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Commercial office :
44, rue de Laborde
75008 PARIS-FRANCE
e-mail : manatec@easynet.fr
tel : (33 1) 43 87 88 13
fax : (33 1) 43 87 70 83

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EXERCISE TESTING AND PHYSIOLOGY

Abstract, European Journal of Applied Physiology, Volume 82 Issue 4 (2000) pp 313-320

A new impedance cardiograph device for the non-invasive evaluation of cardiac output at rest and during exercise: comparison with the "direct" Fick method

Anne Charloux, Evelyne Lonsdorfer-Wolf, Ruddy Richard, Eliane Lampert, Monique Oswald-Mammosser, Bertrand Mettauer, Bernard Geny, Jean Lonsdorfer

Service des Explorations Fonctionnelles Respiratoires, Cardio-Circulatoires et de l'Exercice, Hôpitaux Universitaires de Strasbourg, Hôpital Civil, BP 426, 67091 Strasbourg Cedex, France e-mail: anne.charloux@physio-ulp.u-strasbg.fr Tel.: +33-388-116122; Fax: +33-388-116467

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Abstract The objectives of this study were to evaluate the reliability and accuracy of a new impedance cardiograph device, the Physio Flow, at rest and during a steady-state dynamic leg exercise (work intensity ranging from 10 to 50 W) performed in the supine position. We compared cardiac output determined simultaneously by two methods, the Physio Flow ($Q\˙_{cPF}$) and the direct Fick ($Q\˙_{cFick}$) methods. Forty patients referred for right cardiac catheterisation, 14 with sleep apnoea syndrome and 26 with chronic obstructive pulmonary disease, took part in this study. The subjects' oxygen consumption values ranged from 0.14 to 1.19 l · min^{-1}. The mean difference between the two methods ($Q\˙_{cFick}$-$Q\˙_{cPF}$) was 0.04 l · min^{-1} at rest and 0.29 l · min^{-1} during exercise. The limits of agreement, defined as mean difference ± 2SD, were -1.34, +1.41 l · min^{-1} at rest and -2.34, +2.92 l · min^{-1} during exercise. The difference between the two methods exceeded 20% in only 2.5% of the cases at rest, and 9.3% of the cases during exercise. Thoracic hyperinflation did not alter $Q\˙_{cPF}$. We conclude that the Physio Flow provides a clinically acceptable and non-invasive evaluation of cardiac output under these conditions. This new impedance cardiograph device deserves further study using other populations and situations.

Key words Impedance cardiography · Cardiac output · Fick principle · Exercise

EXERCISE TESTING AND PHYSIOLOGY

Abstract , European Journal of Applied Physiology, Volume 85 Issue 3/4 (2001) pp 202-207
DOI 10.1007/s004210100458

Non-invasive cardiac output evaluation during a maximal progressive exercise test, using a new impedance cardiograph device

Authors : Ruddy Richard, Evelyne Lonsdorfer-Wolf, Anne Charloux, Stéphane Doutreleau, Martin Buchheit, Monique Oswald-Mammosser, Eliane Lampert, Bertrand Mettauer, Bernard Geny, Jean Lonsdorfer

Service des Explorations Fonctionnelles Respiratoires, Cardio-Circulatoires et de l'Exercice, Hôpitaux Universitaires de Strasbourg, Hôpital Civil, BP 426, 67091 Strasbourg Cedex, France E-mail: ruddy.richard@physio-ulp.u-strasbg.fr
Phone: +33-388116122 Fax: +33-388116467

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Abstract. One of the greatest challenges in exercise physiology is to develop a valid, reliable, non-invasive and affordable measurement of cardiac output (CO). The purpose of this study was to evaluate the reproducibility and accuracy of a new impedance cardiograph device, the Physio Flow, during a 1-min step incremental exercise test from rest to maximal peak effort. A group of 12 subjects was evaluated to determine the reproducibility of the method as follows: (1) each subject performed two comparable tests while their CO was measured by impedance cardiography using the new device (CO_{Imp1}, CO_{Imp2}), and (2) in a subgroup of 7 subjects CO was also determined by the direct Fick method (CO_{Fick}) during the second test. The mean difference between the values obtained by impedance (i.e. CO_{Imp1}-CO_{Imp2}) was -0.009 l·min^{-1} (95% confidence interval: -4.2 l·min^{-1}, 4.2 l·min^{-1}), and CO ranged from 3.55 l·min^{-1} to 26.75 l·min^{-1} (n=146). When expressed as a percentage, the difference (CO_{Imp1}-CO_{Imp2}) did not vary with increasing CO. The correlation coefficient between the values of CO_{Imp} and CO_{Fick} obtained during the second exercise test was r=0.94 (P<0.01, n=50). The mean difference expressed as percentage was -2.78% (95% confidence interval: -27.44%, 21.78%). We conclude that CO_{Imp} provides a clinically acceptable evaluation of CO in healthy subjects during an incremental exercise.

Keywords. Impedance · Cardiography · Cardiac output · Maximal exercise test

EXERCISE TESTING AND PHYSIOLOGY

Accepted by Canadian Journal Of Applied Physiology, May 27, 2002

Cardiovascular and oxygen uptake kinetics during sequential heavy cycling exercises

Authors : Stéphane Perrey [1], Jodie Scott [1,2], Laurent Mourot [1, 3], Jean-Denis Rouillon [1]
(1) Laboratoire des sciences du sport, place St Jacques, 25030 Besançon, France
(2) University of Waterloo, Department of Kinesiology, Waterloo, On, N2L 3Gl, Canada
(3) Laboratoire de Physiologie, place St Jacques, 25030 Besançon, France

Current address :
Stéphane Perrey Ph.D.
Faculté des sciences du sport,
UPRES EA 2991 Sport Performance Santé
700 Av du pic saint loup 34090 Montpellier France
Phone: + 33-4 67 41 57 49
Fax: +33-4 67 41 57 50
e-mail: s. perrey@staps.univ-montpl.fr

Abstract :
The purpose of the present study was to assess the relationship between the rapidity of increased oxygen uptake (VO_2) and increased cardiac output (CO) during heavy exercise. Six subjects performed repeated bouts on a cycle ergometer above the ventilatory threshold (~80% of peak VO_2) separated by 10-min recovery cycling at 35% peak VO_2. VO_2 was determined breath-by-breath and CO was determined continuously by impedance cardiography (PhysioFlow, Paris, France). CO and VO_2 values were significantly higher during the 2-min period preceding the second bout. The overall responses for VO_2 and CO were significantly related, and were faster during the second bout.
Prior heavy exercise resulted in a significant increase in the amplitude of the fast component of VO_2, with no change in the time constant, and a decrease in the slow component. Under these circumstances, the amplitude of the fast component was more sensitive to prior heavy exercise than was the associated time constant.

EXERCISE TESTING AND PHYSIOLOGY

European Underwater and Baromedical Society News letter, 2000

Post immersion delayed vasomotor adjustments to dehydration ?

Authors : Wolf JP[1], Galland F[2], Robinet C[2], Bouhaddi M[1], Boussuges A[3], Courtière A[2], Meliet JL[2], Regnard J[1].
1 : Physiologie, C.H.U. 25030 Besançon, 2 : IMNSSA, 83800 Toulon Naval, 3 : Réanimation, Hôpital Salvador, 13274 Marseille. France.

Abstract : While hemodynamic and fluid balance changes have been fairly well studied during immersion, the corresponding changes post-immersion are almost totally ignored.
Ten trained divers (33 +/- 5 years) underwent two similar 6 hours hyperbaric hyperoxic exposures with intermittent cycling exercise, one day in dry ambience (DY) and three weeks later immersed up to the neck (IM). They had no food nor beverage intake during either session.
Whole body weight was assessed, and venous blood samples were taken before and 15 min after each exposure session. Venous occlusion of the thighs was performed at 30, 40, 50, 60 mmHg during segmental weighing before and after each session. Segmental weighing performed with our original device allows measuring rapid changes in weight of lower limbs, abdomen-pelvis, and thorax related fluid shifts in the body. The data collected during these manoeuvres provided information about venous tone in the legs through distensibility and compliance assessments, and about arterial flow in the leg and splanchnic vessels. During segmental weighing, stroke volume (SV), cardiac output (CO) and heart rate (HR) were recorded using a Physioflow® impedance cardiography device.
As described in a companion paper, on average, the final weight losses were similar in the two ambiences (2.2 kg in DY vs 2.3 kg in IM), whereas plasma contraction was greater in the IM session (-14.7% vs –9.7% in DY ; $p<0.001$) as evidenced by changes. In hematocrite, blood haemoglobin and plasma proteins. Plasma levels of noradrenaline (NA), arginine-vasopressin (APV) were increased 20 min after each session versus pre-exposure, a change 3 times higher after IM than DY ($p>0.01$). Inversely, atrial and brain natriuretic peptides (ANP and BNP) as well as cyclic guanosine monophosphate (cGMP) remained increased 20 min post IM ($p<0.05$). Heart rate was decreased after DY (-7 min^{-1} ; $p<0.05$) but slightly increased after IM (+3 min^{-1} ; $p<0.05$). Conversely, stroke volume was more reduced after IM than DY (-9 mL vs –4 mL respectively ; $p<0.05$). Venous compliance and distensibility of the legs were reduced after DY ($p<0.05$) but preserved after IM. Indexes of arterial flow in both the leg and splanchnic vascular bed were reduced following DY.
Thus on the other hand, after DY the increase in plasma vasoconstrictive mediators (NA, APV) likely supported the increased venous and arterial vasomotor tone required to preserve cardiac output and blood pressure, in turn slightly lowering heart rate through baroreflex activation.
On the other hand, the paradoxical coexistence of markedly increased levels of NA and APV 30 min post IM together with unchanged vasomotor tone 1) was consistent with the decreased SV and CO but slightly increased HR ; 2) was likely explained by the persistence of high level of natriuretic peptides within the first hour post-immersion.

EXERCISE TESTING AND PHYSIOLOGY

Effect of exercise intensity on relationship between VO_{2max} and cardiac output

Med. Sci. Sports Exerc., Vol. 36, No. 8, pp. 000–000, 2004.

Authors : Jean-Marie Lepretre [1], Jean-Pierre Koralsztein [2] and Veronique L. Billat [1.2]
[1] LIGE Département of Sciences and Technology in Sports and Physical Activities (STAPS), University of Evry Val d'Essonne, Evry, France, and [2] Sport Medical Center of the CCAS, Paris, France.

Abstract : Effect of Exercise Intensity on Relationship between VO_{2max} and Cardiac Output
Purpose: The purpose of this study was to determine whether the maximal oxygen uptake (VO_{2max}) is attained with the same central and peripheral factors according to the exercise intensity.
Methods: Nine well-trained males performed an incremental exercise test on a cycle ergometer to determine the maximal power associated with VO_{2max} (pVO_{2max}) and maximal cardiac output (Q_{max}). Two days later, they performed two continuous cycling exercises at 100% (tlim 100 = 5 min 12 s ± 2 min 25 s) and at an intermediate work rate between the lactate threshold and pVO_{2max} (tlim 50 = 12 min 6 s ± 3 min 5 s). Heart rate and stroke volume (SV) were measured (by impedance) continuously during all tests. Cardiac output (Q) and arterial-venous O_2 difference (a-vO_2 diff) were calculated using standard equations.
Results: Repeated measures ANOVA indicated that: 1) maximal heart rate, VE, blood lactate, and VO_2 (VO_{2max}) were not different between the three exercises but Q was lower in tlim 50 than in the incremental test (24.4 ± 3.6 $L \cdot min^{-1}$ vs 28.4 ± 4.1 $L \cdot min^{-1}$; $P < 0.05$) due to a lower SV (143 ± 27 $mL \cdot beat^{-1}$ vs 179 ± 34 $mL \cdot beat^{-1}$; $P < 0.05$), and 2) maximal values of a-vO_2 diff were not significantly different between all the exercise protocols but reduced later in tlim 50 compared with tlim100 (6 min 58 s ± 4 min 29 s vs 3 min 6 s ± 1 min 3 s, $P = 0.05$). This reduction in a-vO_2 diff was correlated with the arterial oxygen desaturation (SaO_2 = -15.3 ± 3.9%) in tlim 50 ($r = -0.74$, $P = 0.05$).
Conclusion: VO_{2max} was not attained with the same central and peripheral factors in exhaustive exercises, and tlim 50 did not elicit the maximal Q. This might be taken into account if the training aim is to enhance the central factors of VO_{2max} using exercise intensities eliciting VO_{2max} but not necessarily Q_{max}.

Key Words: STROKE VOLUME, ARTERIAL-VENOUS DIFFERENCE, CYCLING, HYPOXEMIA

EXERCISE TESTING AND PHYSIOLOGY

Cardiac output and oxygen release during very high-intensity exercise performed until exhaustion

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Authors :
R.Richard.E.Lonssdorf-Wolf.S.Dufour.S.Doutreleau.M.Oswald-Mammoser.J.Lonsdorfer
Unité de Physiologie et des Explorations Fonctionnelles de l'Exercice, Service de Physiologie Clinique, Hôpitaux Universitaires de Strasbourg, Hôpital Civil, BP 426, 67091 Strasbourg Cedex, France.

V.L Billat
Département STAPS, UFR de Sciences, Université d'Evry Val-d'Essone, 91025 Evry Cedex, France.

R.Richard
Phone : +33-3-88 11 61 22
Fax +33-3-88 11 64 67
e-mail ; Ruddy.Richard@physio-ulp.u-strasb.fr

Abstract : Our objectives were firstly, to study the patterns of the cardiac output (Q) and the arteriovenous oxygen difference [(a-v)O2] responses to oxygen uptake (VO2) during constant workload exercise (CWE) performed above the respiratory compensation point (RCP), and secondly, to establish the relationships between their kinetics and the time to exhaustion. Nine subjects performed two tests: a maximal incremental exercise test (IET) to determine the maximal VO2 (VO2peak), and a CWE test to exhaustion, performed at pΔ50 (intermediate power between RCP and VO2 peak). During CWE, VO2 was measured breath-by-breath? Q was measured beat-by-beat with and impedance device, and blood lactate (LA) was sampled each minute. To calculate (a-v-)O2, the values of VO2 and Q were synchronised over 10 intervals. A fitting method was used to describe the VO2, Q and (a-v)O2 kinetics. The (a-v) O2 difference followed a rapid monoexponential function, whereas both VO2 and Q were best fitted by a single exponential plus linear increase: the time constant (τ) VO2 [57 (20s] was similar to τ(a-v) O2, whereas τ for Q was significantly higher [89(34)s, P<0.05] (values expressed as the mean and standard error). LA started to increase after 2 min CWE then increased rapidly, reaching a similar maximal value as that seen during the IET. During CWE, the rapid component of VO2 uptake was determined by a rapid and maximal (a-v)O2 extraction coupled with a two-fold longer Q increase. It is likely that lactic acidosis markedly increased oxygen availability, which when associated with the slow linear increase of Q, may account for the VO2 slow component. Time to exhaustion was larger in individuals with shorter time delay for (a-v)O2 and greater τ for Q.

Key Words: Oxygen slow component - Cardiac Output - Arteriovenous oxygen difference - Time to exhaustion

EXERCISE TESTING AND PHYSIOLOGY

Short-term vasomotor adjustments to post immersion dehydration are hindered by natriuretic peptides.

UHM 2004, Vol. 31, No. 2 - Vasomotor regulation in post-immersion dehydration

L. MOUROT[1], JP WOLF[1], F.GALLAND[2], C. ROBINET[2], A. COURTIÈRE[2], M. BOUHADDI[1], J.L. MELIET[2], J. REGNARD[1]

[1] *Physiologie Médecine and EA 479, Faculté de Médecine et de Pharmacie, Place St Jacques 25030 Besançon Cedex France*
[2] *Institut de Médecine Navale du Service de Santé des Armées, BP-610, 83800 Toulon Naval*

Abstract : Short-term vasomotor adjustments to post immersion dehydration are hindered by natriuretic peptides. Undersea Hyperb Med 2004, 31(2) :000-000. Many studies have described the physiology of water immersion (WI), whereas few have focused on post WI physiology, which faces the global water loss of the large WI diuresis. Therefore, we compared hemodynamics and vasomotor tone in 10 trained supine divers before and after two 6h sessions in dry (DY) and head out WI environments. During each exposure (DY and WI) two exercise periods (each one hour 75W ergometer cycling) started after the 3rd and 5th hours. Weight losses were significant (-2.24 ± 0.13 kg and -2.38 ± 0.19 kg, after DY and WI, respectively), but not different between the two conditions. Plasma volume was reduced at the end of the two conditions (-9.7 ± 1.6 % and -14.7 ± 1.6 %, respectively; $p<0.05$). This post-WI decrease was deeper than post DY ($p<0.05$). Cardiac output (CO) and mean arterial blood pressure were maintained after the two exposures. Plasma levels of noradrenaline, antidiuretic hormone and ANP were twofold higher after WI than after DY ($p<0.05$). After DY total peripheral resistances (TPR) were increased ($p<0.05$) and heart rate (HR) was reduced ($p<0.05$). After WI there was a trend for a decrease in stroke volume ($p=0.07$) with unchanged TPR and HR, despite more sizeable increases in plasma noradrenaline and vasopressin than after DY. We hypothesized that the higher levels of plasma natriuretic peptides after WI were likely counteracting the dehydration-required vasomotor adjustments.

EXERCISE TESTING AND PHYSIOLOGY

Journées francophones ALVEOLE, Montpellier, Mars 2004. Dyspnées cardiologiques difficiles

Faut-il mesurer le débit cardiaque à l'exercice ?

Auteurs : J. Lonsdorfer, E. Lonsdorfe-Wolf, S. Doutreleau et R. Richard, service de Physiologie appliquée et des Explorations Fonctionnelles, Hôpitaux Universitaires de Strasbourg.

Méthodes : La mesure du Q à l'effort par impédancemétrie revalorisée par les acquisitions de la technologie moderne (PhysioFlow – Manatec) offre de solides perspectives par rapport aux autres méthodes non invasives (CO_2 rebreathing, échocardiographie, doppler…). Nous l'avons validée par comparaison avec la méthode invasive de Fick au cours de mesures simultanées répétées lors d'une épreuve à puissance constante [3] et lors d'un test d'effort maximal [4] et l'utilisons à présent systématiquement dans nos ECRM. La variation d'impédance produite par la systole permet d'obtenir Q cycle par cycle et de là le VES. En parallèle cette mesure associée à la mesure simultanée de la VO_2 aboutit à une détermination quasi continue de la da v O_2 grâce au calcul du rapport VO_2/Q.

Résultats :
1/ **A puissance constante ou lors d'un test maximal** à charges croissantes on obtient une détermination directe et quasi continue des ajustements centraux (VES) et périphériques (da v O_2). Nous avons observé ainsi chez les patients des VES d'emblée maximaux ou au contraire s'ajustant jusqu'aux paliers sous maximaux de l'effort. Aucune cinétique évolutive "standard" du VES de l'effort ne peut plus être actuellement affirmée. De même s'agissant de la da v O_2 les valeurs mesurées sont souvent très différentes chez les malades désadaptés que celles communément admises chez les sujets sains, sédentaires ou sportifs.
2/ **L'épreuve temps limite** : au cours de ce test qui consiste à soutenir à 90% de la VO_2 max du sujet nous pouvons suivre grâce au **PhysioFlow** la cinétique des grandeurs, Q, FC, VES et, VO_2, da v O_2 et déterminer notamment la constante de temps (τ, tôt) de chaque monoexponensielle qui les décrit. Chez ces sujets sains la contribution de chaque élément de l'équation de Fick pour assurer à chaque moment l'ajustement de la VO_2 peut être représentée graphiquement – en % de leur valeur maximale. Une telle approche dynamique des ajustements s'avère précieuse chez les cardiaques, tant au plan explicatif que prédictif : ainsi KOIKE et al ont montré la relation entre les constantes de temps de VO_2 et de Q mesurées lors d'un ***effort*** constant et les valeurs des fractions d'éjection ventriculaire gauche mesurées ***au repos***.

Conclusion : L'origine de toute dyspnée d'effort est certes multifactorielle ; mais chez le cardiaque prédominent le dysfonctionnement myocardique et ses conséquences : la sédentarité, et donc le déconditionnement physique. La mesure continue du débit cardiaque par impédancemétrie (**PhysioFlow**), associée aux données de l'épreuve cardiorespiratoire, permet de cerner tous les facteurs d'ajustement de la VO2 tels qu'exprimés dans l'équation de Fick. La généralisation de cette évaluation « intégrative » grâce à une mesure continue et « non invasive » du débit cardiaque devrait ouvrir vers une meilleure compréhension des « dyspnées ».

EXERCISE TESTING AND PHYSIOLOGY

Articles in presS J Appl Physiol (December 23, 2004). doi : 10.1152/japplphysiol.00837.2004

Heart rate deflection point as a strategy to defend stroke volume during incremental exercise.

Running head : HRDP and SVmax achievement during incremental test

Authors : Pierre-Marie LEPRETRE[1], Carl FOSTER[2], Jean-Pierre KORALSZTEIN[3] and Véronique L. BILLAT, FACSM[1,3]

[1] LEPHE, Department of Science and Technology in Sports and Physical Activities (STAPS), University of Evry val d'Essonne, Boulevard François Mitterrand, Evry, F-91025, France.
[2] University of Wisconcin – La Croose, 145 Main Hall, 1725 States Street, La Crosse, WI 54601, United States of America.
[3] Sport Medecine Center of the CCAS, 2 Avenue Richerand, Paris F-75010, France.

Corresponding authors : Pierre-MarieLEPRETRE, LEPHE, Department of STAPS, University of Evry Val d'Essonne,
Sports Medecine Center of the CCAS, 2 Avenue Richerand, Paris, F-75010, France

Tel : (33) 142 02 08 18, Fax : (33) 142 39 20 83

Email : lepretre.pierre-marie@wanadoo.fr

ABSTRACT

Purpose: The purpose of this study was to examine whether the heart rate deflection point (HRDP) in the heart rate – power relationship is concomitant with the maximal stroke volume value achievement (SV_{max}) in endurance-trained subjects. **Methods:** twenty-two international male cyclists (30.3±7.3yrs, 179.7±7.2cm, 71.3±5.5kg) undertook a graded cycling exercise (50 watts every 3 minutes) in the upright position. Thoracic impedance was used to measure continuously the heart rate (HR) and stroke volume (SV) values. The HRDP was estimated by the third order curvilinear regression method (D_{max}). **Results:** 72.7% of the subjects (HRDP-group, n=16) presented a break point in their HR – work rate curve at 89.9±2.8% of their maximal HR value. The SV value increased until 78.0±9.3% of the power associated with VO_{2max} (pVO_{2max}) in the HRDP-group whereas it increased until 94.4±8.6% of pVO_{2max} in six other subjects (No-HRDP-group, *P=0.004*). Neither SV_{max} ($mL.beat^{-1}$ or $mL.beat^{-1}.m^{-2}$) nor VO_{2max} ($mL.min^{-1}$ or $mL.kg^{-1}.min^{-1}$) were different between both groups. However, SV significantly decreased before exhaustion in the HRDP-group (153±44 vs. 144±40$mL.beat^{-1}$, *P=0.005*). In the HDRP-group, 62% of the variance in the power associated at the SV_{max} (pSV_{max}) could be also predicted by the power output at which HRDP appeared. **Conclusion:** In well-trained subjects, the pSV_{max} – HRDP relationship supposed that the heart rate deflection coincided with the optimal cardiac work for which SV_{max} was attained.

Keywords: physical work curve break point, left ventricular ejection fraction, cycling graded test.

EXERCISE TESTING AND PHYSIOLOGY

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Cardiac output and oxygen release during very high intensity exercise performed until exhaustion

Authors: Rudy RICHARD, Evelyne LONSDERFER – WOLF, Stéphane DUFOUR, Stéphane DOUTRELEAU, Monique OSWALD –MAMMOSSER, Véronique L. BILLAT, Jean LONSDERFER

Abstract Our objectives were firstly, to study the patterns of the cardiac output ($\dot{Q}$) and the arteriovenous oxygen difference [$(a-\bar{v})O_2$] responses to oxygen uptake ($\dot{V}O_2$) during constant workload exercise (CWE) performed above the respiratory compensation point (RCP), and secondly, to establish the relationships between their kinetics and the time to exhaustion. Nine subjects performed two tests: a maximal incremental exercise test (IET) to determine the maximal $\dot{V}O_2$ ($\dot{V}O_2$peak), and a CWE test to exhaustion, performed at $p\,\Delta 50$ (intermediate power between RCP and $\dot{V}O_2$peak). During CWE, $\dot{V}O_2$ was measured breath-by-breath, $\dot{Q}$ was measured beat-by-beat with an impedance device, and blood lactate (LA) was sampled each minute. To calculate $(a-\bar{v})O_2$, the values of $\dot{V}O_2$ and $\dot{Q}$ were synchronised over 10 s intervals. A fitting method was used to describe the $\dot{V}O_2$, $\dot{Q}$ and $(a-\bar{v})O_2$ kinetics. The $(a-\bar{v})O_2$ difference followed a rapid monoexponential function, whereas both $\dot{V}O_2$ and $\dot{Q}$ were best fitted by a single exponential plus linear increase: the time constant (τ) $\dot{V}O_2$ [57 (20 s)] was similar to τ $(a-\bar{v})O_2$, whereas τ for $\dot{Q}$ was significantly higher [89 (34) s, $P<0.05$] (values expressed as the mean and standard error). LA started to increase after 2 min CWE then increased rapidly, reaching a similar maximal value as that seen during the IET. During CWE, the rapid component of $\dot{V}O_2$ uptake was determined by a rapid and maximal $(a-\bar{v})O_2$ extraction coupled with a two-fold longer $\dot{Q}$ increase. It is likely that lactic acidosis markedly increased oxygen availability, which when associated with the slow linear increase of $\dot{Q}$, may account for the $\dot{V}O_2$ slow component. Time to exhaustion was larger in individuals with shorter time delay for $(a-\bar{v})O_2$ and a greater τ for $\dot{Q}$.

Keywords Oxygen slow component · Cardiac output · Arteriovenous oxygen difference · Time to exhaustion

EXERCISE TESTING AND PHYSIOLOGY

Eccentric Cycle Exercise : Training Application of Specific Circulatory Adjusments

Authors: Stéphane P. DUFOUR[1], Eliane LAMPERT[1], Stéphane DOUTRELEAU[1] Evelyne LONSDERFER-WOLF[1], Véronique L. BILLAT[2], François PICQUARD[1] and Ruddy RICHARD[1]

[1]Respiratory , Cardiocirculatory and Exercise Functionals Explorations department, Civil Hospital Strasbourg, France, and Physiology department Faculty of Medecine, Strasbourg, France and [2]LIGE Laboratory, UFR of Fundamental And Applied Sciences, University of Evry Val d'Essonne, France

ABSTRACT

DUFOUR, S. P., E. LAMPERT, S. DOUTRELEAU, E. LONSDORFER-WOLF, V. L. BILLAT, F. PIQUARD, and R. RICHARD. Eccentric Cycle Exercise: Training Application of Specific Circulatory Adjustments. *Med. Sci. Sports Exerc.*, Vol. 36, No. 11, pp. 1900–1906, 2004. **Purpose:** Despite identical oxygen uptake ($\dot{V}O_2$), enhanced heart rate (HR) and cardiac output ($\dot{Q}$) responses have been reported in eccentric (ECC) versus concentric (CON) cycle exercise. The aim of this study was to describe the specific circulatory adjustments (HR and stroke volume (SV)) to incremental ECC cycle exercise in order to: 1) determine the HR values leading to identical $\dot{V}O_2$ in ECC and CON cycling; and 2) estimate the interindividual variability of this HR correspondence between the two exercise modes, with emphasis upon rehabilitation and training purposes. **Methods:** Eight healthy male subjects (age, 28 ± 2 yr) participated in this study. They performed CON and ECC cycle incremental exercises (power output increases of 50 W every 3 min). Breath-by-breath gas exchange analysis and beat-by-beat thoracic impedancemetry were used to determine $\dot{V}O_2$ and $\dot{Q}$, respectively. **Results**: At the same metabolic power ($\dot{V}O_2$ of 1.08 ± 0.05 L·min^{-1} in CON vs 1.04 ± 0.06 L·min^{-1} in ECC), SV was not different, but HR was 17% higher in ECC ($P < 0.01$), leading to a 27% enhanced $\dot{Q}$ ($P < 0.01$). $\dot{Q}$ and HR net adjustments (exercise minus resting values) in ECC versus CON muscle involvement demonstrated important interindividual variability with coefficients of variation amounting to 32% and 30%, respectively. **Conclusion**. In practice, if a given level of $\dot{V}O_2$ is to be reached, ECC HR has to be set above the CON one. Taking into account the interindividual variability of the circulatory adjustments in ECC versus CON muscle involvement, a precise HR correspondence can be established individually from the $\dot{V}O_2$/HR relationship obtained using ECC incremental testing, allowing prescription of accurate target HR for rehabilitation or training purposes. **Key Words:** CARDIOVASCULAR ADAPTATIONS, MUSCLE ACTION TYPES, IMPEDANCE CARDIOGRAPHY, INCREMENTAL EXERCISE TESTING

EXERCISE TESTING AND PHYSIOLOGY

Sildenafil inhibits Altitude-induced Hypoxemia and Pulmonary Hypertension

Authors: Jean-paul RICHALET, Pierre GRATADOUR, Paul ROBACH, Isabelle PHAM, Michèle DECHAUX, Aude JONQUIERT-LATARJET, Pascal MOLLARD, Julien BRUGNIAUX and Jeremy CORNOLO

Laboratoire réponse cellulaires et fonctionnelles à l'hypoxie, Université Paris 13 Bobigny ; Service de Physiologie et Explorations Fonctionnelles, Hôpital Avicenne, Bobigny ; Service d'Anesthésie-Réanimation, Hôpital Hôtel-Dieu, Lyon, Service de Physiologie, Hôpital Jean-Verdier, Bondy; Ecole Nationale de Ski et d'Alpinisme, Chamonix, laboratoire de Physiologie, hôpital Necker, paris, france

Abstract :

Exposure to high altitude induces pulmonary hypertension that may lead to life-threatening conditions. In a randomized, double-blind, placebo-controlled study, the effects of oral sildenafil on altitude-induced pulmonary hypertension and gas exchange in normal subjects were examined. Twelve subjects (sildenafil [SIL] n = 6; placebo [PLA] n = 6) were exposed for 6 days at 4,350 m. Treatment (3 × 40 mg/day) was started 6 to 8 hours after arrival from sea level to high altitude and maintained for 6 days. Systolic pulmonary artery pressure (echocardiography) increased at high altitude before treatment (+29% versus sea level, $p < 0.01$), then normalized in SIL (−6% versus sea level, NS) and remained elevated in PLA (+21% versus sea level, $p < 0.05$). Pulmonary acceleration time decreased by 27% in PLA versus 6% in SIL ($p < 0.01$). Cardiac output and systemic blood pressures increased at high altitude then decreased similarly in both groups. Pa_{O_2} was higher and alveolar-arterial difference in O_2 lower in SIL than in PLA at rest and exercise ($p < 0.05$). The altitude-induced decrease in maximal O_2 consumption was smaller in SIL than in PLA ($p < 0.05$). Sildenafil protects against the development of altitude-induced pulmonary hypertension and improves gas exchange, limiting the altitude-induced hypoxemia and decrease in exercise performance.

Keywords: cardiac output; exercise; gas exchange; hypoxia

EXERCISE TESTING AND PHYSIOLOGY

Reliability of peak VO^2 and maximum cardiac output assessed using thoracic cardiac bioimpedance in children

Eur J Appl physiol 2005 April 13th

Welsman J, Bywater K, Farr C, Welford D, Armstrong N.

Children's Health and Exercise Research Centre, University of Exeter, Heavitree Road, Exeter, EX1 2LU, UK, j.r.welsman@ex.ac.uk.

The purpose of this study was to evaluate the reliability of a thoracic electrical bioimpedance based device (PhysioFlow) for the determination of cardiac output and stroke volume during exercise at peak oxygen uptake (peak VO² in children. The reliability of peak VO² is also reported. Eleven boys and nine girls aged 10-11 years completed a cycle ergometer test to voluntary exhaustion on three occasions each 1 week apart. Peak VO² was determined and cardiac output and stroke volume at peak VO² were measured using a thoracic bioelectrical impedance device (PhysioFlow). The reliability of peak VO² cardiac output and stroke volume were determined initially from pairwise comparisons and subsequently across all three trials analysed together through calculation of typical error and intraclass correlation. The pairwise comparisons revealed no consistent bias across tests for all three measures and there was no evidence of non-uniform errors (heteroscedasticity). When three trials were analysed together typical error expressed as a coefficient of variation was 4.1% for peak VO²9.3% for cardiac output and 9.3% for stroke volume. Results analysed by sex revealed no consistent differences. The PhysioFlow method allows non-invasive, beat-to-beat determination of cardiac output and stroke volume which is feasible for measurements during maximal exercise in children. The reliability of the PhysioFlow falls between that demonstrated for Doppler echocardiography (5%) and CO(2) rebreathing (12%) at maximal exercise but combines the significant advantages of portability, lower expense and requires less technical expertise to obtain reliable results.

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CARDIOLOGY

Heart journal. June 2000 Volume 83 supplement II

Best detection of coronary artery disease using a new generation impedance cardiography. Comparison to exercise thallium 201 scintigraphy.

Authors : JM Dupuis, F Prunier, W Abi-Khalil, Ph Pezard, F Bour, Ph Geslin, department of cardiology, C.H.U. Angers France.

Abstract : During exercise in patients with ischemia, contractility is impeded before electrical signs or angina appear. Therefore, measurement of contractility impairment could provide a highly sensitive approach to the detection of an ischemia. The protocol was designed to determine if a new, non invasive cardiac output measuring device (Physio Flow® : PF03, Manatec France) whose measurements are based on analysis of instant thoracic impedance (ICG) variations could be helpful to detect ischemia during exercise thallium scintigraphy.
Methods : The efficiency of ICG in detecting myocardial ischemia was compared to treadmill exercise/redistribution thallium-201 scintigraphy. During exercise, patients had simultaneous measurement of stroke volume with ICG. ICG was considered abnormal if stroke volume at the peak of exercise was lower than another stroke volume measured before, and separated by at least 1 min from peak. Clinical was considered as positive if typical angina occurred and an abnormal ECG if ST-segment horizontal or descending depression > 1 mV lasting for at least 30 seconds. Ischemia was affirmed by a mismatch between exercise/redistribution thallium-201 scintigraphy.
Results : 36 patients (30 men, age 62+/-11 years), 30 with proved CAD were submitted to treadmill exercise/redistribution thallium-201 scintigraphy. Stroke volume profile alteration always occurred earlier in exercise than ECG ST segment depression and angina. The sensitivity (Se), specificity (Sp), positive (PPV) and negative (NPV) predictive values are summarized in the following table.

	Se	Sp	PPV	NPV
Angina	46%	74%	50%	71%
ECG(+)	31%	65%	33%	63%
ECG(+) and/or Angina	41%	66%	41%	66%
ECG(+) and Angina	33%	76%	43%	68%
ICG(-)	100%	74%	67%	100%

Conclusions : Use of ICG during exercise allows for the estimation of stroke volume changes over time. These preliminary results show that it is a promising technique compared to ECG or other criteria for the detection of ischemia during exercise test with an excellent NPV.

CARDIOLOGY

Heart journal. June 2000 Volume 83 supplement II

Detection of coronary artery disease (CAD) during bicycle exercise, using new generation impedance cardiography.

Authors : JM Dupuis, J Bour, P Abraham, K Kalife, C.H.U. Angers France.

Abstract : During exercise in patients with CAD, contractility is impeded before electrical signs or angina appear. Therefore, measurement of contractility impairment could provide a highly sensitive approach to the detection of CAD. The protocol was designed to determine if a new, non invasive cardiac output measuring device (Physio Flow® : PF03, Manatec France) whose measurements are based on analysis of instant thoracic impedance (ICG) variations that does not use average impedance baseline values could be helpful to detect CAD.
Methods : On a 12 months period, subjects suspected of CAD had been submitted to an incremental bicycle exercise test (30 W / 2 min). Those who presented either an interpretable and abnormal ECG : [ECG(+)] ST-segment horizontal or descending depression > 1 mV lasting for at least 30 seconds, or typical angina during the exercise test were submitted to coronarography (n=29. 18 men/11 women, age = 57+/-10 years. Weight = 80+/-12 Kg. Height = 170+/-9 cm). Coronarography, considered as the gold standard for comparison, were performed and analyzed by independent observers and quoted abnormal for at least 50% stenosis of the coronary arteries : coro(+). During exercise, patients had simultaneous measurement of stroke volume with ICG. ICG was considered abnormal if stroke volume at the peak of exercise was lower than another stroke volume measured before, and separated by at least 1 min from peak.
Results : Number of patients in each group are summarized in the table. Stroke volume profile alteration always occurred earlier in exercise than ECG ST segment depression. The sensitivity, specificity, positive and negative predictive values were respectively : 63, 20, 60, 22% for ECG alone ; 68, 20, 62, 25 for angina alone : 84, 10, 64, 25% for ECG or angina ; 100, 50, 79, 100% for ICG.

	coro(+) n=19	coro(-) n=10
ECG(+)	12	8
Angina	13	8
ECG(+) and Angina	9	7
ECG(+) and/or Angina	16	9
ICG SV depression	19	5

Conclusions : Use of ICG during exercise allows for the estimation of stroke volume changes over time. As such, these preliminary results show that it is a promising technique for the non-invasive diagnosis of CAD.

CARDIOLOGY

Accepted by Clinical Science October 21st 2002

Changes in transthoracic impedance signal predict outcome of 70º head-up tilt test.

Authors : Elisabeth Bellard[*], Jacques-Olivier Fortrat[*], Daniel Schang[†], Jean-Marc Dupuis[‡], Jacques Victor[‡] and Georges Lefthériotis[*] (Pr G. Lefthériotis, Laboratoire de Physiologie, UPRES-EA 2170, Faculté de médecine, rue haute de Reculée, 49035 Angers. Tel: 0-33-2-41-35-46-17, Fax: 0-33-2-41-35-50-42 email: geleftheriotis@chu-angers.fr)

From the [*]Laboratoire de Physiologie - UPRES EA 2170, Faculté de Médecine, rue haute de Reculée, 49035 Angers, France, [†]Ecole Supérieure d'Electronique de l'Ouest, 4 rue Merlet de la Boulaye, PO Box 926, 49009 Angers Cedex 01, France, [‡]Département de Cardiologie, Centre Hospitalier d'Angers, rue Larrey, 49033 Angers cedex, France.

Abstract : We determined if the early changes in central hemodynamics determined by transthoracic impedance induced by head-upright tilt test (70°HUT) could predict syncope. Heart rate, arterial blood pressure and central hemodynamics (pre-ejection period and rapid left ventricular ejection time (T_1), slow ejection time (T_2) and dZ/dt_{max}, assessed by the transthoracic impedance technique), were recorded during supine rest and 45 min 70°HUT in 68 patients (40±2 years) with history of unexplained recurrent syncope. Thirty-eight patients (42 ±3 years) had a symptomatic outcome to 70°HUT (fainters) and 30 (39±2 years) had a negative outcome (non-fainters). Between the 5th and 10th minutes of 70°HUT, T_2 increased significantly only in the fainters and a change of T_2 >40 ms from baseline predicted a positive outcome with a sensitivity of 68% and a specificity of 70%. During supine rest, fainters exhibited a shorter T_2 than non-fainters (183±10 ms vs. 233±14 ms, $p<0.01$). A T_2 <199ms predicted a positive 70°HUT outcome with a sensitivity of 68% and a specificity of 63%. The combination to the changes from rest to 70°HUT of the other hemodynamic variables (heart rate >11 bpm, systolic <2 mmHg, diastolic <7 mmHg and pulse <-3 mmHg pressures) increased the specificity to 97% as well as the positive predictive value (93%). Transthoracic impedance could detect differences between fainters and non-fainters in central hemodynamics during supine rest and the initial period of 70°HUT with a consistent sensitivity and specificity when combined with peripheral hemodynamic variables.

CARDIOLOGY

European Journal of Physiology (2002, 444, R49, S3 26) (Physiomed 2002 Société de Physiology Abstracts of the 70th Annual Meeting 18-20 Septembre 2002, Québec, Canada)

Head-upright tilt test with sublingual nitroglycerin predicts hemodynamic abnormalities in 70° head-upright tilt.

Authors : Bellard Elisabeth, Fortrat Jacques-Olivier, Dupuis Jean-Marc, Victor Jacques, Lefthériotis Georges.
Pflugers Arch - Eur J Physiol (2002) 444: R49,S3 26.

Abstract : We aimed to determine if the outcome to a head upright tilt test (70°HUT) with sublingual nitroglycerin (NTG) could retrospectively help to determine abnormal changes in central and peripheral hemodynamics to a standard (STD) 45 min 70°HUT without NTG in patients with unexplained syncope. 32 patients with negative outcome to a 70°HUT-STD were submitted to consecutive 70°HUT+NTG. Heart rate, arterial blood pressure (BP) and central hemodynamic assessed by transthoracic impedance variables (pre ejection +rapid left ventricular ejection time (T_1, ms) and peak of first derivative of signal (dZ/dt_{max}) were recorded during supine rest, initial 5 min and 40-45 min of a 70°HUT-STD. Changes from rest value of these variables (mean+/-SEM) were retrospectively compared (unpaired T test) between patients with a negative (n=15,NTG-) and positive (n=17,NTG+) outcome to a 70°HUT+NTG. Differences were only observed during 40-45 min of 70°HUT-STD: systolic (NTG+:-18+/-4 vs NTG-:-2+/-4 mmHg;$p<0.01$), mean BP (-1+/-2 vs 6+/-2 mmHg;$p<0.05$) and dZ/dt_{max} (-51+/-30 vs 35+/-21 $Ohm.s^{-1}$;$p<0.05$). A drop of systolic BP >10mmHg and/or dZ/dt_{max} >13 $Ohm.s^{-1}$ predicted positive outcome to 70°HUT+NTG with a sensitivity of 82% and a specificity of 60% suggesting that abnormal response to a 70°HUT+NTG was linked to 70°HUT-STD outcome.

CARDIOLOGY

Accepted for the British Thoracic Society winter meeting

Haemodynamics During Exercise are a Better measure of Vasodilator Response in Human Subjects with Pulmonary Hypertension

Authors: R. Syyed, A.J.Peacock Scottish Pulmonary Vascular Unit, Western Infirmary, Glasgow,UK

Abstract : Patients with pulmonary hypertension (PHT) are deemed 'non-responders' (NR) if they show no response to vasodilators at rest. We therefore decided to investigate the effects of vasodilators on pulmonary haemodynamics during exercise.

Methods: We investigated 4 patients, (2 female, 2 male) with PHT to determine pressure and flow changes over a range of flows. Flow was changed by straight leg raising. A micromanometer tipped continuous pulmonary artery pressure (PAP) catheter was inserted. All 4 were non-responders to a vasodilator challenge (defined as a reduction of >20% in pulmonary vascular resistance). Resting pressure was measured and then 3 mins of supine alternate straight leg raising was performed. , whilst the subjects inhaled air or nitric oxide (NO, 40-80 ppm) and oxygen (O2, 15L min). Cardiac Output (CO) was measured by non-invasive impedance cardiography. Subject data was pooled using the method described by Poon (J. Appl Physiol. 1998;64:854-9). The best-fit line for Pressure Flow (P-Q) plots was determined by linear regression. An adjusted two paired student t-test was used to compare the line gradients.

Results: We found that although total pulmonary vascular resistance (as defined as mean PAP/ CO) showed no change at rest, the slope of the P-Q plots decreased with vasodilators during exercise ($p<0.0005$).

Conclusion: In each of these 4 subjects, whilst there was no vasodilator response at rest, there was an improving relationship between pressure and flow during exercise whilst receiving the vasodilators NO & O2. In patients with PHT, the assessment of vasodilator response may be better performed during exercise than at rest.

CARDIOLOGY

Japanese Journal of Cardiology, reprinted from 2003 July, Vol. 42 n°1 : 37-42 (Japanese College of Cardiology)

Impedance Cardiography And Quantitative Tissue Doppler Echocardiography For Evaluating The Effect Of Cardiac Resynchronization Therapy

Authors : Hitoshi ADACHI, MD ; Tomoya HIRATSUJI, MD ; Shigeki SAKURAI, MD ; Hiroshi TADA, MD ; Takuji TOMOYA, MD FJCC ; Shigeto NAITO, MD ; Hiroshi HOSHIZAKI, MD ; Shigeru OSHIMA, MD FJCC ; Koichi TANIGUCHI, MD FJCC.
From Division of Cardiology, Gunma Prefectural Cardiovascular Center Gunma

Abstract : An 83-year-old woman presented with dilated cardiomyopathy. Cardiac resynchronization therapy was performed. Two weeks later, cardiac output and ventricular wall motion were estimated using impedance cardiography and tissue Doppler echocardiography with and without pacing. Cardiac output increased from 3.5 to 4.5 *l*/m during biventricular pacing with a 120 msec atrioventricular interval. Intraventricular phase difference for contraction decreased from 190 to 150 msec. When the atrioventricular interval was 180 msec, cardiac output and phase difference became 4.6 *l*/m and 170 msec. These assessments were performed rapidly and non-invasively. New impedance cardiography and tissue Doppler echocardiography are useful to evaluate the effect of cardiac resynchronization therapy.

Conclusion : The present case demonstrate usefulness of impedance cardiography and tissue Doppler echocardiography in the evaluation of the effect of cardiac resynchronization therapy on cardiac function. Using impedance cardiography, the cardiac output could be assessed easily and non-invasively. Impedance cardiography and tissue Doppler are useful for evaluating the beneficial effect of cardiac resynchronization therapy and determined the optimal AV delay interval.

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CARDIOLOGY

Respiration and Circulation (Japan), vol. 51 N°12, December 2003

Dynamic Monitoring During Exercise in Familial Amyloid Polyneuropathy (FAP) Type I

Authors : Tetsuro Kusaba[1], Yoshifumi Nakahara, Akiyoshi Matsumuro, Takashi Nakamura, Shouhei Sawada, Masamitsu Nakazato[2].

[1] Department of Cardiology, Saiseikai Shiga Hospital
[2] Third Department of Internal Medicine, Miyazaki Medical College

Abstract : A 64-years-old man was admitted to our hospital with complaints of orthostatic faintness and occasional diarrhea. An echocardiogram of the left ventricule demonstrated a severe restrictive disorder and granular sparkling appearance in the thickened walls. Microscopic findings of the myocardial biopsy revealed massive intramuscular accumulation of eosinophilic exudates and severe atrophy of myocytes. Cardiac ^{99m} Tc-pyrophosphate (PYP) findings showed diffuse marked uptake in both left and right ventricules. Cardiac ^{123}I-meta-iodobenzyl-guanidine (MIBG) findings showed complete defect on both early and delayed images. Genetic analysis revealed a single amino acid substitution at codon 30 of transthyretine (TTR), named FAP type I. Dynamic monitoring of the cardiac index peripheral vascular resistance in postural positions and exercise was measured by non invasive methods (PhysioFlow™ Lab-1). The results of analysis indicated that the fall in blood pressure during exercise in our case was markedly affected by the lowering of peripheral vascular resistance. The cardiac index showed almost the same value during monitoring.
These findings suggest that orthostatic hypotension without increase in heart rate and output in a denervated myocardium is markedly accelerated by peripheral vascular sympathetic denervation in FAP type I. The present case is considered to be the first one encountered in Shiga.

Key words : FAP type I, cardiac amyloidosis, PhysioFlow™ Lab-1

CARDIOLOGY

Non invasive assessment of wave reflection phenomena in the central aorta

SUBMITTED TO THE 19TH SCIENTIFIC MEETING OF INTERNATIONAL SOCIETY OF HYPERTENSION, 23-27 JUNE , 2002, PRAGUE, CZECH REPUBLIC

Avolio A, Cook D, Old R , Halliday A,
[1]graduate School of Biomedical Engineering, University of New South Wales, Sydney, Australia

Objective.The central aortic pressure waveform is a result of interaction of left ventricular (LV) ejection, aortic characteristic impedance (Zo) and wave reflection. Wave reflection in systole can cause late systolic pressure augmentation thus increasing LV load. This study describes a new non-invasive method of quantifying wave reflection in the central aorta.

Design and Methods. Central aortic pressure (CAP) was determined non-invasively from the radial pulse using a SphygmoCor device (AtCor Medical, Sydney), and stroke volume (SV) using the Physioflow bioimpedance device (Manatec Biomedical, France). Aortic flow was derived by fitting a triangular wave in systole with time of peak flow corresponding with time of early systolic inflection of CAP and the area equivalent to measured SV. Zo was determined from the slope of pressure and flow in early systole. Forward (Pf) and backward (Pb) pressure waves were calculated from aortic pressure (Pa) and flow (Qa) waves: Pb = 0.5(Pa-Zo.Qa); Pf = Pb-Pa. A global reflection index (GRI) was determined as the Root Mean Squares (RMS) ratio of Pb/Pf. Rate of reflected pressure increase (RPI) was calculated from Pb between time of peak flow and end systole. Augmentation Index (AI) was determined as the ratio of pulse pressure (or late systolic shoulder) to pressure at peak flow. The technique is illustrated by performing calculations in 10 supine measurements in both a 21 year old (Young) and 56 year old (Old) subject.

Results.

	YOUNG		OLD		
	Mean	SEM	Mean	SEM	P
Heart Rate (bpm)	63.7	0.57	53.5	0.41	< 0.001
Ejection Duration (ms)	341	2.78	350	0.89	< 0.010
CAPP (mmHg)	25	0.32	42	0.19	< 0.001
SV (mL)	101	0.82	116	0.63	< 0.001
AI (%)	-5.4	2.97	31	1.08	< 0.001
GRI	0.48	0.01	0.56	0.01	< 0.001
RPI (mmHg/sec)	71	4.02	140	2.02	< 0.001

INTENSIVE CARE

Annals of Cardiac Anaesthesia 2002; 5:141-148

Advances in Noninvasive Cardiac Output Monitoring

Authors : David M. Linton and Dan Gilon Medical Intensive Care Unit and Departement of Cardiology Hadassah

Abstract : In EIC (Electrical Impedance Cardiographs) devices using Zo baseline impedance, large amounts of thoracic fluid may interfere with the impedance signal, making haemodynamic data unattainable or unreliable.[52-54] Severe pulmonary oedema may decrease the signal-to-noise ratio, damp the dZ/dt waveform, and inhibit haemodynamic data acquisition.

The latest methods of EIC (PhysioFlow®) are baseline impedance independent and use more advanced forms of impedance waveform morphology analysis.[43-46] New noninvasive irnpedance monitors are able to provide continuous trend monitoring of HR and SV giving derived CO and index parameters without the need for baseline impedance measurement. They use stroke waveform morphology analysis to determine SV and then calculate all the derived parameters.
Preload assessment is essential in any patient who may be at a risk of hypoperfusion. Assessment and management of preload catheter can be a challenge for clinicians. The insertion of a CVP catheter may help decision making but isolated measurements of CVP are not very informative. The trend of the CVP and in particular its response to a fluid challenge is far more valuable in planning the therapy. In PA catheterisation, the PAOP indirectly measures LV end-diastolic pressure and is related to LV end-diastolic volume, or preload. However, many factors affect the extrapolation of the PAOP to LV preload, such as reduced L V compliance, pulmonary hypertension or mechanical ventilation.

A simple manoeuvre using EIC to assess intravascular volume is to give a fluid challenge using the patient's own circulating volume as the fluid bolus. By elevating the legs or placing the patient in the "head clown" position, fluid moves from the lower extremities, increasing venous return. In a normal heart, the SV will increase. Patients who are hypovolaemic may show a significant increase in SV and would benefit from volume administration.

Patients with LV dysfunction or fluid overload may have minimal or no change in SV in response to a physiologic fluid bolus. These individuals do not have adequate cardiac reserve and cannot tolerate additional fluid. These patients may require treatment with inotropes or agents that reduce preload and afterload. Use of EIC to assess preload with a fluid affords valuable information regarding the patient's ability to tolerate additional fluids. The latest methods of El use advanced waveform morphology analysis to determine a filling index (FI) for the heart. Where CVP measurements are available the information can be used to supplement the FI data. The trend of the FI is likely to be o more value than isolated measurements particularly for monitoring response to interventions or planning therapy.

Medical Organization, P.O. Box 12000, Jerusalem II 911201

Conclusion

Recent technological advances have allowed the development of noninvasive methods of measuring CO with continuous on-line measurement and trending of SV and HR. Derived parameters such as SVI, CI, SVR, LCWI and EF can also be shown and recorded continuously. The new noninvasive technology is safe, reliable and relatively inexpensive and is increasingly being used in clinical practice and research. Completely noninvasive CO monitoring by modern EIC technology is suitable for continuous on-line and trend monitoring of SV, HR and derived parameters; and echocardiography, mainly TEE in the ICU, should be used for structural and functional evaluation of the heart as well as confirmation of SV and EF.

INTENSIVE CARE

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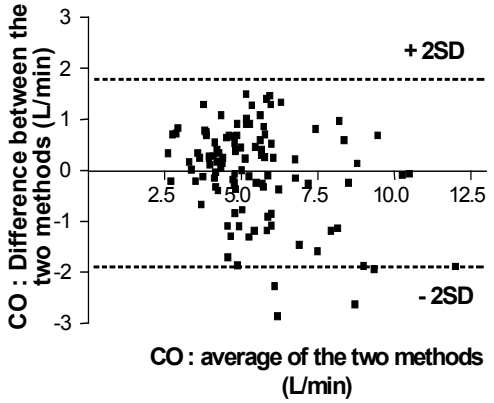
Cardiac output measurements : comparison between a new transthoracic electrical biomimpedance method (Physioflow™) and the Swan-Ganz method (Continuous Cardiac Output or Bolus Technique)

Authors : Moreau X, Rousseau JM*, Thiranos JC**, Dubé L, Corbeau JJ, Granry JC, Beydon L.
ICU – University Hospital Angers
* ICU, Val de Grâce Military Hospital, Paris
** ICU, Cardiovascular Surgery, Strasbourg

Abstract : Cardiac Output (CO) measurement using Transthoracic Electrical Bioimpedance (TEB) has been recently improved. We have tested a system using exclusively relative values of the impedance signal, and not absolute values (Z0). Indeed, the Z0 value has been described as being at origin of the practical limitations of TEB. We have chosen the Swan-Ganz method to provide reference values, using boluses (B), or continuous cardiac output (CCO) (BAXTER™ Vigilance®).
Results : 107 ICU patients underwent simultaneous CO measurements using the two methods (CO Swan Ganz : 20 B and 87 CCO). One measurement was performed on every patient (84 Male/23 Female, age 69±11 years, weight 75±15 Kg, height 167±8 cm). Pathologies : aortic and bypass surgery 65 %, septic shock 18%, heart failure 7%, pulmonary patients 7%, misc. 3%. Linear regression factor was 0.88 ($p<0.001$). CO PhysioFlow = 0.75 CO Swan + 1.33. Bland and Altman diagram is represented below (bias = -0.014 L/min).



Conclusion : This study has been done under the most difficult conditions for TEB : one single measurement per patient, and patients presenting a very large variety of pathologies. This new TEB method deserves further investigations, using the Fick method, on the same range of unselected ICU patients. Indeed, literature displays that Fick as a reference method features a reduced dispersion of results compared to thermodilution.[1]
References : 1. Charloux et al., Eur. J. Appl. Physiol. (2000) 82 313-320

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Hemodynamic responses of a spontaneous breathing trial monitoring by an impedance cardiograph.

Authors : Le Tacon S, Kara F, Harlay ML, Bosquet C, Hasselmann M and Sauder P. Service de réanimation médicale. Hôpital Civil, Strasbourg, France.

Introduction : Left ventricular insufficiency is a common cause of ventilator weaning failure. We evaluated the hemodynamic parameters during a T-piece trial.

Methods : We conducted a prospective, open study in an intensive care unit. Heart rate (Hr), stroke volume (SV) and cardiac index (Ci) measurements were performed by PhysioFlow^{TM} in ventilated adults ready for weaning. Patients with a SaO2>90% while breathing with a FiO2 of 40% or less, a PEEP<5cmH2O, a hemoglobin level above 8g/dl and without electrolyte disorders were included. Patients with inotropic drugs, altered mental status or pregnant women were excluded. We assessed the cardiac function during mechanical ventilation (MV) and during a T -piece trial of 30 minutes (SV). If a patient had any signs of poor tolerance during the trial the mechanical ventilation was reinstituted. Comparison of continuous variables was done with Student's T-test. A p value under 0.05 was considered as significant. Results are expressed as mean +/- standard error.

Results : 7 patients were included and 10 trials were executed. The rate of success was 70%. Three patients failed the trial (two met the criteria of a respiratory distress (respiratory frequency greater than 30/min) and one altered his Glasgow score. For the patients with a respiratory distress the Hr (108 +/- 11 bpm vs 108+/- 15 bpm), Sv (73 +/- 10 ml vs 89 +/- 16 ml) and Ci (4.5 +/- 1.5 l/min.m^2 vs 5.6 +/- 2.1 l/min.m^2) were unchanged during SV compared with MV. For the other patients Hr increased from 85 +/- 21 bpm to 90 +/- 19 bpm ($p<0.05$), Sv dropped from 80 +/- 10 ml to 72 +/- 14 ml ($p<0.05$) and Ci was unchanged with 3.5 +/- 0.7 vs 3.3 +/- 0.6 l/min.m^2.

Conclusion : We showed that the hemodynamic consequences of a spontaneous breathing trial was a decrease of Sv for the patients without signs of respiratory distress. Thoracic bioimpedance could be a good tool for the hemodynamic assessment during ventilator weaning.