chrono- and inotropic regulation, vasomotion and baroreflex function) for each phase of the examination protocol (supine rest, head-up tilt, supine recovery).

Only subtle differences between PD patients and control subjects were found. Comparison of PD patients subtypes revealed more prominent cardiovascular dysregulation in the body first PD subtype. It was reflected mostly in heart rate and blood pressure variability, in a decreased baroreflex sensitivity and in an impaired nighttime blood pressure dipping.

We conclude that it is possible to detect subtle initial subclinical cardiovascular autonomic dysregulation features even in early stages of PD applying complex analysis of autonomic regulation. This dysregulation is more prominent in the body first subtype of PD confirming the validity of SOC model of PD pathogenesis.

Supported by grant VEGA no. 1/0107/25.

PIERWSZY W POLSCE ZAPIS MAGNETOKARDIOGRAMU W WARUNKACH KLINICZNYCH

FIRST MAGNETOCARDIOGRAPHIC RECORDING IN A CLINICAL ENVIRONMENT IN POLAND

KAZIMIERZ PĘCZALSKI[1] | JUDYTA SOBIECH[2] | TEODOR BUCHNER[2] | MATEUSZ BROCZKOWSKI[3] | TOMASZ GDOWSKI[4] | DARIUSZ WOJCIECHOWSKI[5]

1 Politechnika Warszawska
2 Politechnika Warszawska Wydział Fizyki
3 Politechnika Warszawska Wydział Mechatroniki
4 Kliniczny Oddział Kardiologiczny Szpitala Wolskiego
5 Szpital Wolski im. dr Anny Gostyńskiej SPZOZ Oddział kardiologiczny

Magnetocardiographic (MCG) recordings are registrations of magnetic fields that result from the flow of ionic currents through the cardiac conductive system. Unlike electrocardiographic (ECG) records, they are true unipolar recordings whose amplitude is strictly dependent on the location of the signal source. In the 1980s, MKG recordings were obtained using cryogenic SQUID sensors in magnetically shielded rooms (MSRs). Due to the need for expensive equipment such as cryogenic sensors requiring liquid helium and expensive MSRs, despite the advantages of this method such as for instance the ability to record fetal heart activity, this method did not enter wider use. The introduction of atomic sensors using changes in the Larmor precession of atoms from the Lithium`s group such as Rubidium and Cesium under the influence of an alternating magnetic field allowed miniaturization of transducers, operation at room temperature and registration without MSRs in clinical conditions. The authors' team performed the first MKG assessment using an atomic spin exchange sensor (SERF) and MSR in 2014 and in 2024 the first recording also using SERF sensor in clinical conditions. This allows the use of MKG as a complementary method to ECG in the evaluation of fetal cardiac activity, precise localization of foci of myocardial ischemia and monitoring of cardiac activity in patients with body surface lesions, such as burns or scars, among other. Here we demonstrate the results of the measurement and discuss possible area of clinical application: medical cases, in which current diagnostic methods are insufficient.

INFORMATION-THEORETIC ANALYSIS OF RESPIRATORY SINUS ARRHYTHMIA IN EARLY-STAGE PARKINSON'S DISEASE

JANA CERNANOVA KROHOVA[1] | BARBORA CZIPPELOVA[1] | JANA OLEKSAKOVA[2] | ZUZANA TURIANIKOVA[1] | MILAN GROFIK[2] | LUCA FAES[3] | EGON KURCA[2] | MICHAL JAVORKA[1]

1 Department of Physiology and Biomedical Centre Martin (BioMed Martin), Jessenius Faculty of Medicine in Martin, Comenius University in Bratislava, Martin, Slovakia
2 Clinic of Neurology, Jessenius Faculty of Medicine in Martin, Comenius University in Bratislava, Martin, Slovakia
3 Department of Engineering, University of Palermo, Palermo, Italy

Respiratory sinus arrhythmia (RSA), a physiological variation in heart rate linked to respiration, is mediated by parasympathetic nerves. In Parkinson's disease (PD), although cardiovascular dysregulation is a well-recognized non-motor feature, previous studies have reported inconsistent findings regarding RSA magnitude. This study aims to reveal if more advanced information-theoretic methods, enabling to separately analyse baroreflex and non-baroreflex mechanisms of RSA, are more sensitive than traditionally used spectral analysis and whether autonomic regulation changes can be detected even in the very early stage of PD.

We analysed 16 early-stage PD patients (<6 months since the onset of motor symptoms) and 16 age- and sex-matched controls. Spectral analysis was performed using fast Fourier transform to obtain spectral power in high-frequency band (HF, 0.15-0.5 Hz). The amount of information transferred from respiration (RESP signal) to R-R interval (RR signal) directly and indirectly through systolic blood pressure (SAP signal) was quantified in the information domain during supine rest, orthostatic challenge (head-up tilt, HUT) and supine recovery.

Spectral analysis revealed significantly lower spectral power in HF band during HUT ($p = 0.038$) in PD patients, with a similar trend observed during the rest phases. Advanced information analysis found no differences in unique transfer entropies from RESP to RR (the component of respiratory sinus arrythmia independent of baroreflex) and from SAP to RR (strength of cardiac baroreflex influence) ($p > 0.050$). In contrast, the PD group exhibited significantly lower values of redundant transfer entropy (RESP->SAP->RR, baroreflex-mediated respiratory effects on heart rate) during supine recovery ($p = 0.022$), with a similar trend in supine rest ($p = 0.076$).

We conclude that both methods detected differences between the control group and PD patients. Our findings also suggest that the indirect RESP→SAP→RR connection is partially impaired in PD, potentially reflecting initial cardiac chronotropic baroreflex impairment.

Funded by the EU NextGenerationEU through the Recovery and Resilience Plan for Slovakia under the project No. 09I03-03-V04-00201.