ISSN 2683-2828

Cardiovascular and Metabolic Science

Continuation of the Revista Mexicana de Cardiología

2024

Asociación Nacional de Cardiólogos de México

- A national crusade against atherosclerosis is urgently
- Effects of high intensity interval training in cancer
- Correlation of the break point of the double product and the ventilatory thresholds
- AF in patient with ulcerative colitis
- Automated external defibrillator records and the national registry of out of hospital cardiac arrest in Mexico

VOLUME 35, NUMBER 3
JULY-SEPTEMBER 2024

Indexed under CUIDEN data base (Granada España)
Complete version on internet (indexed and compiled):
Medigraphic, Literatura Biomédica: www.medigraphic.org.mx

ARMSTRONG®
Comprometidos con tu salud

Angiotrofin A.P.®

Diltiazem

farmacias benavides · Farmacias del Ahorro · San Pablo FARMACIA · Soriana · yza FARMACIAS · H-E-B® · Walmart

Promoción en la compra de una caja de las siguientes presentaciones: Angiotrofin® 30 mg con 30 comprimidos, Angiotrofin® 60 mg con 30 comprimidos, Angiotrofin AP® 90 mg con 20 tabletas, Angiotrofin AP® 120 mg con 20 tabletas.
Promoción válida del 01 de abril al 31 de enero de 2025. En Farmacias Benavides, Farmacias del Ahorro®, Farmacia San Pablo, Soriana, Yza, HEB® y Walmart®


NUEVO
Evipress-H®
Toma el control
Integra en una SOLA cápsula
Eficacia antihipertensiva de lercanidipino
+
Efecto diurético de hidroclorotiazida
Permite alcanzar cifras meta
Evipress-H
Lercanidipino/Hidroclorotiazida
ALTIA
cápsula
10 mg/12.5 mg
Caja con 30 cápsulas
Mejora la adherencia y persistencia al tratamiento, logrando un mejor control.
Revisar IPP:
EVIP-H-01A-24
NO. DE ENTRADA: 2311032002C00013
ALTIA®
Senosiain®

Bibliotecas e Índices en los que ha sido registrada e indizada la Revista Cardiovascular and Metabolic Science

Medigraphic, literatura biomédica
http://www.medigraphic.org.mx

Free Medical Journals
http://www.freemedicaljournals.com/f.php?f=es

Biblioteca de la Universidad de Regensburg, Alemania
http://www.bibliothek.uni-regensburg.de/ezeit/fl.phtml?notation=WW-YZ&bibid=ZBMED&colors=3&frames=&toc=&ssg=

Biblioteca de la Universidad Federal de Sao Paulo, Brasil
http://www.unifesp.br/dis/bibliotecas/revistas.htm

Biblioteca del Instituto de Investigaciones Biomédicas, UNAM
http://www.revbiomedicas.unam.mx/_biblioteca/revistas.html

Universidad de Laussane, Suiza
http://www2.unil.ch/perunil/pu2/

Biblioteca de la Universidad Norte de Paraná, Brasil
http://www.unopar.br/bibli01/biologicas_periodicos.htm

LATINDEX. Sistema Regional de Información en Línea para Revistas Científicas de América Latina, el Caribe, España y Portugal
http://www.latindex.unam.mx/

Biblioteca Virtual en Salud (BVS, Brasil)
http://portal.revistas.bvs.br

Biblioteca del Instituto de Biotecnología, UNAM
http://www.biblioteca.ibt.unam.mx/revistas.php

Asociación Italiana de Bibliotecas (AIB)
http://www.aib.it/aib/commiss/cnur/peb/peba.htm3

Biblioteca Médica Estatal del Ministerio de Patrimonio y Cultura, Italia
http://bms.beniculturali.it/ejnls/index.php

Fundación Ginebrina para la Formación y la Investigación Médica, Suiza
http://www.gfmer.ch/Medical_journals/Revistas_medicas_acceso_libre.htm

PERIODICA (Índice de Revistas Latinoamericanas en Ciencias) UNAM
http://periodica.unam.mx

Google Académico
http://scholar.google.com.mx/

Wissenschaftszentrum Berlin für Sozialforschung, Berlin WZB
http://rzblx1.uni-regensburg.de/ezeit/detail.phtml?bibid=WZB&colors=3&lang=de

Virtuelle Bibliothek Universität des Saarlandes, German
http://rzblx1.uni-regensburg.de/ezeit/search.phtml?bibid=SULB&colors=7&lang=de

University of South Australia. Library Catalogue
http://search.library.unisa.edu.au/az/a

Biblioteca electrónica de la Universidad de Heidelberg, Alemania
http://rzblx1.uni-regensburg.de/ezeit/search.phtml?bibid=UBHE&colors=3&lang=de

Biblioteca de la Universidad de Bielefeld, Alemania
https://www.digibib.net/jumpto?D_SERVICE=TEMPLATE&D_SUBSERVICE=EZB_BROWSE&DP_COLORS=7&DP_BIBID=UBBIE&DP_PAGE=search&LOCATION=361

Department of Library Services, Christian Medical College - Vellore
http://dodd.cmcvellore.ac.in/ftext/free%20e-journalR.htm

Mercyhurst University. Hammermill Library. Erie, Pennsylvania
http://services.trueserials.com/CJDB/MERCYHURST/browse

Memorial University of Newfoundland, Canada
http://www.library.mun.ca/copyright/index_new.php?showAll=1&page=1

Journals for free
http://www.journals4free.com/

Google Books
http://www.google.com.mx/books?id=w0GaAAAAIAAJ&lr=&hl=en&redir_esc=y

Research Institute of Molecular Pathology (IMP)/ Institute of Molecular Biotechnology (IMBA) Electronic Journals Library, Viena, Austria
http://cores.imp.ac.at/max-perutz-library/journals/details/?tx_ezbfe_pi3%5Bjournal_id%5D=15597&cHash=ce986bc3bc6d621dbca9ddbfea98424b

Scielo México
http://www.scielo.org.mx

Cardiovascular and Metabolic Science

Continuation of the Revista Mexicana de Cardiología

Official communication organ of:

- Asociación Nacional de Cardiólogos de México
- Sociedad de Cardiología Intervencionista de México
- Asociación Nacional de Cardiólogos del Centro Médico La Raza
- Asociación Nacional de Cardiólogos al Servicio de los Trabajadores del Estado
- Asociación Mexicana para la Prevención de la Aterosclerosis y sus Complicaciones
- Alianza por un Corazón Saludable
- Sociedad Mexicana de Cardiología Preventiva
- Sociedad Mexicana de Electrofisiología y Estimulación Cardiaca
- Asociación Médica del Hospital de Cardiología Centro Médico Nacional Siglo XXI

Contents

Cardiovascular and Metabolic Science (continuation of Revista Mexicana de Cardiología), is the official organ of following medical societies and associations: Asociación Nacional de Cardiólogos de México (ANCAM), Sociedad de Cardiología Intervencionista de México (SOCIME), Asociación Nacional de Cardiólogos del Centro Médico La Raza (ANCCMR), Asociación Nacional de Cardiólogos al Servicio de los Trabajadores del Estado (ANCISSSTE), Asociación Mexicana para la Prevención de la Aterosclerosis y sus Complicaciones (AMPAC), Sociedad Mexicana de Electrofisiología y Estimulación Cardiaca (SOMEEC), Asociación Médica del Hospital de Cardiología Centro Médico Nacional Siglo XXI A.C., Sociedad Mexicana de Cardiología Preventiva, and Alianza por un Corazón Saludable. Address: Magdalena 135, Col. del Valle Norte, Benito Juárez, CP 03103. revmexcardiol@gmail.com, revistamexicanadecardiologia@medigraphic.com.
Cardiovascular and Metabolic Science publishes quarterly, one volume per year. Copyright reservation 04-2019-022717130200-102. Freely distributed with title Certificate in process and Content Certificate in process. ISSN: 2683-2828. eISSN: 2954-3835. Print run: 2,000 copies. The partial or total reproduction of the content of this number can be done with prior authorization of the publisher and mention of the source. **The concepts published in the articles are the entire responsibility of the authors. Cardiovascular and Metabolic Science** is registered in the following indexes: Scopus, EBSCO, Scielo, El Caribe, España y Portugal (LATINDEX, by its Spanish abbreviation), Medigraphic, Literatura Biomédica, Sistema Regional de Información en Línea para Revistas Científicas de América Latina, Literatura Latinoamericana en Ciencias de la Salud (LILACS), Google Scholar, Biblioteca Virtual en Salud, Brasil (BVS), Periódica-UNAM, and University of Salamanca Library, Spain.
Electronic address: **www.cardiovascularandmetabolicscience.org.mx** / **ancam@ancam.org.mx** / **www.medigraphic.com/cms** / **E-mail addresses: revmexcardiol@gmail.com**
Art, design, typesetting, printing and distribution by **Graphimedic, SA de CV.** Address: Coquimbo 936, Col. Lindavista, Alcaldía Gustavo A. Madero. C.P. 07300. Ciudad de México. Tels.: 55 8589-8527 al 32. E-mail: graphimedic@medigraphic.com ***Printed in Mexico.***

Contents

Contents / *Contenido*

Vol. 35 No. 3
July-September 2024

CARDIOVASCULAR AND METABOLIC SCIENCE www.ancam.org.mx

EDITORIAL COMMENT

Vol. 35 No. 3
July-September 2024

doi: 10.35366/117825

The terrible epidemic that devastates Mexico. A national crusade against atherosclerosis is urgently needed+

La terrible epidemia que devasta México. Urge una cruzada nacional contra la aterosclerosis+

Martín Rosas-Peralta,* Eduardo Meaney‡

On behalf of Members of GERETRA-HCL:

Carlos Aguilar Salinas, MD, PhD. Instituto Nacional de Ciencias Médicas y Nutrición «Salvador Zubirán».
Luis Alcocer Díaz-Barreiro, MD, MSc, GRETHA (Grupo de Expertos en Hipertensión Arterial).
Alejandro Alcocer Chauvet, MD, Presidente, ANCISSTE (Asociación Nacional de Cardiólogos al Servicio de los Trabajadores del Estado).
Simón Barquera, MD, PhD, Centro de Investigación en Nutrición y Salud, Instituto Nacional de Salud Pública de México (CINyS-INSP).
Gabriela Borrayo Sánchez, MD, PhD, Facultad de Medicina, UNAM (Universidad Nacional Autónoma de México).
Guillermo Ceballos Reyes, MD, PhD, Escuela Superior de Medicina, Instituto Politécnico Nacional (IPN).
Héctor Galván Oseguera, MD. UMAE Hospital de Cardiología del Centro Médico Nacional Siglo XXI del Instituto Mexicano del Seguro Social (IMSS).
Efraín Gaxiola López, MD, Presidente Sociedad Mexicana de Cardiología (SMC).
Enrique Gómez Álvarez, MD, Centro Médico Nacional 20 de Noviembre del Instituto de Seguridad y Servicios Sociales de los Trabajadores del Estado (ISSSTE).
Antonio González Chávez, MD, Hospital General de México «Dr. Eduardo Liceaga».
Arturo Guerra López, MD, FACC, Presidente, ANCAM (Asociación Nacional de Cardiólogos de México).
Patricia Martin Hernández. MD, MSc, Servicio de Cardiología. Secretaría de la Defensa Nacional (SEDENA).
Nayelli Nájera, PhD, Escuela Superior de Medicina, Instituto Politécnico Nacional (IPN).
Juan José Parcero Valdés, MD, FACC, FSCAI, FSIAC, Presidente, AMPAC (Asociación Mexicana para la Prevención de la Aterosclerosis).
Rosbel Toledo Ortiz, MD, PhD, Titular de Educación. IMSS-Bienestar.

* Academia Nacional de Medicina. Mexico.
‡ Escuela Superior de Medicina, Instituto Politécnico Nacional (IPN). Mexico.

+ From GERETRA-HCL (*Grupo de Expertos para la Recomendación Estratégica del TRAtamiento de la HiperColesteroLemia en México* [Group of Experts for the Strategic Recommendation of the Treatment of Hypercholesterolemia in Mexico]).

The socioeconomic, political, and cultural changes that Mexico experienced over recent decades substantially modified its population's nutritional, anthropometric, and epidemiological profiles to give rise to a rapid and regionally uneven epidemiological transition. Without completely disappearing, the old epidemics of previous times, rooted in extreme poverty, malnutrition, ignorance, and lack of basic hygiene, such as malaria, diarrheal diseases, tuberculosis, and others, have given way to a wave of chronic degenerative epidemics, such as obesity, type 2 diabetes mellitus, atherosclerotic diseases, and malignancies, in part originate from an unhealthy lifestyle and which are now the leading public health problems in Mexico. In 2023, 774,110 deaths occurred in the country, of which 50.5% corresponded to the sum of deceases due to heart diseases (24.4%),

How to cite: Rosas-Peralta M, Meaney E. The terrible epidemic that devastates Mexico. A national crusade against atherosclerosis is urgently needed. Cardiovasc Metab Sci. 2024; 35 (3): 82-88. https://dx.doi.org/10.35366/117825

diabetes mellitus (14.2%), and cancerous diseases (11.8%). Ischemic heart disease (mainly myocardial infarction) accounted for 75.5% of all cases of heart disease.[1] A prominent fact that must be noted first is that, currently, people with diabetes do not die from this disease but instead largely from cardiovascular complications, mainly myocardial infarction.[2,3] In this way, to the number of deaths due to ischemic heart disease, we would have to add an unknown but presumably significant number of deceases reported due to diabetes in the outdated death certificates still in use. Of similar relevance is the fact that a pathogenic phenomenon underlying atherosclerotic diseases, diabetes, and a vast proportion of cancerous diseases is obesity. According to the 2022 version of the National Health and Nutrition Survey (*Encuesta Nacional de Salud y Nutrición 2022* [Ensanut 2022]), 38.3% of the subjects surveyed were overweight, and 36.9% were obese, meaning that four-fifths of the adult population had an unhealthy weight.[4] Meanwhile, in school-age children and adolescents, the proportion of overweight was 19.2 and 23.9%, and obesity was 18.1 and 17.2%, respectively.[5] Those figures showed that nearly one-fifth of these young age groups have a weight problem. The exponential growth of obesity in our society is appalling, indicating that neither the Mexican state, the medical corporations, nor civil society, in general, have undertaken solid corrective actions to reduce the intensity of this epidemic flagellum. To make matters worse, if cardiovascular and cardiometabolic primary prevention is poorly and incompletely carried out, the clinical management (diagnosis and treatment) of both ischemic heart disease and diabetes is, in general, dreadfully performed.[6,7] The direct and indirect costs of ischemic heart disease and diabetes have not been fully estimated in Mexico in terms of clinical attention expenses, loss of years of life, early disability, and work absenteeism, but presumably must be very high.

An immovable medical paradigm is that lipid abnormalities are crucial in the genesis of atherosclerotic lesions.[8,9] The role of all lipid particles containing apoB100 has been well established,[10] particularly the more atherogenic lipid particle, the low-density lipoprotein (LDL).[11] Less universally accepted is the atherogenic effect of both hypertriglyceridemia and low concentrations of high-density lipoprotein (HDL), the so-called hypoalphalipoproteinemia. However, there is a robust body of evidence about the role of the increased concentration of triglycerides as a risk factor for atherosclerotic cardiovascular diseases (ASCVD).[12-15] The role of low HDL concentration is more elusive because, on the one hand, the protective effect of HDL depends not only on its plasma concentration but also on the tissue cholesterol extraction capacity of some genetic variants of its principal apolipoprotein ApoA-1.[16] Equally important is the fact that HDL sometimes behaves as a Janic molecule, being pro-inflammatory and atherogenic instead of protective.[17] Also, most of the once very promising CETP (cholesteryl ester transfer protein) inhibitor drugs (trapibs) have failed to show cardiovascular protection (CV) despite the remarkable increment of HDL concentrations. Only in the REVEAL study did one of these drugs, anacetrapib, show a moderate protective benefit.[18]

A set of dyslipidemic phenotypes assails the contemporary Mexican population: between 40% and 66% of the adult population is hypercholesterolemic, two-thirds have hypoalphalipoproteinemia, and more than 50% have hypertriglyceridemia.[19-21] As overweight and obesity are associated in a large proportion of the cases with insulin resistance syndrome and secondary hyperinsulinism, the Mexican overweight/obese and diabetic populations frequently present a consequence of these metabolic disarrays, a dyslipidemic complex named «atherogenic dyslipidemia» or «lipid triad». It is characterized by hypertriglyceridemia, hypoalphalipoproteinemia, and an increase of small and dense LDL lipoproteins,[22,23] and it is associated with a remarkable atherogenic power.[24] Some indications need to be corroborated in further studies that this type of dyslipidemia is a significant determinant of myocardial infarction in our population.[25] Finally, the role of lipoprotein(a) [Lp(a)]has been established as a relevant risk factor for ASCVD, aortic stenosis, and thrombosis.[26,27] As it is known, there are considerable interethnic differences in Lp(a) concentrations, which depend fundamentally on genetic influence. To our knowledge, only one group of Mexican researchers has studied this lipid in our population, showing an inverse correlation with the so-called metabolic syndrome and two alleles directly associated with coronary and aortic valve calcification.[28-30] More studies are necessary to confirm the influence of this lipoprotein on the ASCVD epidemic in Mexico.

Of the most significant importance is that various studies using different risk scales showed an ominous reality and a somber prognosis of Mexico's public health. The study REMECAR[31] comprehended subjects from a private registry with known or suspected cardiovascular diseases or carriers of cardiovascular risk factors. Using European risk scales (SCORE-2 and SCORE-OP),[32,33] it was estimated that 95% of these patients had high or very high risk. Despite this, around two-thirds of the participants were not on any lipid-lowering therapy, and only 12.4% received treatment with a high-intensity statin. Unsurprisingly, less than 20% of patients with established CV disease have goal LDL-c values less than 55 mg/dL.

Additionally, only a quarter of the patients with diabetes and 14% of subjects with other CV risk factors and high CV risk attained the LDL-c goals. In the primary prevention Lindavista study,[20] participants were not medicated with cholesterol-lowering drugs at the time of recruitment. In this study, the American College of Cardiology/American Heart Association ASCVD Risk Estimator system[34] and the GLOBORISK[35] tool showed that half of the cohort population had intermediate or high risk. However, both scales grossly underestimate the risk when their results were compared with the quotient TG/HDL (as a marker of insulin resistance and an index of CV forecasting).[12,36] The data from these studies reveal that in our country, in both sceneries of primary and secondary prevention, LDL-c goals are not achieved in most of the patients, because the diagnosis is not carried out, or statins are not used, inclusively in those conditions where they are mandatory, or because high-intensity statins are not used at the appropriate doses.

Despite everything described above, the Mexican national health system, fragmented as it is, devoid for political reasons of clear leadership at the national level, suffering a chronic shortage of financial resources, and in the absence of long-range preventive programs and solid public policies, has not identified the problem of dyslipidemia as a priority for the country's public health.[19]

To point out just a few of the severe limitations that make it difficult the primary and secondary prevention of ASCVD, mainly ischemic heart disease, we enlist the following problems:

1. **Mexico needs to spend more and better on health.** Mexican health spending (the sum of medical care goods and the cost of all services of clinical attention and prevention)[37] is one of the lowest not only among the 38 market-oriented economies encompassed in the OECD (Organization for Economic Cooperation and Development) but also among Latin American countries. For example, describing total health expenses as a percentage of the Gross Domestic Product (GDP, an index expressing the national wealth), Cuba spends 14%, Argentina, Brazil, Uruguay, El Salvador, Nicaragua, and Panama above or around 10%, and 8% Costa Rica.[38] In comparison, in 2022, Mexican health spending represented 5.1% of the national GDP,[39] at any rate, far from the 6% recommended by international organizations.[40] Still, even worse, only 2.93% came from the government (the rest went out of the citizen's pockets). In this context, health spending in Mexico is comparable to the poorest sub-Saharan African countries. With this scarcity of economic resources, achieving an efficient, universal, and modern level of clinical care is impossible, and neither is it possible to achieve effective cardiovascular prevention. That amount of health expenses is inadmissible for a country with the 12 or 14th world[41] economy (at the same level as Spain, Australia, and Korea).
2. **Control of the overweight and obesity epidemic, facing powerful resistance, is still far away.** Although some estimable advances have been made against the epidemics of overweight/obesity (for

example, the new labeling of food products different from the old one, designed and imposed by the food industry),[42] we are still far from implementing a series of public policies that limit on the one hand the mass consumption of ultra-processed junk food, sweetened beverages, and other poisonous products. On the other hand, the nation does not effectively encourage the achievement of cardiovascular and cardiometabolic health in our society, promoting, especially in childhood and adolescence, the frequent practice of physical exercise, a healthy diet, and the abstention from the consumption of tobacco products and other addictive substances. There is overwhelming evidence about the benefit of weight loss diminishing several atherogenic variables and mortality from CV outcomes.[43,44] Unfortunately, the frontal fight against this epidemic naturally faces opposition from powerful economic and political interests.[42]

3. **The country does not have the regulatory and legislative framework to establish public policies to reduce the ASCVD epidemic's force.** The nation lacks both legal framework and solid public policies, scientifically based, long-lasting, well-funded, and extensively publicized to reduce the incidence and lethality of ASCVD risk factors, mainly obesity, high blood pressure, lipid abnormalities, and smoking in our population. Before the era of statins, the North Karelia Project (then extended to all of Finland)[45] could reduce cardiovascular mortality (65% in men and 70% in women) in a brief lapse, simply convincing the Finnish society to reduce the consumption of saturated fat and salt, better control of blood pressure, and less smoking. These remarkable results were achieved by utilizing community interventions, public policies, and pertinent legislation, with the joint actions of the state organs, the industry, communications media, health personnel, and civil society.
4. **Clinical diagnosis of ASCVD risk factors, drug treatment, and therapeutic lifestyle modifications of dyslipidemias and other atherogenic determinants are generally not well carried out, especially at the first level of care, public and private.** This problem begins in primary medical education, as the curricula of almost all the 168 medical schools nationwide need to prioritize the prevention, diagnosis, and treatment of the nation's leading health problems. Neither, in general, the postgraduate residencies dedicate a special effort to increase in this field, with due depth and extent, future specialists' clinical and preventive skills. To make this problem even worse, the continuing medical education provided by the state to the physicians serving in public health institutions is scarce and occasional. The critical mission of raising and maintaining the knowledge and skills of physicians is mainly carried out by respected medical societies and congregations, sometimes with the economic assistance and help of the health industry. However, it is not always free of commercial intentions and distortions. As a result, in our most important health institutions, especially at the first level of care, as a general phenomenon (and, of course, with admirable exceptions), the clinical management of the most important CV risks is not the most appropriate, nor the closest to the current state of the art. Some data that backed up this last statement are addressed by several studies (some of them contradictories) on the control of different ASCVD determinants in Mexico. These results show a rate of dyslipidemia control of 30%, rates of control of high blood pressure from 21 to 50%, and adequate glycemic control in patients with diabetes at about 40%.[46-49] Health institutions do not regularly provide the diagnostic and therapeutic tools necessary for correctly managing ASCVD risk factors, mainly in the first and second levels of medical care. For example, the lipids usually measured in first-contact clinics are only total cholesterol and triglycerides. Without the measurement of HDL, it is impossible to estimate (with all the known limitations) LDL nor the non-HDL cholesterol and lipid triad, which are essential goals in a population like ours. Usually, dyslipidemia is diagnosed very late,

generally when there is already a clinical episode of ASCVD. The recommendation to determine the complete lipid profile of the entire population, starting at 18 years of age, is not followed.[50]

5. **In primary prevention, recognition of new cases of CV risk factors and estimation of risk are equally important.** In this respect, the nation does not have its own risk score, which properly considers certain frequent traits of the Mexican population. To tailor the intensity of treatment according to the level of risk, it is necessary to have a proper risk score that considers the anthropometric and metabolic traits of the Mexican population, mainly abdominal circumference and triglyceride concentrations, that are set out apart in all the most risk score systems done in other populations (the United States and Europe) very different to ours.[12,29-31] It is time to carry out our score system derived from a long-running, nationwide study of the main CV risk factors.

With all the above background, a group of academic-oriented physicians and scientists deeply involved in lipidology and cardiovascular prevention are interested in presenting a strategic plan to the new health authorities that would be simple, practical, and advantageous in cost-benefit relations. Although the other ASCVD risk factors (diabetes, hypertension, smoking, and obesity) have similar importance, our group called GERETRA-HCL (an acronym for the Spanish name of *Grupo de Expertos para la Recomendación Estratégica del TRAtamiento de la HiperColesteroLemia en* México, i.e., Group of Experts for the Strategic Recommendation of the Treatment of Hypercholesterolemia in Mexico) would focus its main interest in the reduction of the blood lipid disorders.

Ours is an entirely apolitical, heterogeneous group formed by persons coming from different institutions and associations: Hospitals of the social security institutions (IMSS, ISSSTE), from the Federal health hospitals (IMSS-Bienestar), cardiology and cardiovascular preventive national associations, several National Health Institutes, the Army, the National Academy of Medicine, and superior education institutions as the National Autonomous University of Mexico and the National Polytechnic Institute. The group does not have another purpose besides the wish to combat the ASCVD epidemic. We respectfully invite other basic, epidemiology, nutrition, or clinical scientists to join us in this crusade against one of the main ASCVD risk factors to alleviate the intensity and extension of the epidemic.

In a second future communication, the group will present to the new Secretary of Health, Dr. David Kershenobich, whose excellent academic accreditations are recognized by everyone, a project of strategic approach funded on international experiences.[51] The crusade that we propose is only possible under the auspices of the state but also requires the decisive involvement and compromise of all of us.

REFERENCES

1. INEGI. Estadísticas de defunciones registradas (EDR) 2023 (preliminar). https://www.inegi.org.mx/contenidos/saladeprensa/boletines/2024/EDR/EDR2023_ene-dic.pdf
2. Raghavan S, Vassy JL, Ho YL, Song RJ, Gagnon DR, Cho K et al. Diabetes mellitus–related all-cause and cardiovascular mortality in a national cohort of adults. J Am Heart Assoc. 2019; 8: e011295. DOI: 10.1161/JAHA.118.011295.
3. Cui J, Liu Y, Li Y, Xu F, Liu Y. Type 2 diabetes and myocardial infarction: recent clinical evidence and perspective. Front Cardiovasc Med. 2021; 8: 644189. https://doi.org/10.3389/fcvm.2021.644189.
4. Campos-Nonato I, Galván-Valencia O, Hernández-Barrera L, Oviedo-Solís C, Barquera S. Prevalence of obesity and associated risk factors in Mexican adults: results of the Ensanut 2022. Salud Publica Mex. 2023; 65 (supl 1): S238-S247. https://doi.org/10.21149/14809.
5. Shamah-Levy T, Gaona-Pineda EB, Cuevas-Nasu L, Morales-Ruan C, Valenzuela-Bravo DG, Méndez-Gómez Humarán I et al. Prevalence of overweight and obesity in Mexican school-aged children and adolescents. Ensanut 2020-2022. Salud Publica Mex. 2023; 65 (supl 1): S218-S224. https://doi.org/10.21149/14762.
6. Martínez-Sánchez C, Arias-Mendoza A, González-Pacheco H, Araiza Garaygordobil D, Marroquín Donday LA, Padilla-Ibarra J et al. Reperfusion therapy of myocardial infarction in Mexico: A challenge for modern cardiology. Arch Cardiol Mex. 2017; 87: 144-150. doi: 10.1016/j.acmx.2016.12.007.
7. Barquera S, Campos-Nonato I, Aguilar-Salinas C, Lopez-Ridaura R, Arredondo A, Rivera-Dommarco J. Diabetes in Mexico: cost and management of diabetes and its complications and challenges for health policy. Global Health. 2013; 9: 3. doi: 10.1186/1744-8603-9-3.
8. Gaggini M, Gorini F, Vassalle C. Lipids in atherosclerosis: Pathophysiology and the role of calculated lipid indices in assessing cardiovascular risk in patients

with hyperlipidemia. Int J Mol Sci. 2023; 24: 75. doi: 10.3390/ijms24010075.

9. Linton MRF, Yancey PG, Davies SS, Gray Jerome W, Linton EF, Song WL et al. The role of lipids and lipoproteins in atherosclerosis. In: Feingold KR, Anawalt B, Blackman MR, Boyce A, Chrousos G, Corpas E et al (editors). Endotext [Internet]. South Dartmouth (MA): MDText.com, Inc.; 2000. https://www.ncbi.nlm.nih.gov/books/NBK343489/.
10. Kounatidis D, Vallianou NG, Poulaki A, Evangelopoulos A, Panagopoulos F, Stratigou T. ApoB100 and atherosclerosis: What's new in the 21st Century? Metabolites. 2024; 14: 123. doi: 10.3390/metabo14020123.
11. Gidding SS, Allen NB. Cholesterol and atherosclerotic cardiovascular disease: a lifelong problem. J Am Heart Assoc. 2019; 8: e012924. doi: 10.1161/JAHA.119.012924.
12. Meaney A, Martínez-Marroquín MY, Samaniego-Méndez V, Fernández-Barros C, Hidalgo I, Nájera N et al. In search of an appropriate risk scale for Mexicans. The insufficiencies of the Globorisk scale. Cardiovasc Metab Sci. 2024; 35: 6-15. https://dx.doi.org/10.35366/114999.
13. Saadatagah S, Pasha AK, Alhalabi L, Sandhyavenu H, Farwati M, Smith CY et al. Coronary heart disease risk associated with primary isolated hypertriglyceridemia; population-based study. J Am Heart Assoc. 2021; 10: e019343. doi: 10.1161/JAHA.120.019343.
14. Farnier M, Zeller M, Masson D, Cottin Y. Triglycerides and risk of atherosclerotic cardiovascular disease: an update. Arch Cardiovasc Dis. 2021; 114: 132-139. doi: 10.1016/j.acvd.2020.11.006.
15. Sarwar N, Danesh J, Eiriksdottir G, Sigurdsson G, Wareham N, Bingham S et al. Triglycerides and the risk of coronary heart disease. 10 158 incident cases among 262 525 participants in 29 western prospective studies. Circulation. 2007; 115: 450-458. https://doi.org/10.1161/CIRCULATIONAHA.106.637793.
16. Sirtori CR, Calabresi L, Franceschini G, Baldassarre D, Amato M, Johansson J et al. Cardiovascular status of carriers of the apolipoprotein A-I(Milano) mutant: the Limone sul Garda study. Circulation. 2001; 103: 1949-1954. doi: 10.1161/01.cir.103.15.1949. PMID: 11306522.
17. G HB, Rao VS, Kakkar VV. Friend turns foe: transformation of anti-inflammatory HDL to proinflammatory HDL during acute–phase response. Cholesterol. 2011; 2011: 274629. http://dx.doi.org/10.1155/2011/274629.
18. Tall AR, Rader DJ. Trials and tribulations of CETP Inhibitors. Circ Res. 2018; 122: 106-112. doi: 10.1161/CIRCRESAHA.117.311978.
19. Rivas-Gomez B, Almeda-Valdés P, Tussié-Luna MT, Aguilar-Salinas CA. Dyslipidemia in Mexico, a call for action. Rev Invest Clin. 2018; 70: 211-216. doi: 10.24875/RIC.18002573.
20. Meaney A, Ceballos-Reyes G, Gutiérrez-Salmean G, Samaniego-Méndez V, Vela-Huerta A, Alcocer L et al. Cardiovascular risk factors in a Mexican middle-class urban population. The Lindavista study. Baseline data. Arch Cardiol Mex. 2013; 83: 249-256. doi: 10.1016/j.acmx.2013.05.002.
21. Meaney E, Pérez-Robles E, Ortiz-Flores M, Pérez-Ishiwara G, Meaney A, Munguía L et al. Overweight, obesity, and age are the main determinants of cardiovascular risk aggregation in the current Mexican population: The FRIMEX III Study. J Clin Med. 2024; 13: 2248. doi: 10.3390/jcm13082248.
22. Lorenzatti A, Toth PP. New perspectives on atherogenic dyslipidaemia and cardiovascular disease. Eur Cardiol Rev. 2020; 15: e04. https://doi.org/10.15420/ecr.2019.06.
23. Vinik AI. The metabolic basis of atherogenic dyslipidemia. Clin Cornerstone. 2005; 7: 27-35. doi: 10.1016/s1098-3597(05)80065-1.
24. Assmann G, Schulte H. The Prospective Cardiovascular Münster (PROCAM) study: prevalence of hyperlipidemia in persons with hypertension and/or diabetes mellitus and the relationship to coronary heart disease. Am Heart J. 1988; 116: 1713-1724. doi: 10.1016/0002-8703(88)90220-7.
25. Estrada-García T, Meaney A, López-Hernández D, Meaney E, Sánchez-Hernández O, Rodríguez-Arellano E et al. Hypertension and lipid triad are the most important attributable risks for myocardial infarction in a middle class urban Mexican population. Ann Nutr Metab. 2013; 63 (s1): 1343 (Abstract).
26. Bhatia HS, Wilkinson MJ. Lipoprotein(a): evidence for role as a causal risk factor in cardiovascular disease and emerging therapies. J Clin Med. 2022; 11: 6040. doi: 10.3390/jcm11206040.
27. Dentali F, Gessi V, Marcucci R, Gianni M, Grandi AM, Franchini M. Lipoprotein(a) as a risk factor for venous thromboembolism: A systematic review and meta-analysis of the literature. Semin Thromb Hemost. 2017; 43: 614-620. doi: 10.1055/s-0036-1598002.
28. Cardoso-Saldaña GC, González-Salazar María del C, Posadas-Sánchez R, Vargas-Alarcón G. Síndrome metabólico, lipoproteína(a) y aterosclerosis subclínica en población mexicana. Arch Cardio Méx. 2021; 91: 307-314. doi: 10.24875/acm.20000276.
29. Cardoso-Saldaña GC, Posadas-Sánchez R, González-Salazar MDC, Fragoso-Lona JM, Vargas-Alarcón G. Coronary artery calcium is associated with LPA gene variant RS7765803-C in Mexican mestizo population. The GEA project. Rev Invest Clin. 2020; 72 (2): 61-68. doi: 10.24875/RIC.19003138.
30. Cardoso-Saldaña G, Fragoso JM, Lale-Farjat S, Torres-Tamayo M, Posadas-Romero C, Vargas-Alarcón G et al. The rs10455872-G allele of the LPA gene is associated with high lipoprotein(a) levels and increased aortic valve calcium in a Mexican adult population. Genet Mol Biol. 2019; 42: 519-525. doi: 10.1590/1678-4685-GMB-2017-0371.19.
31. De Los Ríos-Ibarra MO, Leiva-Pons JL, Rodríguez-Reyes H, Alcocer-Gamba MA, Cortés-Lawrenz J, Vizcaíno-Rios FM et al. Risk stratification and lipid evaluation in Mexican patients, evidence of lipid and cardiovascular analysis in REMECAR. The Mexican registry of cardiovascular diseases (REMECAR group). Atheroscler Plus. 2022; 50: 32-39. doi: 10.1016/j.athplu.2022.08.002.
32. SCORE2 working group and ESC Cardiovascular risk collaboration. SCORE2 risk prediction algorithms: new models to estimate 10-year risk of cardiovascular

disease in Europe. Eur Heart J. 2021; 42: 2439-2454. doi: 10.1093/eurheartj/ehab309.

33. SCORE2-OP working group and ESC Cardiovascular risk collaboration. SCORE2-OP risk prediction algorithms: estimating incident cardiovascular event risk in older persons in four geographical risk regions. Eur Heart J. 2021; 42: 2455-2467. doi: 10.1093/eurheartj/ehab312.
34. Goff DC Jr, Lloyd-Jones DM, Bennett G, Coady S, D'Agostino RB, Gibbons R et al. 2013 ACC/AHA Guideline on the Assessment of Cardiovascular Risk: A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. J Am Coll Cardiol. 2014; 129 (Suppl. S2): S49-S73. doi: 10.1161/01.cir.0000437741.48606.98.
35. Hajifathalian K, Ueda P, Lu Y, Woodward M, Ahmadvand A, Aguilar-Salinas CA et al. A novel risk score to predict cardiovascular disease risk in national populations (Globorisk): a pooled analysis of prospective cohorts and health examination surveys. Lancet Diabetes Endocrinol. 2015; 3: 339-355. doi: 10.1016/S2213-8587(15)00081-9.
36. Martínez-Marroquín Y, Meaney A, Samaniego-Méndez V, Nájera N, Ceballos G, Fernández-Barros C et al. The TG/HDL-c lipid ratio as a cardiovascular risk marker in a Mexican urban middle-class population: Do we need a risk score tailored for Mexicans? J Clin Med. 2023;12: 6005. doi: 10.3390/jcm12186005.
37. OECD. Health spending. https://www.oecd.org/en/data/indicators/health-spending.html
38. Statista. Healthcare expenditure as percentage of gross domestic product (GDP) in Latin America and the Caribbean in 2021, by country. https://www.statista.com/statistics/899278/latin-america-health-expenditure-share-gdp-country/#statisticContainer.
39. INEGI. Cuenta satélite del sector salud de México (CSSSM) 2022. https://www.inegi.org.mx/contenidos/saladeprensa/boletines/2023/CSSSM/CSSSM2022.pdf
40. London School of Hygiene and Tropical Medicine. Resyst. A target for UHC: How much should governments spend on health? https://resyst.lshtm.ac.uk/
41. International Monetary Fund. https://www.imf.org/external/datamapper/NGDPD@WEO/OEMDC/ADVEC/WEOWORLD/CHN.
42. White M, Barquera S. Mexico adopts food warning labels, why now? Health Syst Reform. 2020; 6 (1): e1752063. https://doi.org/10.1080/23288604.2020.1752063.
43. Ryan DH, Yockey SR. Weight loss and improvement in comorbidity: differences at 5%, 10%, 15%, and over. Curr Obes Rep. 2017; 6: 187. https://doi.org/10.1007/s13679-017-0262-y
44. Doehner W, Gerstein HC, Ried J, Jung H, Asbrand C, Hess S et al. Obesity and weight loss are inversely related to mortality and cardiovascular outcome in prediabetes and type 2 diabetes: data from the ORIGIN trial. Eur Heart J. 2020; 41: 2668-2677. doi: 10.1093/eurheartj/ehaa293.
45. Puska P, Jaini P. The North Karelia Project: prevention of cardiovascular disease in Finland through population-based lifestyle interventions. Am J Lifestyle Med. 2020; 14: 495-499. https://doi.org/10.1177/1559827620910981.
46. Morales-Villegas EC, Yarleque C, Almeida ML. Management of hypertension and dyslipidemia in Mexico: Evidence, gaps, and approach. Arch Cardiol Mex. 2023; 93: 077-087. doi: 10.24875/ACM.21000330.
47. Basto-Abreu A, López-Olmedo N, Rojas-Martínez R, Aguilar-Salinas CA, De la Cruz-Góngora V, Rivera-Dommarco J et al. Prevalencia de diabetes y control glucémico en México: resultados nacionales 2018 y 2020. Salud Publica Mex. 2021; 63: 725-733. https://doi.org/10.21149/12842.
48. Meaney E. High blood pressure: the ambushed raider. Introductory remarks. Cardiovasc Metab Sci. 2022; 33 (Suppl 3): s173-s178. https://dx.doi.org/10.35366/105181.
49. Meaney E, Pérez-Robles E, Ortiz-Flores M, Perez-Ishiwara G, Meaney A, Munguía L et al. Overweight, obesity, and age are the main determinants of cardiovascular risk aggregation in the current Mexican population: The FRIMEX III study. J Clin Med. 2024; 13: 2248. doi: 10.3390/jcm13082248.
50. Grundy SM, Cleeman JI, Merz CN, Brewer HB Jr, Clark LT, Hunninghake DB et al. National Heart, Lung, and Blood Institute; American College of Cardiology Foundation; American Heart Association. Implications of recent clinical trials for the National Cholesterol Education Program Adult Treatment Panel III guidelines. Circulation. 2004; 110: 227-239. doi: 10.1161/01.CIR.0000133317.49796.0E.
51. Klaic M, Kapp S, Hudson P, Chapman W, Denehy L, Story D et al. Implementability of healthcare interventions: an overview of reviews and development of a conceptual framework. Implement Sci. 2022; 17 (1): 10. https://doi.org/10.1186/s13012-021-01171-737.

Correspondence:
Martín Rosas-Peralta, MD, PhD.
E-mail: martin99.rosas99@gmail.com
Eduardo Meaney, MD, PhD.
E-mail: lalitomini1@gmail.com

CARDIOVASCULAR AND METABOLIC SCIENCE www.ancam.org.mx

ORIGINAL RESEARCH

Vol. 35 No. 3
July-September 2024

doi: 10.35366/117826

Effects of high intensity interval training in cancer patients newly diagnosed with cardiovascular disease

Efectos del entrenamiento interválico de alta intensidad en pacientes con cáncer con nuevo diagnóstico de enfermedad cardiovascular

Javier Eliecer Pereira-Rodríguez,* Jorge Antonio Lara-Vargas,‡ Diana Marcela Ortega-Garavito,§ Dafne Guadalupe Palacios-Toledo,¶ Fernando Rivera-Theurel||

Keywords: high-intensity interval training, exercise, cancer, cardiovascular disease.

Palabras clave: *entrenamiento interválico de alta intensidad, ejercicio, cáncer, enfermedad cardiovascular.*

* Physiotherapist, Specialist in Cardiopulmonary Rehabilitation, Specialist in Epidemiology, Master in Palliative Care. PhD in Physiology. Centro de Estudios e Investigación FISICOL. Bogota, Colombia. ORCID: 0000-0002-9136-7603

‡ Physician, Cardiologist, Specialist in Cardiovascular Rehabilitation and Secondary Prevention. Master in Bioethics. Centro Médico 20 de Noviembre ISSSTE and Cardiofit, CDMX, Mexico. ORCID: 0000-0002-6683-9859

§ Physiotherapist, Specialist in Hand and Upper Extremity, Master in Education. Centro de Estudios e Investigación FISICOL. Cucuta,

ABSTRACT

Introduction: cancer and cardiovascular diseases (CVD) are among the main causes of mortality worldwide. In CVD patients, continuous moderate-intensity training and High-Intensity Interval Training (HIIT) are safe, effective, and may be a strategy to improve cardiovascular health. **Material and methods:** a prospective experimental study was performed with a sample of 275 cancer survivors recently diagnosed with CVD and low functional capacity, less than 4 METs (metabolic equivalent of task). A training program lasting 36 weeks was applied with assistance three times a week of 70 minutes per intervention and with pre and post-measurements of anthropometry by bioimpedance, New York Heart Association (NYHA) Scale, stress test, echocardiogram, sarcopenia (Anthropometry, muscular strength, and functionality), lipid profile, quality of life European Organization for Research and Treatment of Cancer Quality of Life Questionnaire Core 30 (EORTG-C30), questionnaire for fatigue (FACT-Fatigue scale), 6 minutes walk test for distance traveled and estimated VO_2. **Results:** significant improvement was reported in ejection fraction (40 ± 4.8 vs 47 ± 5.6; $p \leq 0.05$), functional capacity reported in METs (2.1 ± 1.6 vs 3.9 ± 0.9), quality of life (108 ± 14 vs 121 ±7.6; $p = 0.002$) and improvement in estimated VO_2max, strength, muscle percentage, and post-intervention blood pressure ($p \leq 0.05$). In addition, the lipid profile, glucose, abdominal circumference, fat percentage ($p \leq 0.05$), and sarcopenia (32 vs 13%; $p = 0.012$) decreased after HIIT training without any adverse events during the interventions in the study population. **Conclusions:** the use of HIIT training is an efficient and safe way to improve physical capacity, quality of life, anthropometric parameters, and control cardiovascular risk factors (CVRF) in cancer survivors with a recent diagnosis of CVD.

RESUMEN

Introducción: *el cáncer y las enfermedades cardiovasculares (ECV) se encuentran entre las principales causas de mortalidad a nivel mundial. En pacientes con ECV, el entrenamiento continuo de intensidad moderada y el entrenamiento en intervalos de alta intensidad (HIIT) son seguros, eficaces y pueden ser una estrategia para mejorar la salud cardiovascular.* ***Material y métodos:*** *estudio experimental prospectivo con una muestra de 275 supervivientes de cáncer con diagnóstico reciente de ECV y baja capacidad funcional, menos de 4 METs (equivalente metabólico). Se aplicó un programa de entrenamiento con duración de 36 semanas con asistencia tres veces por semana de 70 minutos por intervención y con mediciones pre y post de antropometría por bioimpedancia, escala de la New York Association, prueba de esfuerzo, ecocardiograma, sarcopenia (antropometría, fuerza y funcionalidad muscular), perfil lipídico, calidad de vida (EORTG-C30), cuestionario de fatiga (escala FACT-Fatigue), prueba de caminata de 6 minutos para distancia recorrida y VO2 estimado.* ***Resultados:*** *se reportó mejoría significativa en la fracción de eyección del ventrículo izquierdo (40 ± 4.8 vs 47 ± 5.6; $p \leq 0,05$), capacidad funcional reportada en METs (2.1 ± 1.6 vs 3.9 ± 0.9), calidad de vida (108 ± 14 vs 121 ± 7.6; $p = 0.002$) y mejora en el VO2 máx, fuerza, porcentaje muscular y presión arterial postintervención ($p \leq 0.05$). Además, el perfil lipídico, la glucosa, la circunferencia abdominal, el porcentaje de grasa ($p \leq 0.05$) y la sarcopenia (32 vs 13%; $p = 0.012$) disminuyeron después del entrenamiento HIIT sin ningún evento adverso durante las intervenciones en la población de estudio.* ***Conclusiones:*** *el uso del entrenamiento HIIT es una forma eficiente y segura de mejorar la capacidad física, la calidad de vida, los parámetros antropométricos y el control de los factores de riesgo cardiovascular (FRCV) en supervivientes de cáncer con diagnóstico reciente de ECV.*

How to cite: Pereira-Rodríguez JE, Lara-Vargas JA, Ortega-Garavito DM, Palacios-Toledo DG, Rivera-Theurel F. Effects of high intensity interval training in cancer patients newly diagnosed with cardiovascular disease. Cardiovasc Metab Sci. 2024; 35 (3): 89-98. https://dx.doi.org/10.35366/117826

Colombia. ORCID: 0000-0003-1001-5049
¶ Physiotherapist, Centro de Estudios e Investigación FISICOL. Puebla, Mexico. ORCID: 0000-0001-7919-1839
‖ Physician, Cardiologist, Specialist in Cardiovascular Rehabilitation & Primary Prevention. Cardiovascular Prevention & Rehabilitation Program, Toronto Rehabilitation Institute. Clinical Fellow of the Ted Rogers Cardiotoxicity and Prevention Program, Peter Munk Cardiac Centre, University Health Network. Toronto, Canada. ORCID: 0000-0002-4986-5414

Received: *02/08/2024*
Accepted: *08/19/2024*

Abbreviations:

1RM = One repetition maximum.
AHA = American Heart Association.
ACS = American Cancer Society.
AMPK = 5′ adenosine monophosphate-activated protein kinase.
BMI = Body mass index.
BPM = Beats per minute.
CaMK = Calcium-calmodulin-dependent protein kinase kinase.
CORE = Cardio-oncology rehabilitation.
CR = Cardiac rehabilitation.
CRF = Cardiorespiratory fitness.
CV = Cardiovascular.
CVD = Cardiovascular diseases.
CVRF = Cardiovascular risk factors.
DBP = Diastolic blood pressure.
EORTC-C30 = European Organization for Research and Treatment of Cancer Quality of Life Questionnaire Core 30.
HIIT = High-Intensity Interval Training.
LDL and HDL = Low and high-density lipoproteins.
LVEF = Left Ventricular Ejection Fraction.
METs = Metabolic equivalent of task.
MHR = Maximal Heart Rate.
NYHA = New York Heart Association.
PGC-1 = Peroxisome proliferator-activated receptor gamma coactivator 1-alpha.
QoL = Quality of life.
SBP = Systolic blood pressure.
VO_2 = Estimated Maximal Oxygen Uptake.

INTRODUCTION

Cancer and Cardiovascular Disease (CVD) are among the leading causes of mortality worldwide.[1] Emerging epidemiological evidence demonstrates the entwined relationship between common etiologies and risk factors between cancer and CVD.[2] In recent times, it has been demonstrated that oncological survivors of most site-specific cancers have increased their risk in the medium-term to long-term compared with the general population.[3] Also, common anti-oncological therapies can be directly injurious to the cardiovascular (CV) system,[4] leading to significantly increased risks for acute and long-term CVD in survivors.[5] This brings the need for more strategies that could reduce the incidence and severity of these associated risk factors within both conditions. Cardiac rehabilitation (CR) has been the cornerstone of primary and secondary CVD treatment for decades. Recently, The American Heart Association (AHA) and the American Cancer Society (ACS) endorsed the adoption of the CR model to improve CVD outcomes in cancer patients and survivors.[6]

Added to the higher risk of CVD and other comorbidities, oncological survivors have a decline in quality of life (QoL) because of the long-term effects of some oncological treatments (surgery, chemotherapy, radiotherapy, hormonal therapy) and the treatment-related adverse effects such as fatigue, pain, decreased activity levels that impair physical capacity, muscle strength, cardiorespiratory fitness, range of motion limitations, lymphedema, and limb dysfunction.[7,8]

Exercise has clearly demonstrated to be a strong pleiotropic intervention with established multi-system benefits in non-cancer populations.[9] These benefits of exercise for oncological survivors have been clearly demonstrated, including improved Cardiorespiratory Fitness capacity (CRF),[10] muscular strength,[11] long-term symptoms (i.e., fatigue, pain),[12] and psychosocial well-being of survivors (i.e., anxiety and depression).[13]

The association between exercise and decreased mortality has led to the investigation of different intervention strategies in cancer patients,[14] including resistance exercises that begin to play a very important role in cancer patients. Concerning High-Intensity Interval Training (HIIT) is a variable-intensity resistance modality that is characterized by having very short periods with high-intensity workloads, which are interspersed by rest or periods at low intensity as recovery.[15] However, as it is a more intense modality for patients, it is not always the first choice for physical exercise, and therefore, the patient must be selected, and this modality must be prescribed carefully and under strict monitoring to ensure the safety of the participants.

HIIT has been shown to be time efficient due to the total time of vigorous exercise is greater than what could be achieved in a continuous exercise session with the same intensity before exhaustion, as well as being a safe option to improve CRF, which is measured by the

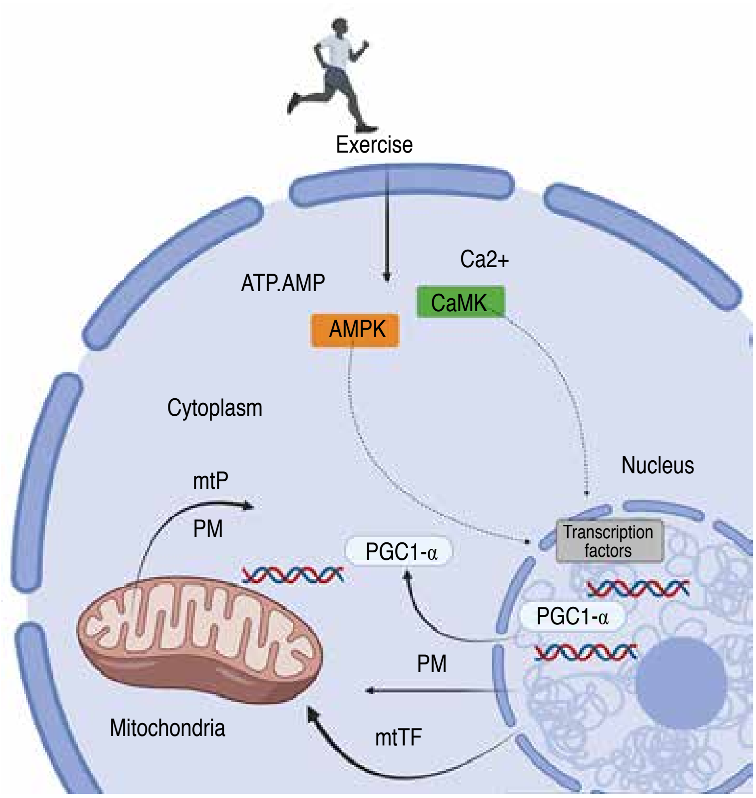


Figure 1: Regulation of mitochondrial biogenesis by HIIT training. 1) During endurance activity, an acute increase in the intracellular concentration of Ca+, ADP, and AMP and a decrease in the concentration of glycogen in contracting muscles is observed. High concentrations of ADP and AMP induce phosphorylation of AMPK, while high concentration of Ca+ causes autophosphorylation of CaMK through the protein calmodulin. This dual activation of AMPK and CaMK regulates transcription factors that modulate PGC-1alpha gene expression, a crucial step in the regulation of mitochondrial biogenesis. 2) AMPK, p38, Gen5, and siRNA, as kinases and acetylation modulators, carry out the phosphorylation and deacetylation of PGC-1a, thus enhancing its activity. 3) The activated form of PGC-1a associates with chromatin regulatory factors, triggering the opening of chromatin to facilitate transcription. Furthermore, PGC-1a establishes interactions with other transcription factors, such as NRF. 4) This process results in an increase in the expression of mitochondrial proteins, as well as the expression of mitochondrial transcription and replication factors (mtTFs) encoded in DNA. 5) Once expressed, mtTFs migrate to the mitochondria, bind to mitochondrial DNA (mtDNA), and catalyze the expression of mtDNA-encoded proteins (mtP), as well as mtDNA replication. Finally, both mtTF and mtP form mature complexes, triggering mitochondrial division and resulting in the formation of new mitochondria. Created with BioRender.com

AMP = adenosine monophosphate. AMPK = 5' adenosine monophosphate-activated protein kinase. AMP-activated protein kinase. ATP = adenosine triphosphate. CaMK = Calcium-calmodulin-dependent protein kinase kinase. PGC-1 = Peroxisome proliferator-activated receptor gamma coactivator 1-alpha. PM = mitochondrial proteins.

maximum oxygen consumption (VO_2max).[8] In addition, its activation effects on AMPK and Calcium-calmodulin-dependent protein kinase kinase (CaMK) pathways increase the activity of PGC-1 alpha and thus improve mitochondrial biogenesis *(Figure 1)*. For this reason, it is posed as a research question: what are the cardiovascular effects of HIIT in cancer patients newly diagnosed with CVD? Therefore, the objective is to identify the cardiovascular effects of high-intensity interval training in cancer patients with the diagnosis of cardiotoxicity.

Physical exercise is a therapeutic strategy that has the ability to act through multiple systems, facilitating the attenuation and prevention of side effects associated with treatments. Until now, exercise recommendations for cancer patients have been focused primarily on low-to-moderate intensity aerobic activity. However, it is currently suggested that high-intensity exercise prescription has the same and even greater effects compared to continuous aerobic exercise and that this could reduce the risk of mortality in cancer.

In patients with CVD, moderate-intensity continuous training and HIIT are both safe and effective in improving CV health.[16] However, HIIT is associated with a greater frequency and magnitude of benefits in the CV function (i.e., increased CRF,[17] CVD risk factors,[18] QoL,[19] and CV morbidity and mortality.[17] For this reason, we may estimate the effects (CV parameters and QoL) of HIIT on oncological survivors newly diagnosed with CVD with low functional capacity.

MATERIAL AND METHODS

Study design

A prospective experimental study was performed with a sample of 275 cancer survivors (stage II cancer) referred by the oncology department who were recently diagnosed with CVD and low functional capacity (less than 4 METs). Participants shared similar in terms of Left Ventricular Ejection Fraction (LVEF), functional fitness capacity (CRF) by New York Heart Association (NYHA) and stress test, percentage of both muscle mass and body fat, and body mass index (BMI), abdominal circumference, and cardiovascular risk factors (CVRF) such as diabetes, hypertension, and dyslipidemia.

Participants

In the present investigation, patients were referred by the oncology service who were newly diagnosed with CVD after their anti-oncological treatment program in Cúcuta, Colombia. The diagnosis of CVD was made with the new onset of CV symptoms, abnormal natriuretic peptides, positive troponin, or decreased LVEF. Patients were referred after one month of the completion of their oncological treatment.

Inclusion and exclusion criteria

Regarding inclusion criteria, the patients had to be in stage II of their oncological process and sign the respective informed consent, that they could attend cardiovascular rehabilitation sessions three times a week, and finally, that they had an LVEF greater than 35% and who were over 18 years of age. Contraindications included those who presented severe pain in both lower and upper limbs; a heart rate above 120 beats per minute (BPM) at rest; patients with moderate or high functional capacity (> 4 METs), systolic blood pressure (SBP) > 190 mmHg or diastolic blood pressure (DBP) > 120 mmHg; unstable angina; people who presented a contraindication for make exercise training and finally those who showed hemodynamic instability without improvement in any test or during the intervention process.

Table 1: Types of cancer. (N = 275).

Types of cancer	Experimental group n (%)
Prostate	82 (29.8)
Breast	70 (25.4)
Colorectal	27 (9.8)
Cervix	13 (4.7)
Thyroid	22 (8.0)
Lung	22 (8.0)
Stomach	13 (4.7)
Liver	8 (2.9)
Pancreas	3 (1.0)
Kidney	13 (4.7)
Esophagus	2 (0.72)

Ethical considerations

This clinical study was carried out following the Declaration of Helsinki, the signing of the informed consent, under the authorization of the subjects involved, and the ethics committee of the Centro de Estudios e Investigación FISICOL with code IP245.

Variables

The anthropometric characteristics data such as weight, height, body mass index, abdominal circumference, percentages of body fat, and muscle mass were collected by bioimpedance. In addition to this, through a questionnaire (created for this research), personal and family history information was obtained.

The clinical and hemodynamic parameters were considered levels of cholesterol, triglycerides, and low and high-density lipoproteins (LDL and HDL) through a blood glucose sample. A two-dimensional echocardiography was also performed to obtain the LVEF and analyze movements in real-time; with this, the New York Heart Association (NYHA) classification was identified in each subject, the perceived dyspnea and the effort was measured using the modified Rating of Perceived Exertion (RPE) by the modified Borg scale,[20] in terms of heart rate, a Polar Multisport RS800CX system monitored it, blood pressure taken manually and oximetry with a portable oximeter.

Regarding the QoL, it was measurable thanks to the European Organization for Research and Treatment of Cancer Quality of Life Questionnaire Core 30 (EORTG-C30)[21] Questionnaire was used with its respective interpretation following the guide of the manual of the European Organization for Research and Treatment of Cancer[22] that consists of 30 questions, with a score of 1-4 items, the higher the score, the better the quality of life. Likewise, the levels of sarcopenia were determined. Where the three criteria of the European Consensus on Sarcopenia[23] in 2010 are as follows: a) Walking, using the

Table 2: Baseline characteristics of the study population. (N = 275).

Characteristics	Experimental group
Sex	
Men	150
Woman	125
Age (years)	56 ± 10
LVEF, (%)	40 ± 4.8
Size, (m)	1.63 ± 14
Weight, (kg)	84 ± 10.7
BMI	34 ± 3.1
Abdominal circumference, (cm)	93 ± 7.5
Fat*	29 ± 4.4
Muscle*	32 ± 9.1
Force, (kg)	27 ± 9.3
Sarcopenia*	32%
Calf circumference	37.9 ± 11.5
Cholesterol, (mg/dL)	195 ± 13.5
Triglycerides, (mg/dL)	130 ± 12.7
LDL, (mg/dL)	118 ± 23.4
HDL, (mg/dL)	41 ± 3.6
Fasting glucose, (mg/dL)	135 ± 11.3
Estimated VO_2	7.5 ± 5.7
METs	2.1 ± 1.6
Fatigue (FACT-F)	16.3 ± 9.7
Quality of life	108 ± 14.0
Distance traveled	243 ± 23.0
MHR in stress test	156 ± 12.0
Overweight and/or obesity*	78
Abdominal obesity*	88
Dyslipidemia*	25
Arterial hypertension*	31
Diabetes mellitus*	56
Renal disease*	11
Sedentary lifestyle*,‡	91
Depression*	57
Anxiety*	18
Smoking*	40
Alcoholism*	15
Improper diet*	56
MI history*	4
Sex female*	45
Age,*,§	5

FACT-F = functional assessment of cancer therapy fatigue. mg/dL = milligrams/deciliters. METs = metabolic equivalent. MHR = maximum heart rate.
* Percentage. ‡ Less than 150 minutes per week. § Over 60 years old.

short physical performance battery (SPPB). b) Muscular strength is measured using dynamometry with values dependent on sex and age. c) Muscle mass, measured with BMI and calf circumference, as a starting point of 31 cm. Finally, fatigue was evaluated according to the Fatigue Scale for Functional Evaluation of Cancer Therapy (FACT-Fatigue scale),[24] which consists of 13 items with a score of 0-4 each, with a higher score reflecting less fatigue associated with cancer.

On the other hand, for the estimated volume of oxygen, a 6-minute walk test (6MWT)[25,26] was performed, the same for meters traveled, VO2 (Estimated Maximal Oxygen Uptake), METs (Metabolic Equivalent of Task), to obtain exact and measurable values of the physical and aerobic capacity accordance with the American Thoracic Society (ATS) Statement: Guidelines for the six-minute walk test of the ATS.[25,26]

Interventions

Firstly, every participant was evaluated by the cardiac rehabilitation department to determine his baseline clinical status and sociodemographic, anthropometric, and physiological characteristics. We performed an Exercise Stress Test through Naughton's protocol for Maximal Heart Rate (MHR) and were able to prescribe exercise effectively and accurately. Regarding the tool to measure strength, the one repetition maximum (1RM) test was used. It is worth mentioning that, during the intervention, the participants received counseling regarding stopping smoking and nutritional support to further improve patient outcomes as the standard of care in the CRP.

The training program lasted 36 weeks with assistance three times a week with 70 minutes per intervention, where 10 minutes were warm-up (breathing exercises, walking, stretching), 20 minutes of strength training, and 30 minutes of aerobic exercise consisted of a protocol created for this experimental group that we call it 30-30. Thirty seconds at moderate intensity (60-80% of MHR obtained by stress test) and 30 seconds at a high intensity (80-90% of MHR obtained by stress test), and the last 10 minutes were for cooling (Coordination, balance, walking and breathing exercises). This exercise program was done with fast walking or endless jogging with the sloping floor to reach the desired intensity, as well as by bicycle, elliptical, and rowing. During the entire intervention, the patient was monitored by a *Polar Multisport RS800CX*, oximetry, and the Borg scale (0-10 points) to avoid exceeding the training intensity (60-80% or 80-90% MHR obtained by stress test, > 7 Borg scale). The inclination, resistance, or speed of the exercises was assigned according to the indicative parameters (MHR obtained by the stress test, VO_2, Borg) for moderate or high intensity.

STATISTIC ANALYSIS

A database was created in Microsoft Excel 16.0 with all patients and their results of tests and questionnaires pre and post-training. Then, descriptive statistics were carried out to estimate and display the data by means of their corresponding standard deviation. The normality of the data was assessed by the Kolmogorov-Smirnov test, and the indication of specificity was evident for all analyses. Also, the ANOVA analysis of variance (one-way analysis of variance) was used, and subsequently, post hoc tests through the Tukey test were used to assess the characteristics of the different age groups, genders, and anthropometry. In all

Table 3: Post workout changes. (N = 275).

	Experimental group		
Variable	Pre	Pos	p
Ejection fraction, (%)	40 ± 4.8	47 ± 5.6	0.001
Weight, (kg)	84 ± 10.7	75 ± 3.5	0.002
BMI	34 ± 3.1	28 ± 1.3	0.001
Abdominal circumference, (cm)	93 ± 7.5	88 ± 5.2	0.002
SBP	139 ± 11.3	129 ± 2.3	0.001
DBP	86 ± 6.2	80 ± 1.3	0.001
Fat, (%)	29 ± 4.4	21 ± 5.5	0.001
Muscle, (%)	32 ± 9.1	36 ± 5.7	0.001
Force (kg)	27 ± 9.3	38.2 ± 8.4	0.001
Sarcopenia, (%)	32.0	13.0	0.012
Calf circumference	37.9 ± 11.5	48.6 ± 4.2	0.000
Cholesterol (mg/dL)	195 ± 13.5	180 ± 11.4	0.001
Triglycerides (mg/dL)	130 ± 12.7	115 ± 11.3	0.000
LDL (mg/dL)	118 ± 23.4	102 ± 12.6	0.001
HDL (mg/dL)	41 ± 3.6	49 ± 4.4	0.001
Fasting glucose (mg/dL)	135 ± 11.3	123 ± 7.1	0.002
VO_2 Estimated	7.5 ± 5.7	13.9 ± 3.3	0.001
METs	2.1 ± 1.6	3.9 ± 0.9	0.003
Fatigue (FACT-F)	16.3 ± 9.7	5.5 ± 4.9	0.002
Quality of life	108 ± 14	121 ± 7.6	0.002
Distance traveled	243 ± 23	312 ± 29	0.001
MHR-stress test	156 ± 12	175 ± 14	0.001

BMI = body mass index. DBP = diastolic blood pressure. HDL = high-density lipoprotein. LDL = low intensity lipoprotein. METs = metabolic equivalent. mg/dL = milligrams over deciliters. MHR = maximum heart rate. SBP = systolic blood pressure. VO_2 = maximum oxygen consumption.

cases, a significance level of 5% ($p \leq 0.05$) was established, and everything done was carried out in the PRISMA program.

RESULTS

After initial exclusions (six patients did not want to participate) and withdrawals, 275 participants were included in the structured CRP using HIIT. Oncological diagnoses are described in *Table 1*. The baseline characteristics of the participants are described in *Table 2*. This study included 125 female participants (45.45%), median age was 56 ± 10. Most of the participants had more than 2 CVRFs, including overweight or/obesity (78%), abdominal obesity (88%), dyslipidemia (25%, hypertension (31%), diabetes mellitus (56%), renal disease (11%) and sedentary lifestyle (91%). Regarding the psychosocial status, half of the participants score for depression (57%) and anxiety (18%). The baseline estimated mean CRF in the participants confirmed their low functional status (METs 2.1 ± 1.6) with an estimated VO_2 (7.5 ± 5.7). Primary outcomes and exploratory outcomes are described below.

Primary outcome: effects on the CRF

There was a significant improvement in the functional capacity after the intervention reported in METs (2.1 ± 1.6 vs 3.9 ± 0.9, $p = 0.003$), currently to the improvement in the estimated VO_2 (7.5 ± 5.7 vs 13.9 ± 13.9 $p = 0.001$). Regarding the 6 MWT, improvements were noted (243 ± 23 vs 312 ± 29 mt, $p = 0.001$). It was found a significant improvement in LVEF (40 ± 4.8 vs 47 ± 5.6%, $p = 0.001$). Other significant improvements were noted in the SBP and DBP *(Table 2)*.

Primary outcome: effects on the QoL

It was reported a significant improvement in patient-perceived QoL (108 ± 14 vs 121 ± 7.6 $p = 0.002$) and improvements in the perceived participant fatigue (16.3 ± 9.7 vs 5.5 ± 4.9%, $p = 0.002$).

Exploratory outcomes: effects on anthropometrics parameters

There was a significant improvement in the participants' weight (84 ± 10.7 vs 75 ± 3.5 kg, $p = 0.002$), abdominal circumference (93 ± 7.5 vs 88 ± 5.2 cm, $p = 0.002$), fat percentage (29 ± 4.4 vs 21 ± 5.5%, $p = 0.001$), muscle percentage (32 ± 9.1 vs 36 ± 5.7%, $p = 0.001$), muscle strength (27 ± 9.3 vs 38.2 ± 8.4%, $p = 0.001$), and sarcopenia (32 vs 13%, $p = 0.012$) *(Table 3)*.

Exploratory outcomes: cardiovascular risk factors management

We noticed an improvement in the metabolic profile of the participants, including weight, lipid profile post-intervention, fasting glucose levels, SBP, and DBP, and as previously mentioned in the anthropometric effects of the intervention.

Safety and adverse events

After the different interventions in the research groups, we can mention that no adverse events, falls, or injuries were reported in the participants. The interventions were fully monitored, and no hemodynamic or metabolic alterations were identified in the research participants. Therefore, the interventions and protocols carried out demonstrated great safety in the study population.

DISCUSSION

The present study is one of the first to evaluate the effects of HIIT in oncological patients with a new diagnosis of CVD and low functional capacity. It compared the effects on CRF and QoL and other exploratory parameters such as CVRFs and anthropometric measurements. The main finding was the statistically significant improvement of the CRF (expressed as METs and estimated VO_2). An improvement of one MET has been demonstrated to reduce CV morbidity and mortality.[27] The effects of HIIT in oncological survivors have been investigated in other studies, and their results were related to an improvement up to 3.77

Contents

mL/kg/min ($p \leq 0.05$),[28] showing similar benefits to our study.

Recently, it has been possible to elucidate with a good level of evidence that the HIIT effect is capable not only of increasing the maximum thresholds of cardiorespiratory fitness (particularly of VO_2) but also of producing a greater degree of positive remodeling in patients with ventricular dysfunction, such as the case of cardio-oncology patients who usually have systolic or diastolic ventricular involvement.[29]

One of the main controversies concerning the intervention is the heterogeneity of the structure of HIIT. The variations of this aerobic resistance training modality respond not only to the number of intervals that the patient can sustain during a 30-minute session but also to the intensity and duration in which the high-intensity interval will be provided. Some studies have proposed HIITs from 30 seconds to 2 minutes, with active breaks of the same duration. This becomes relevant when the cut-off points for the maximum intensity of HIIT are established, which, in patients with heart disease, vary between 85 and 90% of VO_2peak or HR reserve, as it was performed in the first pilot studies with cardio-oncology rehabilitation (CORE).[30,31] What is certain is that, for the HIIT-based intervention to differ from MICT, it is important that not only do high-intensity intervals exist on a continuous moderate basis, but that, in general, the HIIT training volume should be hypercaloric compared to the one achieved in MICT, as has been attempted in training strategies in patients with chronic heart failure.[32] In our study, our high-intensity intervals were formulated in 30-second pulses at an intensity of almost 90% of the HRR, reaching for gains in cardiorespiratory fitness.

One of the great strengths of our study lies in the interdisciplinary intervention that patients received, beyond the HIIT strategy coupled with muscle strength training. The last one should be repeated until it becomes difficult to continue the exercise because of its effects on muscular function and body composition, as has been reported in the meta-analysis of Strasser B et al.[33] The control of risk factors and nutritional care with a view to metabolic control is part of the recognized processes within CORE, as established in the Scientific Statement from the American Heart Association.[34]

Health-related QoL is an important factor in this population due to the impact of the decreased functional dimensions of physical, social, cognitive, and emotional well-being. Previous and most recent evidence showed similar improvements of a HIIT intervention on global quality of life, physical functioning, role functioning, cognitive functioning, fatigue, pain, dyspnea, and insomnia compared to an inactive control group.[35] Cardio-oncology rehabilitation is a comprehensive approach with a focus on QoL, cardiovascular risk profile, and cardiorespiratory fitness, as developed in our study.[36]

Limitations

To further understand the impact of a structured CRP using HIIT, we need to compare the unique potential benefits of HIIT to a MICT control group, which in this study was not possible to do. We still have some questions about the impact and effects of a standard CRP in oncological survivors compared to only receiving standard care. We need to further evaluate the long-term effects of this intervention and to see if the potential benefits can be maintained during a prolonged time.

One of the remaining questions is to evaluate if the reported effects of the intervention can be greater by the underlying oncological diagnosis or to the specific presenting CVD.

A limitation to consider in this study is the absence of nutritional and pharmacological control and monitoring in this type of population. These are important interventions that contribute to the outcome of these patients. Therefore, it is suggested that for future research of this type, an analysis of these variables can be made and the participation of suitable professionals for this purpose, either in the role of co-authors or research advisors.

CONCLUSIONS

The overlap in risk factors and disease prevention for cancer and CVD suggests that both diseases share common underlying pathophysiology pathways, such as chronic inflammation, which would potentially lead to worse patient outcomes. For this reason, our study suggests that using HIIT intervention is an efficient way with a security profile to improve fitness capacity, QoL, and anthropometric parameters and control CVRF in participants survivors of cancer who presented a recent CV event or CVD. We further need more randomized control studies to establish clearer and stronger evidence of the effects of this type of training. These results need to be compared with moderate-intensity continuous training (MICT) to define a preference strategy in cardio-oncological patients.

ACKNOWLEDGEMENT

We thank all the researchers at the Centro de Estudios e Investigación FISICOL.

REFERENCES

1. The top 10 causes of death, World Health Organization, 2020. Available in: www.who.int
2. Koene RJ. Shared Risk Factors in Cardiovascular Disease and Cancer. Circulation. 2016; 5 (11): 1104-14. doi: 10.1161/CIRCULATIONAHA.115.020406.
3. Blaes AH Shenoy C. Is it time to include cancer in cardiovascular risk prediction tools? Lancet. 2019; 21; 394 (10203): 986-988. doi: 10.1016/S0140-6736(19)31886-0.
4. Curigliano G, Cardinale D, Dent S et al. Cardiotoxicity of anticancer treatments: Epidemiology, detection, and management. CA Cancer J Clin. 2016; 66: 309-325. doi: 10.3322/caac.21341.
5. Khanna A, Pequeno P, Gupta S et al. Increased risk of all cardiovascular disease subtypes among childhood cancer survivors: population-based matched cohort study. Circulation. 2019; 140: 1041-1043. doi: 10.1161/CIRCULATIONAHA.119.041403.
6. Gilchrist SC, Barac A, Ades PA et al. Cardio-oncology rehabilitation to manage cardiovascular outcomes in cancer patients and survivors: a scientific statement from the American Heart Association. Circulation. 2019; 139: e997-e1012. doi: 10.1161/CIR.0000000000000679.
7. Lavín-Pérez A, Collado-Mateo D, Mayo X, Humphreys L, Liouri G, Copeland R et al. High-intensity exercise to improve cardiorespiratory fitness in cancer patients and survivors: A systematic review and meta-analysis. Scand J Med Sci Sports. 2021; 31 (2): 265-294. doi: 10.1111/sms.13861.
8. Mijwel S, Backman M, Bolam K, Olofsson E, Norrbom J, Bergh J et al. Highly favorable physiological responses to concurrent resistance and high-intensity interval training during chemotherapy. the OptiTrain breast cancer trial. Breast Cancer Res Treat. 2018; 169 (1): 93-103. doi: 10.1007/s10549-018-4663-8.
9. Pedersen BK, Saltin B. Exercise as medicine-evidence for prescribing exercise as therapy in 26 different chronic diseases. Scand J Med Sci Sports. 2015; 25: 1-72. doi: 10.1111/sms.12581.
10. Scott JM, Zabor EC, Schwitzer E et al. Efficacy of exercise therapy on cardiorespiratory fitness in patients with cancer: A systematic review and meta-analysis. J Clin Oncol. 2018; 36 (22): 2297-2305. doi: 10.1200/JCO.2017.77.5809.
11. Sweegers MG, Altenburg TM, Brug J et al. Effects and moderators of exercise on muscle strength, muscle function and aerobic fitness in patients with cancer: a meta-analysis of individual patient data. Br J Sports Med. 2019; 53: 812. doi: 10.1136/bjsports-2018-099191.
12. Kessels E, Husson O, van der Feltz-Cornelis CM. The effect of exercise on cancer-related fatigue in cancer survivors: a systematic review and meta-analysis. Neuropsychiatr Dis Treat. 2018; 14: 479-494. doi: 10.2147/NDT.S150464.
13. Nakano J, Hashizume K, Fukushima T et al. Effects of aerobic and resistance exercises on physical symptoms in cancer patients: a meta-analysis. Integr Cancer Ther. 2018; 17: 1048-1058. doi: 10.1177/1534735418807555.
14. Tsuji K, Matsuoka Y, Ochi E. High-intensity interval training in breast cancer survivors: a systematic review. BMC. 2021; 21 (184): 1-11. doi: 10.1186/s12885-021-07804-w.
15. Palma S, Hasenoehrl T, Jordakieva G, Ramazanova D, Crevenna R. High-intensity interval training in the prehabilitation of cancer patients-a systematic review and meta-analysis. Support Care Cancer. 2021; 29: 1781-1794. doi: 10.1007/s00520-020-05834-x.
16. Tucker WJ, Lijauco CC, Hearon CM, Jr. et al. Mechanisms of the improvement in peak VO_2 with exercise training in heart failure with reduced or preserved ejection fraction. Heart Lung Circ. 2018; 27 (1): 9-21. doi: 10.1016/j.hlc.2017.07.002.
17. Swank AM, Horton J, Fleg JL et al. Modest increase in peak VO_2 is related to better clinical outcomes in chronic heart failure patients: results from heart failure and a controlled trial to investigate outcomes of exercise training. Circ Heart Fai. 2012; 15 (5): 579-585. doi: 10.1161/CIRCHEARTFAILURE.111.965186.
18. Hollekim-Strand SM, Bjorgaas MR, Albrektsen G et al. High-intensity interval exercise effectively improves cardiac function in patients with type 2 diabetes mellitus and diastolic dysfunction: a randomized controlled trial. J Am Coll Cardiol. 2014; 64 (16): 1758-1760. doi: 10.1016/j.jacc.2014.07.971.
19. Adams SC, DeLorey DS, Davenport MH et al. Effects of high-intensity interval training on fatigue and quality of life in testicular cancer survivors. Br J Cancer. 2018; 118 (10): 1313-1321. doi: 10.1038/s41416-018-0044-7.
20. Borg GA. Psychophysical bases of perceived exertion. Med Sci Sports Exerc. 1982; 14 (5): 377-381.
21. Aaronson NK, Ahmedzai S, Bergman B et al. The European Organization for Research and Treatment of Cancer QLQ-C30: a quality-of-life instrument for use in

international clinical trials in oncology. J Natl Cancer Inst. 1993; 85 (5): 365-376. doi: 10.1093/jnci/85.5.365.
22. Fayers PM, Aaronson NK, Bjordal K et al. The EORTC QLQ-C30 Scoring Manual (3rd ed). Published by: European Organization for Research and Treatment of Cancer, Brussels. 2001. Online in: https://www.eortc.org/app/uploads/sites/2/2018/02/SCmanual.pdf
23. Cruz-Jentofta AJ, Baeyens JP, Bauer JM et al. Sarcopenia: European consensus on definition and diagnosis. Age Ageing. 2019; 48 (4): 601. doi: 10.1093/ageing/afz046.
24. Yellen SB, Cella DF, Webster K et al. Measuring fatigue and other anemia-related symptoms with the Functional Assessment of Cancer Therapy (FACT) measurement system. J Pain Symptom Manag. 1997; 13 (2): 63-74. doi: 10.1016/s0885-3924(96)00274-6.
25. Enright P, Sherrill D. Reference equations for the six-minute walk in healthy adults. Am J Respir Crit Care Med. 2000; 161: 1396. doi: 10.1164/ajrccm.161.4.16147a.
26. American Thoracic Society. ATS statement: guidelines for the six-minute walk test. Am J Respir Crit Care Med. 2002; 166 (1): 111-117. doi: 10.1164/ajrccm.166.1.at1102.
27. Lind L, Sundström J, Arnlov J et al. A longitudinal study over 40 years to study the metabolic syndrome as a risk factor for cardiovascular diseases. Sci Rep. 2021; 11: 2978. doi: 10.1038/s41598-021-82398-8.
28. Samhan A, Ahmed A, Mahmoud W et al. Effects of high-intensity interval training on cardiorespiratory fitness, body composition, and quality of life in overweight and obese survivors of breast cancer. Rehabilitation Oncology. 2021; 39: 168-174. doi: 10.1097/01.REO.0000000000000270.
29. Tucker W, Beaudry R, Liang Y et al. Meta-analysis of exercise training on left ventricular ejection fraction in heart failure with reduced ejection fraction; a 10 year update. Prog Cardiovasc Dis. 2019; 62 (2): 163-171. doi: 10.1016/j.pcad.2018.08.006.
30. Dolan LB, Campbell K, Gelmon K et al. Interval versus continuous aerobic exercise training in breast cancer survivors--a pilot RCT. Support Care Cancer. 2016; 24 (1): 119-127. doi: 10.1007/s00520-015-2749-y.
31. Toohey K, Pumpa KL. Arnolda L et al. A pilot study examining the effects of low-volume high-intensity interval training and continuous low to moderate intensity training on quality of life, functional capacity and cardiovascular risk factors in cancer survivors. Peer J. 2016; 20 (4): e2613. doi: 10.7717/peerj.2613.
32. Xie B, Yan X, Cai X et al. Effects of high-intensity interval training on aerobic capacity in cardiac patients: a systematic review with meta-analysis. BioMed Research International. 2017; 5420840. doi: 10.1155/2017/5420840.
33. Strasser B, Steindorf K, Wiskemann J et al. Impact of resistance training in cancer survivors: a meta-analysis. Med Sci Sports Exerc. 2013; 45 (11): 2080-2090. doi: 10.1249/MSS.0b013e31829a3b63.
34. Gilchrist SC, Barac A, Ades PA et al. American heart association exercise, cardiac rehabilitation and secondary prevention committee of the council on clinical cardiology; council on cardiovascular and stroke nursing; and council on peripheral vascular disease. cardio-oncology rehabilitation to manage cardiovascular outcomes in cancer patients and survivors: a scientific statement from the american heart association. Circulation. 2019; 139 (21): e997-e1012. doi: 10.1161/CIR.0000000000000679.
35. Lavín-Pérez AM, Collado-Mateo D, Mayo X et al. Effects of high-intensity training on the quality of life of cancer patients and survivors: a systematic review with meta-analysis. Sci Rep. 2021; 11 (1): 15089. doi: 10.1038/s41598-021-94476-y.
36. Sasse K, Kida K, Furukawa Y. Cardio-oncology rehabilitation-challenges and opportunities to improve cardiovascular outcomes in cancer patients and survivors. J Cardiol. 2020; 76 (6): 559-567. doi: 10.1016/j.jjcc.2020.07.014.

Protection of people and animals: the authors declare that the procedures followed were in accordance with the ethical standards of the responsible human experimentation committee and in accordance with the World Medical Association and the Declaration of Helsinki, and all the project was approved by Centro de Estudios e Investigación FISICOL.
Data confidentiality: the authors declare that they have followed their workplace's protocols regarding the publication of patient data.
Right to privacy and informed consent: the authors have obtained informed consent from the patients and subjects referred to in the article. This document is in the possession of the corresponding author.
Clinical trial registration and approval number: this clinical study was carried out following the Declaration of Helsinki, the signing of the informed consent, under the authorization of the subjects involved, and the ethics committee of the institution with code IP245. Part of this investigation was registered in clinical trial NCT03915288.
Funding: no financial support was received for this study.
Declaration of interests: the authors declare no conflict of interest.

Correspondence:
Javier Pereira-Rodriguez
E-mail: jepr87@hotmail.com

Cardiovascular and Metabolic Science www.ancam.org.mx

Original research

Vol. 35 No. 3
July-September 2024

doi: 10.35366/117827

Correlation of the break point of the double product and the ventilatory thresholds

Correlación del punto de quiebre del doble producto y los umbrales ventilatorios

Jorge A Lara-Vargas,* Marco A Reza-Orozco,* José A Pineda-Juárez,‡ Catalina Salgado-Solorio,* Antonio Citalán-Jiménez,* Eduardo A Leyva-Valadez,* Rodolfo Arteaga-Martínez,* Javier Miguel Ávalos-Ríos*

Keywords: double product, cardiopulmonary exercise test, double product break point, ventilatory thresholds.

Palabras clave: *doble producto, prueba de ejercicio cardiopulmonar, punto de quiebre del doble producto, umbrales ventilatorios.*

ABSTRACT

Introduction: during physical exercise with incremental load, the double product is increased by sympathetic stimulus, and its increase presents a positive inflection called the double product breaking point or break point of double product (BPDP). Commonly, there is a correlation between this and the lactic threshold (LT), but we do not know its association with the ventilatory thresholds that are usually used to prescribe training. **Objective:** to determine the correlation of the BPDP with the ventilatory thresholds. **Material and methods:** a descriptive, prospective, analytical, non-randomized study was carried out in which patients with heart disease who underwent maximal cardiopulmonary exercise tests were included. The PD was obtained and plotted as a function of time (every minute) to establish the BPDP by line drawing. The correlation was made with the ventilatory thresholds obtained from the CPET gas analysis using the ventilatory equivalents method. **Results:** twenty-one patients between 49 and 59 years old (14.3% women) were studied. The Spearman correlation coefficient was applied, and it was found that there is a strong-moderate positive correlation between BPDP and VAT-DP with statistical significance ($p = 0.004$, $r = 0.60$) and in the same way between BPDP and moderate correlation with VT2-DP ($p = 0.005$, $r = 0.59$). **Conclusion:** determination of PD is a reproducible and easily accessible method for determining ventilatory thresholds. The BPDP correlates with the aerobic-anaerobic ventilatory threshold (VAT), determining training intensity in patients with heart disease.

RESUMEN

Introducción: *durante el ejercicio físico en carga incremental se eleva el doble producto por estímulo simpático y su incremento presenta una inflexión positiva denominada punto de quiebre del doble producto (PQDP). Comúnmente existe una correlación entre éste y el umbral láctico (UL), pero desconocemos su asociación con los umbrales ventilatorios que suelen emplearse para la prescripción del entrenamiento.* ***Objetivo:*** *determinar la correlación del PQDP con los umbrales ventilatorios.* ***Material y métodos:*** *estudio descriptivo, prospectivo, analítico, no aleatorizado, se incluyeron pacientes con cardiopatía que realizaron prueba máxima de ejercicio cardiopulmonar. Se obtuvo el DP y se graficó en función del tiempo (cada minuto) para establecer mediante trazado de rectas el PQDP. Se hizo la correlación con los umbrales ventilatorios obtenidos del análisis de gases del CPET, por método de los equivalentes ventilatorios.* ***Resultados:*** *se estudiaron 21 pacientes entre 49 y 59 años (14.3% mujeres). Se aplicó el coeficiente de correlación de Spearman y se encontró que existe una fuerte-moderada correlación positiva entre el PQDP y el VAT-DP con significancia estadística ($p = 0.004$, $r = 0.60$) y de la misma manera entre PQDP y correlación moderada con VT2-DP ($p = 0.005$, $r = 0.59$).* ***Conclusión:*** *la determinación del DP es un método reproducible y de fácil acceso para determinación de umbrales ventilatorios. El PQDP correlaciona con el umbral ventilatorio aeróbico-anaeróbico (VAT), por lo que puede ser utilizado para determinar la intensidad en el entrenamiento de los pacientes con cardiopatías.*

* Servicio de Rehabilitación Cardiaca, División de Servicios Modulares, Facultad de Medicina, Universidad La Salle, México.
‡ Departamento de Investigación Clínica, Centro Médico Nacional 20 de Noviembre, ISSSTE, México.

Received: 07/17/2024
Accepted: 08/19/2024

How to cite: Lara-Vargas JA, Reza-Orozco MA, Pineda-Juárez JA, Salgado-Solorio C, Citalán-Jiménez A, Leyva-Valadez EA et al. Correlation of the break point of the double product and the ventilatory thresholds. Cardiovasc Metab Sci. 2024; 35 (3): 99-105. https://dx.doi.org/10.35366/117827

Abbreviations:

BMI = Body mass index.
BPDP = Break point of double product.
CO = Cardiac output.
CPET = Cardiopulmonary exercise test.
DP = Double product.
HR = Heart rate.
LT = Lactic threshold.
MHR = Maximum heart rate.
MVO_2 = Myocardial oxygen consumption.
NYHA = New York Heart Association.
$PaCO_2$ = Partial pressure of carbon dioxide.
$PETO_2$ = End-tidal oxygen tension.
RER = Respiratory Exchange Ratio.
SBP = Systolic blood presure.
SPSS = Social Package for Social Sciences.
VAT = Aerobic-anaerobic threshold.
VCO_2 = CO_2 production.
VE = Pulmonary ventilation.
VO_2 = Oxygen consumption.
VT = Ventilatory threshold.
VT1 = 1st ventilatory threshold.

INTRODUCTION

Physical exercise is a stimulus that generates a body response, both centrally and peripherally, secondary to the increase in oxygen demand. The adaptations are immediate at the time of the effort and become chronic by maintaining the stimulus in a sustained manner. With the start of exercise and its intensity increasing, the demand for oxygen increases, mainly due to the stimuli found in activity.[1] The magnitude of the hemodynamic response to exercise depends on the intensity, the muscle mass involved, and the ability of the heart to increase its stroke volume.[1]

Blood pressure reflects cardiac output (CO), heart rate (HR), peripheral vascular resistance, and blood volume variations. Since 1972, Kimura et al. were the first to discuss the product of heart rate – blood pressure, or double product (DP), as a predictor of coronary blood flow and myocardial oxygen consumption (MVO_2) in healthy young subjects.[1,2] DP is the index that best correlates with MVO_2 in patients with ischemic heart disease.[3] Plasma catecholamine concentration rises exponentially with increasing workloads;[4] this event is influenced by the increased stimulation of the sympathetic nervous system that occurs above the lactate threshold and a gradual decrease in parasympathetic activity. Likewise, there is a disproportionate increase in systolic blood pressure above the ventilatory threshold.[5] During the incremental load exercise, the slope of the double product presented a positive inflection called the break point of double product (BPDP),[6] and the same phenomenon occurs in a similar way to the lactic threshold (LT), keeping a strong relationship with the ventilatory threshold (VT) described by Wasserman.[7,8] The anaerobic threshold or VT can be identified using several markers that represent different physiological systems,[4,7,9-13] including the double product.[14-20]

Tanaka et al. found that the DP increases steeply above the LT, and, as a result, the BPDP is considered a valid and useful parameter as a marker of the LT.[6,14] According to the Skinner and McLellan triphasic model, incremental load exercise is structured in three phases or stages of increasing intensity from rest to maximum intensity.[20] These phases are:

1. Phase I. An increase in CO_2 production (VCO_2) occurs in relation to oxygen consumption (VO_2) and cellular lactate buffering.
2. Phase II. By increasing VCO_2, there is a proportional increase in pulmonary ventilation (VE), keeping $PaCO_2$ constant, which is called «isocapnic buffering».
3. Phase III. Respiratory compensation of metabolic acidosis, with decreased $PaCO_2$.

Previously, the correlation of the break point of the double product as an indicator of the anaerobic threshold (LT or VT) has been pointed out, being consistent in patients with heart disease as well as in healthy subjects or athletes;[21,22] however, there is little evidence of its correlation with ventilatory thresholds (VT1 and VT2). Due to its correlation with the LT and the more abrupt change in cellular metabolism during the incremental load of the oxidative system to the glycolytic system, the BPDP could be more related to the ventilatory threshold (VT1). The objective of this work is to correlate BPDP and ventilatory behavior during incremental load exercise in patients with heart disease.

Table 1: Demographic, comorbidity clinical, pharmacological, and biochemical characteristics of the study population. (N = 21).

Characteristics	n (%)
Demographics	
Age [years]	58 (49.5-59)
Gender	
Male	18 (85.7)
Female	3 (14.3)
Etiology	
Ischaemic cardiomyopathy	16 (76.2)
Chronic heart failure	5 (23.8)
Cardiac valve disease	2 (9.5)
Pulmonary arterial hypertension	1 (4.8)
Congenital heart disease	1 (4.8)
Comorbidities	
Dyslipidemia	8 (38.1)
Obesity	14 (66.7)
Type 2 diabetes mellitus	6 (28.6)
Systemic arterial hypertension	12 (57.1)
Smoking	8 (38.1)
Clinical	
BMI [kg/m^2]	28.6 (26.4-29.7)
LVEF [%]	55 (38-62)
Functional class	
1	17 (81.0)
2	3 (14.3)
3	1 (4.8)
IscT	4 (19.0)
ArrT	1 (4.8)
Pharmacological	
ACEI	10 (47.6)
ARA	4 (19.0)
AAP	18 (85.7)
Estatinas	18 (85.7)
BB	14 (66.7)
CA	4 (19.0)
Diuréticos	5 (23.8)
Biochemical, (mg/dL)*	
Glucose	99 [61.5-135.2]
C-HDL	29.3 [21.7-36.2]
C-LDL	72 [30.7-121.7]
Triglycerides	156 [50.2-233]

AAP = antiplatelet agents. ACEI = angiotensin converting enzyme inhibitor. ARA = angiotensin receptor antagonist. ArrT = arrhythmical threshold. BB = beta-blockers. BMI = body mass index. CA = calcium antagonists. IscT = ischaemic threshold. LVEF = left ventricular ejection fraction.
* Data are presented in means [p25-p75]

MATERIAL AND METHODS

This is a descriptive, prospective, analytical, non-randomized study at a cardiac rehabilitation center in Mexico City during the months of July to December 2020. The patients underwent a cardiopulmonary stress test under the ramped modified Bruce protocol on the treadmill. The inclusion criteria were patients with any heart disease older than 18 years and who had undergone cardiopulmonary testing (CPET, with expired gas analysis, BTL CardioPoint®-Ergo v. 2.33.201.0.a. Patients who had a contraindication to perform the test and had reason to suspend the study, also eliminating patients who did not perform a maximum exercise test or presented a hypotensive response associated with physical exercise. The criteria that determined the maximum were MHR > 85%, RER > 1.15, and Borg > 17). All participants signed informed consent regarding the risks and complications of performing the test. Ethics, research, and biosafety regulations were complied with.

For all the selected patients, a record of HR (automated) and blood pressure (manually with a sphygmomanometer by the doctor) was obtained every minute. The perception of effort was evaluated with the Borg scale.[6-19,23] The DP was obtained using the formula HR × SBP. The DP curve was plotted as a function of time, and by drawing straight lines on the figure, the point where an abrupt inflection occurred was sought to determine the BPDP. The analysis of the slopes plotted on the graph obtained was reviewed by experts in the area.

The ventilatory thresholds were obtained from the gas analysis of the CPET during the stress test, in curves 4 and 7 of Wasserman in the following way:[7,11,20]

1. VT1: ↑VE/VO_2 + ↑$PETO_2$;
2. VT2: ↑ VE/VCO_2 + ↓$PETCO_2$;
3. VAT: RER (VCO_2/VO_2) = 1.0.

Where VT1 is the 1st ventilatory threshold, defined as the turning point of the curve for the ventilatory equivalent of oxygen (VE/VO_2), and the positive inflection of the oxygen pressure at the end of expiration; VT2 is the 2nd ventilatory threshold, defined as the break point of the curve for the ventilatory equivalent of carbon dioxide (VE/VCO_2), and the negative inflection of the carbon dioxide pressure at the end of expiration; and VAT is the aerobic-anaerobic threshold that is equivalent to the RER or respiratory quotient equal to 1.0 (crossing point of the VO_2 curve and elimination of carbon dioxide).[11] When there was doubt or discrepancy in the measurement of ventilatory thresholds through the method of equivalents that was used for this study, we resorted to the support of the V-slope. Subsequently, an analysis and correlation of the thresholds with respect to the BPDP was carried out.

Statistic analysis

The data was captured in a database in the Microsoft Excel program and analyzed in the statistical package Social Package for Social Sciences (SPSS) version 24. For the continuous variables, the results were presented in medians and percentiles and as frequencies and percentages in the case of categorical variables. For the correlation of the variables of interest, the Spearman correlation coefficient was used. In all cases, moderate correlation coefficients > 0.50 and statistically significant values < 0.05 were taken.

Table 2: Characteristics of the stress test of the study population. (N = 21).

Characteristics	
HR (bpm)	68 (62-77.2)
M-HR (bpm)	152 (133-163.7)
SBP (mm/Hg)	120 (107.5-127.0)
M-SBP (mm/Hg)	155 (143.7-165.0)
METS	
M-METS	10.4 (8.3-12.3)
VO_2 (mL/kg/min)	
M-VO_2 (mL/kg/min)	2,591 (1,791.5-3,630.5)
B-DP*	8,430 [6,757.2-9,957.5]
VT1-DP*	11,410 [10,297.5-13,485]
VAT-DP*	18,300 [15,190-19,620]
VT2-DP*	20,580 [17,662.5-22,237.5]
M-DP*	23,210 [20,175-26,740]
BPDP*	16,090 [14,815-19,157.5]
VT1-T*	2.4 [2-4.1]
VAT-T*	8.7 [6.4-10.5]
VT2-T*	10.5 [9.1-12.7]

B = basal. BPDP = break point of the double product. DP = double product. HR = heart rate. M = maximum. METS = metabolic equivalent. SBP = systolic blood pressure. T = time. VAT = anaerobic aerobic ventilatory threshold. VO_2 = oxygen consumption. VT1 = ventilatory threshold 1. VT2 = ventilatory threshold 2.
* Data are presented in medians [p25-p75].

RESULTS

A total of 21 patients with a mean age of 58 years (range 49.5 to 59 years) were included, where 85.7% were men and 14.3% were women. The average BMI was 27.6. The cardiovascular risk factors present were obesity, systemic arterial hypertension, smoking, dyslipidemia, and diabetes mellitus. The heart diseases presented by the patients are ischemic heart disease, heart failure, valve disease, one case of congenital heart disease, and one of pulmonary arterial hypertension. 81.8% were in NYHA functional class I and 13.6% in NYHA functional class II. *Table 1* shows the demographic data, comorbidities, pharmacological treatment, and biochemical characteristics of the study population.

All patients underwent cardiopulmonary testing. The most common reason for suspension was fatigue. Only four presented an ischemic threshold without limiting angina; none presented hypotensive response or important ventricular arrhythmias. There were no incidents or complications in all the exercise tests performed. It was possible to identify the BPDP and the ventilatory thresholds of all the chosen subjects. *Table 2* shows the results of the population characteristics of the stress test. An example of the determination of the double product breakpoint by plotting the double product against time during cardiopulmonary stress testing is shown in *Figure 1*.

The relationship between ventilatory thresholds (expressed in DP) and BPDP was analyzed. For this, the Spearman rank correlation coefficient was applied as a statistical method, and it was found that there is a strong-moderate positive correlation between the BPDP and the VAT-DP with statistical significance (p = 0.004, with values

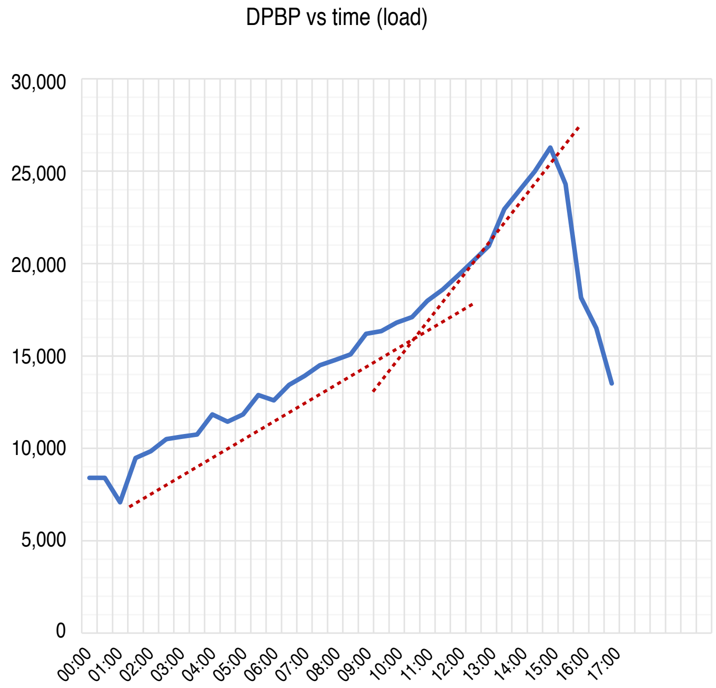


Figure 1: Calculation to determine the break point of the double product. DPBP = double product break point.

of r = 0.60). The statistical method was also applied to the relationship between the BPDP and the VT2-DP, and it was observed that there was a positive and statistically significant correlation ($p = 0.005$, $r = 0.59$). *Figure 2* shows these correlations using the Spearman method.

DISCUSSION

In the traditional determination of the change from aerobic or oxidative to anaerobic or glycolytic metabolism, the LT and VT were used in physiological terms as clear turning points in which a differentiation of the energy reserve used by the patient in an exercise in incremental load. For prescription purposes, this has always generated support for calculating the optimal level of intensity of aerobic endurance training in patients with heart disease. However, starting from the understanding that there is not only a clear point of inflection in which the metabolism changes from one energy reserve to another but also that it is an aerobic-anaerobic transition zone determined by two ventilatory thresholds,[11,20,24] BPDP analysis becomes a more imminent need for cardiac rehabilitators who want to specify their prescription in the absence of expired gas analysis.

Brubaker compared BPDP with VT (determined through V-Slope) in 88 patients with heart disease during incremental load exercise testing, finding a difference of 5% in VO_2 measured between thresholds (Pearson $r = 0.81$ $p < 0.001$) (fifteen). For his part, Riley compared a group of 10 healthy subjects and 10 with heart disease and found that the mean value in VO_2 of the BPDP was significantly higher than that of the LT in patients with heart disease, and the BPDP was correlated with the LT ($r = 0.865$, $p < 0.0001$), and LT is commonly associated with VT1.[16] This contrasting evidence was what motivated the present investigation to find a more precise association with the BPDP. Although the V-Slope method is plausible for calculating VT, our study used the ventilatory equivalents methodology to find the most precise degree of correlation in the aerobic-anaerobic transition phase through the two thresholds, VT1 and VT2, with the intention of translating this correlation with the training prescription using the Skinner-McLellan triphasic scheme.

In addition to finding a correlation between the increase in DP before and after its breakpoint (286.2 vs 98.5/W, $p < 0.001$), Omiya found that BPDP had a strong correlation with VT ($r = 0.93$, $p < 0.01$) and LT ($r = 0.95$, $p < 0.01$), concluding that the BPDP can be used as an index of exercise intensity in patients with CAD similar to VT or LT. Another finding was that the non-invasive measurement of the BPDP is comparable to the invasive method.[17]

Hargens observed that, like the VT, the BPDP, after eight weeks of dynamic training, occurs at a higher intensity. He concluded that BPDP could be a useful marker for VAT (RER = 1), easier to obtain than VT or LT, using it in healthy populations as an independent parameter of exercise intensity.[18] In our study, it was found that the threshold that most correlate with the BPDP is the aerobic-anaerobic ventilatory threshold (VAT);

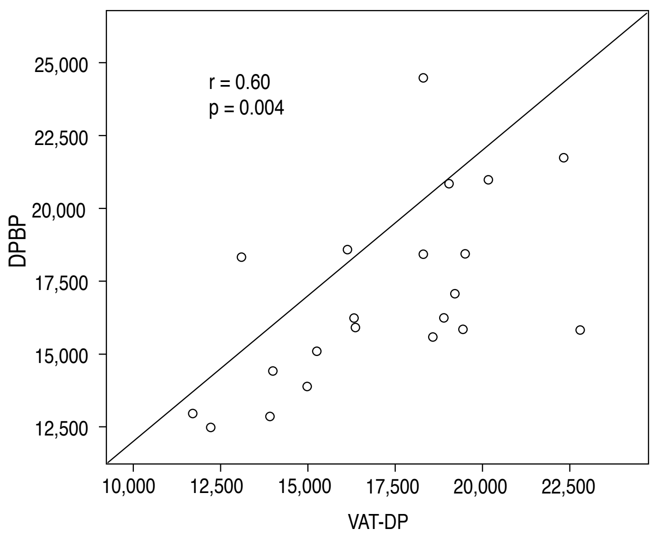
although 4% of the patients studied matched it with VT1, it was not the objective of the study to correlate the displacement of the BPDP with some other threshold after the training process.

In our methodology, blood pressure measurement was determined manually (non-invasively), recording minute by minute, achieving an adequate graphical representation when determining the BPDP, consistently regardless of the magnitude of the increase in SBP or HR.[22,23] The variation between the pressure increments was very stable, being carried out at intervals every 3 minutes without affecting the determination of the BPDP. Compared to previous studies,[15,17,18,21,25] where automated and other invasive recordings are used, performing the measurement manually allows the double product to be reliably established, as well as its breakpoint.[23,24] Although the degree of correlation measured by Spearman was not greater than 0.90 and therefore cannot be considered a surrogate methodology, the clinician's approach based on this BPDP measurement methodology may represent a more useful tool that could help determine the training intensity that ideally occurs between the ventilatory threshold phase.[26]

More studies, with a larger volume of patients, are required to confirm these data and to elucidate in future research whether this BPDP manages to move towards VT2, as it usually happens physiologically when patients with heart disease adapt to a cardiac rehabilitation program based on physical training. One limitation of our study was not having correlated these thresholds with the lactate analysis, but their use is not routine or practical in the clinical evaluation of patients admitted to these programs. Therefore, the strength of our study lay in measuring, through the gold standard (the stress test with expired gas analysis), the training zones through the ventilatory thresholds.

CONCLUSIONS

The determination of DP is a reproducible and easily accessible method for determining ventilatory thresholds. The BPDP moderately correlates with the aerobic-anaerobic ventilatory threshold (VAT), so it can be used to determine the training intensity of patients with heart disease in the absence of cardiopulmonary exercise testing or lactate testing by defining the limit of the depletion of the oxidative reserve and, therefore, the beginning of metabolic instability.



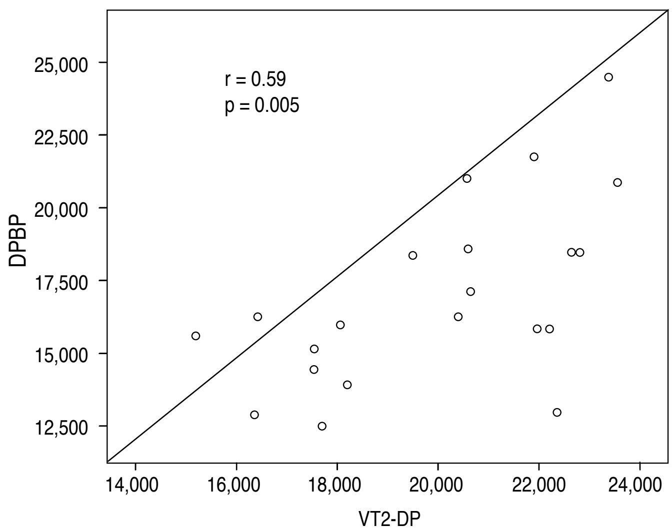


Figure 2: Spearman correlation between aerobic-anaerobic ventilatory threshold-double product (VAT-DP) and ventilatory threshold 2-double product (VAT-2-DP) with the calculated double product break point.
DPBP = double product break point.

REFERENCES

1. Braunwald E. Control of myocardial oxygen consumption. Am J Cardiol. 1971; 27: 416-432.
2. Brubaker P, Kitzman D. Chronotropic incompetence: causes, consequences and management. Circulation 2011; 123: 1010-1020.
3. McArdle W, Katch F, Katch V. Exercise physiology. 4th ed. Williams & Wilkins Editorial. 1996.
4. Mazzeo RS, Marshall P. Influence of plasma catecholamines on the lactate threshold during graded exercise. J Appl Physiol 1985. 1989; 67: 1319-1322.
5. SchneiderD, McLellan T, Gass G. Plasma catecholamine and blood lactate responses to incremental arm and leg exercise. Med Sci Sports Exerc. 2000; 32: 608-613.
6. Tanaka H, Kiyonaga A, Kagimura M et al. Relationship between lactate threshold and double product break point during graded exercise test. Kokyu To Junkan. 1995; 43: 495-499.
7. Wasserman K. Determinants and detection of anaerobic threshold and consequences of exercise above it. Circulation. 1987; 76: VI29-VI39.
8. Weltman A. The blood lactate response to exercise. Monograph number 4. Human Kinetics Eds. 1995.
9. Sales MM, Campbell CS, Morais PK et al. Noninvasive method to estimate anaerobic threshold in individuals with type 2 diabetes. Diabetol Metab Syndr. 2011; 3: 1.
10. Simoes HG, Campbell CS, Kushnick MR et al. Blood glucose threshold and the metabolic responses to incremental exercise tests with and without prior lactic acidosis induction. Eur J Appl Physiol. 2003; 89: 603-611.
11. Whipp BJ: Physiological mechanisms dissociating pulmonary CO2 and O2 exchange dynamics during exercise in humans. Exp Physiol. 2007; 92: 347-355.
12. Brubaker PH, Kiyonaga A, Matrazzo BA et al. Identification of the anaerobic threshold using double product in patients with coronary artery disease. Am J Cardiol. 1997; 79: 360-362.
13. Riley M, Maehara K, Pórszász J et al. Association between the anaerobic threshold and the break-point in the double product/work rate relationship. Eur J Appl Physiol Occup Physiol. 1997; 75: 14-21.
14. Tanaka H, Kiyonaga A, Terao Y et al. Double product response is accelerated above the blood lactate threshold. Med Sci Sports Exerc. 1997; 29: 503-508.
15. Omiya K, Itoh H, Harada N et al. Relationship between double product break point, lactate threshold, and ventilatory threshold in cardiac patients. Eur J Appl Physiol. 2004; 91: 224-229.
16. Hargens TA, Griffin DC, Kaminsky LA et al. The influence of aerobic exercise training on the double product break point in low-to-moderate risk adults. Eur J Appl Physiol. 2011; 111: 313–3-8.
17. Ohtsuki K, Watanabe S. Effect of incremental load of circulatory response on double product break point detection. J Phys Ther Sci- 2007; 19: 293-298.
18. Ohtsuki K, Watanabe S. The product-break-point derived from measurements with a digital automatic sphygmomanometer. J Phys Ther Sci. 2008; 20: 1-5.
19. Skinner JS, McLellan TM. The transition from aerobic to anaerobic metabolism. Res Q Exerc Sport. 1980; 51 (1): 234-248.
20. Silva NM, Pereira LN, Tucher G: Relacao entre o limiar de lactato e o break point do duplo produto em jogadores de futebol. Bra J Biomotricity. 2011; 5: 9.
21. Pérez ML, Lachitiello J. Identification of the double product break point in patients with chronic heart failure. J Cardiopulmonary Rehab 1999; 19: 288 (abstract).
22. Resnik M, De Roia G, Lobo P et al. Double product breakpoint as an indicator of metabolic transition during exercise in coronary patients. Insuf Card. 2016; 11 (4): 160-167.
23. Victor de Sousa C, Sales MM, Aguiar Sda S et al. Double product break point estimates ventilatory threshold in individuals with type 2 diabetes. J Phys Ther Sci. 2016; 28 (6): 1775-1780.
24. Akizuki K, Yasaki S, Echizenya Y, Ohashi Y. Anaerobic threshold and salivary a amylase during incremental exercise. J Phys Ther Sci. 2014; 26: 1059-1063.
25. Agostoni P, Piepoli M, et al. Prognostic value of indeterminable anaerobic threshold in heart failure. Circ Heart Fail. 2013; 6: 977-987.
26. Coyle E. Integration of the physiological factors determining endurance performance ability Exe and Sports Sci Rev. 1995; 23: 25-63.

Declaration of confidentiality and patients consent: the authors declare they have followed their workplace protocols for using patient data. Also, they certify that the patient has received sufficient information and has given written informed consent for his/her/their images and other clinical information to be reported in the journal, without names or initials, to protect the right to privacy.

Clinical trial registration and approval number: the authors declare they have followed their workplace protocols for using patient data. Also, they certify that the patient has received sufficient information and has given written informed consent for his/her/their images and other clinical information to be reported in the journal, without names or initials, to protect the right to privacy.

Funding: no financial support was received for this study.

Declaration of interests: the authors declare no conflict of interest.

Correspondence:
Jorge A Lara-Vargas
E-mail: ikcaban@yahoo.com.mx

Cardiovascular and Metabolic Science www.ancam.org.mx

Clinical case

Vol. 35 No. 3
July-September 2024

doi: 10.35366/117828

Cryoablation and left atrial appendage closure for atrial fibrillation in a patient with ulcerative colitis: case report

Crioablación y cierre de orejuela izquierda por fibrilación auricular en un paciente con colitis ulcerativa: reporte de caso

Juan Carlos Ibarrola-Peña,[*,‡] Christian Eduardo Juarez-Gavino,[*,§]
Mauricio Cortes-Aguirre,[*,¶] Daniel Lira-Lozano,[*,‖] Gerardo Rodriguez-Diez[**]

Keywords: cryoablation, ulcerative colitis, closure of the left atrial appendage, atrial fibrillation.

Palabras clave: *crioablación, colitis ulcerativa, cierre de orejuela auricular izquierda, fibrilación auricular.*

ABSTRACT

Introduction: when choosing treatment for atrial fibrillation, it is necessary to understand the patient beyond risk scores, to understand the need to drive to sinus rhythm or treatment goals and the speed to be employed given the risk conferred by their chronic diseases and the challenges these diseases pose to conventional strategies. **Case report:** 69-year-old male with a history of chronic non-specific ulcerative colitis (CUCI), operated on with subtotal colectomy, since then with abundant, intermittent rectorrhagia. Preoperative assessment of para-stomal hernia revealed AF with an increase in bleeding after the start of anticoagulation, with a high number of episodes, even requiring hospitalization. Due to the hypercoagulable state and immuno-thromboinflammation associated with UC, it was considered a priority to revert to sinus rhythm. Pharmacological cardioversion with amiodarone was attempted without success. He was considered a candidate for cryotherapy ablation after unsuccessful electrical cardioversion, in addition to closure of the left atrial appendage, as he was not considered a candidate for long-term anticoagulation. Cryoablation of the four pulmonary veins was performed without achieving a return to sinus rhythm, so ablation was extended to the posterior wall and left atrial appendage, successfully jugulating the arrhythmia. Finally, a left atrial appendage closure device was placed. After three months of optimal medical management, the patient remained in sinus rhythm, and anticoagulation was discontinued. More than one year after the procedure, the patient is free of thrombotic and bleeding events. **Conclusions:** this case demonstrates the importance of individualizing the approach in atrial fibrillation. Furthermore, extended ablation in atrial fibrillation without origin in the pulmonary veins, and atrial appendage closure, is important as a treatment strategy for patients in complex scenarios who are not candidates for anticoagulation.

RESUMEN

Introducción: *al momento de elegir el tratamiento de la fibrilación auricular, es necesario entender al paciente más allá de las puntuaciones de riesgo, comprender la necesidad de llevar a ritmo sinusal o a metas de tratamiento y la rapidez que debe emplearse dado el riesgo que confieran sus enfermedades crónicas y los retos que plantean estas enfermedades a las estrategias convencionales.* ***Presentación de caso:*** *masculino de 69 años, con antecedente de colitis ulcerativa crónica inespecífica (CUCI), intervenido con colectomía subtotal, desde entonces con rectorragia abundante, intermitente. En valoración preoperatoria de hernia paraestomal se descubre FA. Con aumento de rectorragia tras inicio de anticoagulación, abundante en cantidad, llegando a requerir hospitalización. Por el estado de hipercoagulabilidad e inmuno-tromboinflamación asociada a CUCI, se consideró prioritario revertir a ritmo sinusal. Se intenta sin éxito cardioversión farmacológica con amiodarona. Fue considerado candidato para realizar ablación con crioterapia tras cardioversión eléctrica fallida, además de cierre de orejuela izquierda por considerarse no candidato a anticoagulación a largo plazo. Se realiza crioablación de las cuatro venas pulmonares sin lograr retorno a ritmo sinusal, por lo que se amplía ablación hacia pared posterior y orejuela izquierda, con lo que se logra yugular la arritmia exitosamente. Por último, se coloca dispositivo de cierre de orejuela izquierdo. Tras tres meses de tratamiento médico óptimo tras cirugía se retira anticoagulación, a más de un año del procedimiento el paciente se encuentra libre de eventos trombóticos y hemorrágicos.* ***Conclusiones:*** *este caso demuestra la importancia de individualizar el abordaje en la fibrilación auricular. Además, la importancia de la ablación extendida en la fibrilación auricular sin origen en las venas pulmonares, así como el cierre del apéndice auricular como estrategia de tratamiento en pacientes en escenarios complejos no candidatos a anticoagulación.*

* Tecnológico de Monterrey. Escuela de Medicina y Ciencias de la Salud. Instituto de Cardiología y Medicina Vascular, TecSalud.
‡ Cardiology Fellow. ORCID: 0000-0003-4271-7512
§ Cardiology Fellow. ORCID: 0009-0001-0390-3577
¶ Electrophysiology Professor. ORCID: 0009-0006-3294-8252
‖ Cardiology Fellow. ORCID: 0000-0002-4745-1277
** Electrophysiology Professor. Unidad de arritmias y Marcapasos. CMN 20 de Noviembre, ISSSTE. ORCID: 0000-0001-8132-0724

How to cite: Ibarrola-Peña JC, Juarez-Gavino CE, Cortes-Aguirre M, Lira-Lozano D, Rodriguez-Diez G. Cryoablation and left atrial appendage closure for atrial fibrillation in a patient with ulcerative colitis: case report. Cardiovasc Metab Sci. 2024; 35 (3): 106-110. https://dx.doi.org/10.35366/117828

Received: 03/17/2024
Accepted: 06/20/2024

INTRODUCTION

Atrial fibrillation (AF) is the most prevalent cardiac arrhythmia in Mexico.[1] It is associated with complications such as stroke, heart failure, and death.

Pulmonary vein isolation is a treatment option that prevents disease progression and prevents complications by restoring sinus rhythm.[2] Simultaneously, embolic events can be prevented with anticoagulation in most cases.

Thromboembolic prevention, guided by international recommendations, continues to be the first-line management. However, sometimes, the preventive benefit of anticoagulants is limited by the increased risk in the bleeding rate. In cases of high bleeding risk, occlusion of the left atrial appendage can be considered an alternative to anticoagulation in complex scenarios who are not candidates for long-term anticoagulation due to having a high risk of bleeding.

CASE PRESENTATION

A male 69-years-old Latino with a history of intense smoking and a sedentary lifestyle underwent a subtotal colectomy in 2016 due to diagnosis of UC disease complicated with an episode of toxic megacolon. Since then, the patient has had episodes of intermittent rectorrhagia. In February 2023, the patient noted the presence of a parasternal hernia; during pre-surgical protocol for hernia repair, an atrial fibrillation rhythm was found. Following the current guidelines, antiarrhythmic medication and oral anticoagulation were started. However, the patient failed to return to sinus rhythm and developed gastrointestinal bleeding due to management, with increased rectorrhagia, which requires admission to the hospital due to bleeding, so he was disregarded as a candidate for lifelong anticoagulation.

In trying to find the trigger and the substrate that triggered the arrhythmia, a non-obstructive CAD in the coronary computed tomography angiography was found, and in the transthoracic echocardiography the findings where a biauricular dilatation and a decreased atrial function, RV dilatation, PASP was 54 mmHg, LV diastolic dysfunction grade III, and preserved biventricular function, without areas of hypokinesia or akinesia - revealing atrial dilatation as the likely trigger.

Even though conventional scores showed a low-risk result, it was considered essential to revert to sinus rhythm due to the strong thrombotic component conditioned by the UC and the contraindication for anticoagulation. An electrophysiological study was performed, followed by cryoablation of the four pulmonary veins *(Figures 1 and 2)*, without achieving

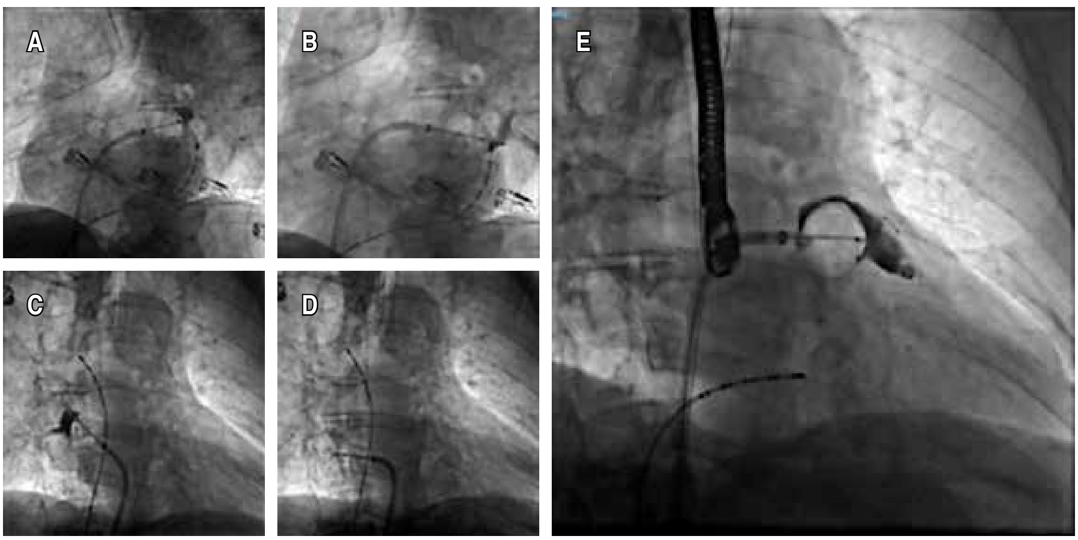


Figure 1: A-D) Cryoablation sequence of the four pulmonary veins. **E)** Cryoablation of the left atrial appendage after failed cardioversion.

Contents

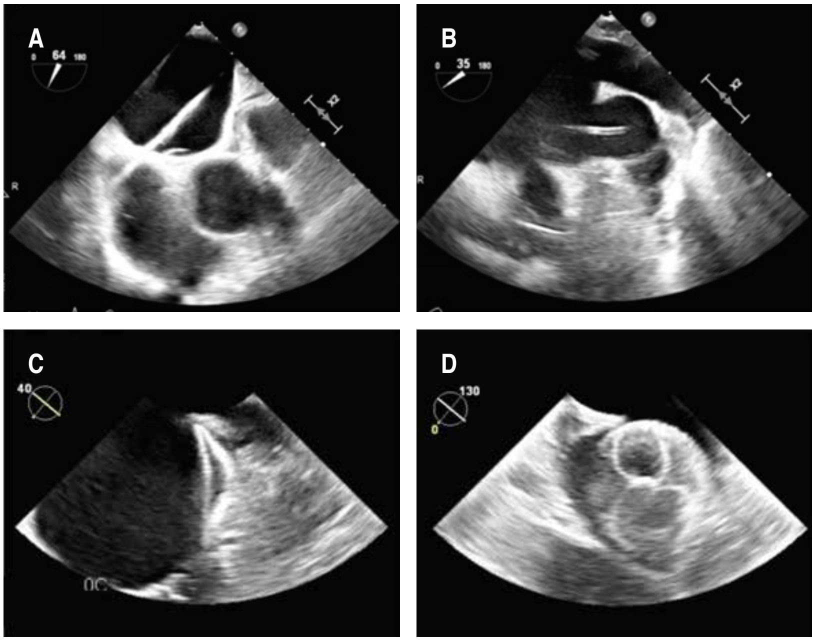


Figure 2: Transesophageal echocardiogram sequence of procedure. **A)** Transeptal puncture. **B)** Left atrial appendage ablation. **C, D)** Positioning of left atrial appendage closure device.

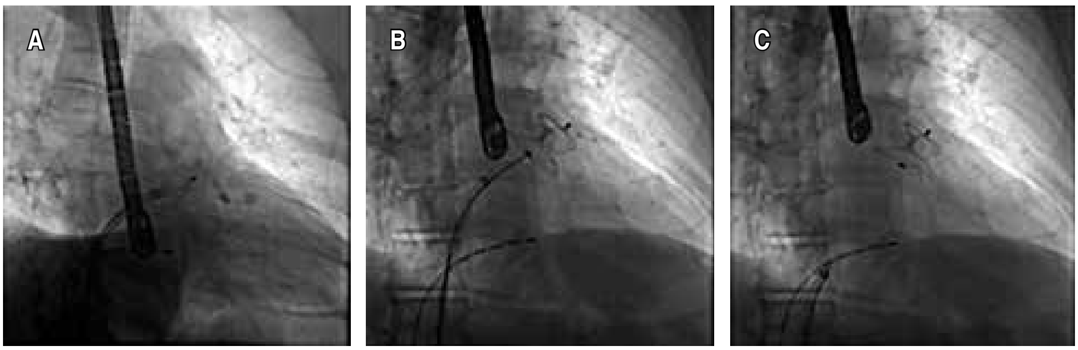


Figure 3: Atrial appendage closure device sequence. **A)** Approach. **B)** Placement. **C)** Release.

sinus rhythm, so it was decided to perform non-success electrical cardioversion twice (200 joules). The intervention team decided to perform a wide antral circumferential ablation (WACA) with posterior wall and left atrial appendage isolation, thus successfully achieving arrhythmia jugulation. Due to the hindrance of anticoagulation, after the left atrial appendage isolation, a closure device was placed in the left atrial appendage *(Figures 2 and 3)*. After three months of optimal medical management with apixaban and amiodarone, the patient remained in sinus rhythm, and anticoagulation was discontinued. The patient is free of thrombotic and bleeding events for more than one year after the procedure and after stopping the anticoagulant.

DISCUSSION

Cryoablation of pulmonary veins is a well-studied and effective treatment strategy for patients with atrial fibrillation. Nevertheless, there is always the possibility of procedural failure or recurrence of arrhythmia. In our patient, the arrhythmogenic substrate was in the left atrial appendage. After isolation, the arrhythmia stopped at a site with low incidence reported in the literature. In these scenarios, wide ablation techniques should be used and the search should be expanded to include structures outside the pulmonary veins.[2] However, previous studies have demonstrated its potential arrhythmic capacity.[3] Therefore, catheter ablation of the posterior wall and left atrial appendage has emerged as an option to increase therapeutic efficacy and improve outcomes in patients with persistent AF originating outside the pulmonary veins.[4,5] It has been suggested that there is a substantial risk of thrombus in those undergoing left atrial appendage isolation, so patients undergoing isolation usually also require LAAC.[2]

This case highlights that anticoagulation given to reduce the risk of stroke carries the burden of an increased risk of bleeding, so finding the right balance is crucial. In patients with atrial fibrillation and high bleeding scores, which also have a high thromboembolic risk due to the thrombotic inflammation and immunothrombosis state by chronic diseases, another alternative must be sought.[6-8] In complex scenarios with a high bleeding risk, occlusion of the left atrial appendage can be considered as an alternative to anticoagulation in those who are not candidates for long-term. In the Prague-17 trial, the use of the left appendage closure device has demonstrated non-inferiority compared to oral anticoagulation to prevent stroke, consistent with what has been reported by studies PROTECT AF and PREVAIL.[2,9]

In this case of ulcerative colitis and persistent atrial fibrillation with failed electric cardioversion, cryoablation of pulmonary veins, and WACA, including left atrial appendage before the placement of an occlusion device resulted in an effective strategy for rhythm control and stroke prevention. Current guidelines support the use of atrial appendage closure devices with a cautious level of recommendation in selected patients, particularly in cases such as this, where the use of anticoagulation is prohibitive.[10] However, in complex scenarios, it is an extremely useful tool, and its use is growing exponentially.

CONCLUSIONS

This case demonstrates the importance of individualizing the approach in a patient at high risk of thrombotic and bleeding events, where the appendage closure device is a good treatment strategy. In addition, cryoballoon ablation of the left atrial appendage and left posterior wall ablation are innovative techniques with few reported cases and were critical to the successful management of our patient.

ACKNOWLEDGEMENT

We want to thank Dr. Carlos Jerjes-Sánchez for his guidance and advice in the realization of this work.

REFERENCES

1. Rodríguez-Reyes H, Laguna-Muñoz CI, Gallegos-de Luna CF, Ríos-Ibarra MO, Salas-Pacheco JL, Leyva-Pons JL et al. Fibrilación auricular en población mexicana: diferencias en presentación, comorbilidades y factores de riesgo entre hombres y mujeres. Arch Cardiol Méx. 2022; 92 (3): 349-357. doi: 10.24875/acm.21000120.
2. Parameswaran R, Al-Kaisey AM, Kalman JM. Catheter ablation for atrial fibrillation: current indications and evolving technologies. Nat Rev Cardiol. 2021; 18 (3): 210-225. doi: 10.1038/s41569-020-00451-x.
3. Al-Rawahi M, Liang J, Kapa S, Lin A, Shirai Y, Kuo L et al. Incidence of left atrial appendage triggers in patients with atrial fibrillation undergoing catheter ablation. J Am Coll Cardiol EP. 2020; 6 (1): 21-30. doi: 10.1016/j.jacep.2019.08.012.
4. He B, Jiang LS, Hao ZY, Wang H, Miao YT. Combination of ablation and left atrial appendage closure as "One-stop" procedure in the treatment of atrial fibrillation: current status and future perspective. Pacing Clin Electrophysiology. 2021; 44 (7): 1259-1266. doi: 10.1111/pace.14201.
5. Yorgun H, Canpolat U, Kocyigit D, Coteli C, Evranos B, Aytemir K. Left atrial appendage isolation in addition to pulmonary vein isolation in persistent atrial fibrillation: one-year clinical outcome after cryoballoon-based ablation. Europace. 2017; 19 (5): 758-768. doi: 10.1093/europace/eux005.
6. Potere N, Abbate A, Kanthi Y, Carrier M, Toldo S, Porreca E et al. Inflammasome signaling, thromboinflammation, and venous thromboembolism. J Am Coll Cardiol Basic Trans Science. 2023; 8 (9): 1245-1261. doi: 10.1016/j.jacbts.2023.03.017.
7. Senchenkova EY, Ansari J, Becker F, Vital SA, Al-Yafeai Z, Sparkenbaugh EM et al. Novel role for the AnxA1-Fpr2/ALX signaling axis as a key regulator of platelet function to promote resolution of inflammation. Circulation. 2019; 140 (4): 319-335. doi: 10.1161/circulationaha.118.039345.
8. Shah AR, Jala V, Arshad H, Bilal M. Evaluation and management of lower gastrointestinal bleeding. Dis A Mon. 2018; 64 (7): 321-332. doi: 10.1016/j.disamonth.2018.02.002.

9. Osmancik P, Herman D, Neuzil P Hala P, Taborsky M, Kala P et al. Left Atrial Appendage Closure Versus Direct Oral Anticoagulants in High-Risk Patients With Atrial Fibrillation. J Am Coll Cardiol. 2020; 75 (25): 3122-3135. doi: 10.1016/j.jacc.2020.04.067.
10. Tzeis S, Gerstenfeld EP, Kalman J, Saad EB, Sepheri Shamloo A, Andrade JG et al. 2024 European heart rhythm association/heart rhythm society/Asia Pacific heart rhythm society/Latin american heart rhythm society expert consensus statement on catheter and surgical ablation of atrial fibrillation. Europace 2024; 26 (4).

Declaration of patient consent: we obtained the patient's signed informed consent form.
Funding: no financial support was received for this study.
Conflict of interests: the authors declare no conflict of interest.

Correspondence:
Gerardo Rodriguez-Diez
E-mail: gerardorodriguezdiez@yahoo.com.mx

Cardiovascular and Metabolic Science www.ancam.org.mx

Review

Vol. 35 No. 3
July-September 2024

doi: 10.35366/117829

The automatic external defibrillators records: another useful resource to take into consideration to create a national registry of out of hospital cardiac arrest in Mexico

Los registros del desfibrilador automático externo: otro punto a considerar para la creación de un registro nacional de paro cardiaco extrahospitalario en México

Jorge Álvarez-de la Cadena-Sillas,* Enrique Asensio-Lafuente,‡ Humberto Rodríguez-Reyes,§ Agustín Urzúa-González,¶ David Martínez-Duncker||

Keywords: automated external defibrillator, out of hospital cardiac arrest, cardio protected areas, Mexico.

Palabras clave: *desfibrilador automático externo, paro cardiaco extrahospitalario, espacios cardioprotegidos, México.*

* Cardiólogo, Instituto de Corazón de Querétaro y práctica privada. San Miguel Allende, Guanajuato, México.
‡ Electrofisiólogo, Instituto de Corazón de Querétaro. México.
§ Electrofisiólogo, Sociedad Cardiovascular y Arritmias. Aguascalientes, México.
¶ Cardiólogo, Unidad de Cuidados Intensivos del Hospital Regional de Alta Especialidad del Bajío. León, Guanajuato, México.
|| Cardiólogo, Universidad Autónoma del Estado de Morelos. Cuernavaca, México.

Received: 02/16/2024
Accepted: 07/10/2024

ABSTRACT

The increased use of the Automated External Defibrillator (AED) and the creation of cardio protected areas in the world and in Mexico contribute to increased survival rates after Out of Hospital Cardiac Arrest (OHCA). When used, the AED records not only the heart rhythm, but also information about Cardiopulmonary Resuscitation (CPR) in the unconscious victim. This data could be important and useful for further diagnosis and treatment. However, there are also some legal questions regarding the use of this information and how it should be managed. To this purpose we suggest the creation of a National Registry of Out-of-Hospital Cardiac Arrest (RENAPACE, for its acronym in Spanish) to handle the AED data. That information could serve for several purposes: 1. Guarantee the availability of data in Mexico for the care of patients who survive an episode of OHCA. 2. To monitor the quality in the use of the AED. 3. Scientific research. 4. To help create a more concise registry of the cause of death and push to include the term «sudden cardiac death» in death certificates. Creating a national AED registry requires, medical and political will and could confront economical, political, legal and organizational problems to address. There are some cities in Mexico developing this program.

RESUMEN

El aumento de los espacios cardioprotegidos y del uso del desfibrilador automático externo (AED, por sus siglas en inglés) en México y en el mundo ha contribuido a mejorar la supervivencia en el paro cardiaco extra hospitalario (OHCA, por sus siglas en inglés). El AED graba el ritmo detectado en la víctima además de información de la reanimación cardiopulmonar (CPR, por sus siglas en inglés). Esta información puede ser importante y de utilidad para el diagnóstico y tratamiento de casos futuros. Sin embargo, hay algunos problemas legales en cuanto el uso de la información y cómo deben manejarse los datos registrados en el AED. Por esta razón sugerimos la creación de un Registro Nacional de Paro Cardiaco Extra Hospitalario (RENAPACE). Este tendrá el propósito de: 1. Ayudar a mejorar y tener acceso a los datos nacionales de los pacientes que sufren y sobreviven a un OHCA. 2. Mejorar la calidad del monitoreo al respecto. 3. Hacer investigación científica al respecto. 4. Documentar con mayor precisión la causa de muerte e impulsar la inclusión del término «muerte súbita cardiaca» en los certificados de defunción en México. La creación de este registro de AED y RENAPACE requiere de voluntad médica y política y tendrá que afrontar y superar problemas económicos, políticos, legales y organizacionales para lograrse. En México varias ciudades han iniciado a implementar este programa.

How to cite: Álvarez-de la Cadena-Sillas J, Asensio-Lafuente E, Rodríguez-Reyes H, Urzúa-González A, Martínez-Duncker D. The automatic external defibrillators records: another useful resource to take into consideration to create a national registry of out of hospital cardiac arrest in Mexico. Cardiovasc Metab Sci. 2024; 35 (3): 111-115. https://dx.doi.org/10.35366/117829

INTRODUCTION

Out of Hospital Cardiac Arrest (OHCA) and Sudden Cardiac Death (SCD), represent approximately 20% of total deaths in adults.[1-4] In developed countries as the United States of America and the European Union, the mortality rate is calculated between 41-155 cases for every 100,000 habitants/year in the population older than 45 years.[5-7]

Patients who suffer an event of SCD secondary to a shockable rhythm, either tachycardia or ventricular fibrillation, and receive early defibrillation have an increased survival rate of 49.5% compared to 32.4% among those who do not receive it.[8] In the survivors' group, 56% received early defibrillation with an Automatic External Defibrillator (AED).[9] This indicates the importance of early defibrillation in the treatment of SCD. Successful Cardiopulmonary Resuscitation (CPR) during an OHCA requires the intervention of a community trained in hands only CPR.[10] They must activate the survival chain, detect the OHCA, notify the emergency system and if necessary, apply and use of the AED.[11] It is important that the general population is aware about and trained in Hands only CPR. Frequently the first responder of an OHCA is a person unrelated with the health system.[6,12] That witness is the ideal person to initiate CPR-By (bystander CPR) and it is the single factor with most impact on the survival rate of the victim. Family members have also been identified as an essential element to witness and initiate CPR, that will probably be performed with more emphasis than by any other bystander. Family member CPR has been associated with more than a two-fold increase in survival rates compared with delayed CPR by the Emergency Medical System (EMS).[13] An AED can be used in an effective way by the first responders or bystanders witnessing an OHCA. The stored data in the AED are underutilized and could potentially help improve its use and the CPR quality by any people. This record is also useful taking into account the increase in the number of AEDs in Mexico in recent years.

WHAT IS THE CLINICAL VALUE OF THE AED DATA?

When EMS take over CPR, they always check the patient's heart rhythm and pulse. In the absence of a shockable rhythm, the possibility that an earlier defibrillation administered by the AED has been successful arises. Sometimes there's even recovery of spontaneous circulation (ROSC), but the AED does not have a mean to display what happened before EMS arrived. These data, including the Electrocardiogram (ECG) records from the AED, are saved in the equipment but there is a special procedure to obtain them. Homma et al found that in 11-13% of OHCA cases, the initial rhythm treated by the AED was stored. That memory retrieval procedure is the only way to have access to the ECG and therapies received by the patient. Nonetheless, a very important step is to transfer the captured data to the EMS and Hospital responsible for the patient's treatment, and that is not always achieved.[14] What happens when the information that the patient was defibrillated for a shockable rhythm like ventricular fibrillation is not available? The physician will not know the cause and subsequently, the patient's condition would be difficult to stabilize because of a lacking proper diagnosis. A syncope, for instance, may not be recognized as cardiac arrest or as an aborted SCD. If the ECG recorded in the AED is not known, the patient potentially may not receive the right treatment, such as an implantable cardioverter-defibrillator (secondary prevention) and the possibility of a new SCD event could still be present.

Sometimes, even knowing the AED delivered a shock probably due to ventricular fibrillation, errors in the diagnosis and treatment could happen.[15] For these reasons, AED/ECG data records should always be analyzed to enhance clinical decision-making. Knowledge about the information stored in an AED is a useful tool to provide correct diagnosis and clinical decision making on patients who survive a SCD event. Also, the AED registers the resuscitation procedures, i.e. chest compressions and ventilations aside from heart rhythm and delivery of the defibrillation shocks, as shown in *Figure 1*.

Figure 1: Example of the start of an (AED) registration. I. Started at 13.41.47 at time point **A**, when the electrodes are connected and seconds later the rhythm analysis starts. II. 13.41.51 The AED analyzes the rhythm. III. After 9 seconds at point **B** (13.41.56) the AED has detected a shockable rhythm and charges itself. IV. Seven seconds after the AED advice, a shock at time point **C** (13.42.06) a defibrillation shock was administered. V. At 13.42.08 the heart rhythm has returned to normal. VI. Eight 8 seconds later at time point **D** (13.42.15), chest compressions are started at a rate approx. 100 per minute (red line). Conclusion from the AED data: 1) The cause of the cardiac arrest was ventricular fibrillation. 2) The first shock reversed the arrhythmia. 3) The rescuer has a good performance.

Modified from: Bak MAR, Blom MT, Koster RW, Ploem MC. Resuscitation with an AED: putting the data to use. Neth Heart J. 2021; 29 (4): 179-185.

Unfortunately, in Mexico the analysis of AED data is not done systematically.[16] In the Netherlands, for example, the AED/ECG data are routinely unloaded and stored. The treating physician will then have information about the initial rhythm registered by the AED in an OHCA. This can help the physician to establish the patient's correct diagnosis and treatment.[17,18] The generalized AED data collection and analysis is not easy and it is expensive, since it involves getting the information from different sites of a community, states etc. It also has to be considered that not all AED models are the same and thus, retrieval systems are not standardized either.[19] A legislation that allows access to that information is not available in Mexico.

Another concerning issue is that if data is not downloaded within a certain period, it might be deleted, lost to new acquired data, or the device might not record new events because of a full memory In Mexico the *Ley de Protección de Datos Personales*[20] (Personal Data Protection law) safeguards the patient's personal data from being disclosed without her/his permission. In this regard, a legislation that allows the access to specific medical information to better understand and know diagnoses, treatments and thus improves survival rates after OHCA could be useful.

We can then conclude that there are different needs for a new legal frame in our country. These could include the items depicted below and others that might arise ulteriorly:

1. A legislation for cardio-protected areas.[21,22]
2. Use of the AED data registry[23] (within the RENAPACE) to analyze the patients' information in any type of OHCA.
3. The possibility to use this medical and epidemiological information for public health purposes, patient diagnosis and treatment, as well as for research and investigation.[24]

The RENAPACE will facilitate access to this information and will point out what data could and should be used. It's important to say that data of a lonely SCD patient will also need a special type of legislation. There is a need for a legal frame and about the rules concerning implementation of cardio protected areas, OHCA registry (RENAPACE), good Samaritan laws, and using and processing a AED as well as its data. This requires an interaction between the government, non-governmental organizations, medical associations and organized (or not) community groups in order to solve logistic, ethical and juridical obstacles to create a legal scenario and structure to collect, store, retrieve and analyze the AED's data for research and emission of public health recommendations or policies.

In Mexico, some places such as Jalisco, Mexico City, Mexico State, Morelos, Nuevo Leon, Puebla, Queretaro, Sonora, Tamaulipas and Yucatan have started community hands-only CPR training and public access defibrillation programs, but unfortunately these efforts have not been implemented nation-wide yet.[25] National Programs in Mexico with permanent implementation of hands-only CPR and public access defibrillation can achieve important improvements in public health: 1) They will increase the knowledge and awareness of the general population and health personnel about the importance of SCD and OHCA; 2) they will help to create preventive measures aimed at the population to reduce OHCA and SCD; 3) they may reduce the incidence of OHCA and SCD, and 4) they might improve the survival rate of the community victims of OHCA.[26] These benefits will require a local and national legislation in the context of the cardio protected areas in our country, the need for medical associations to prioritize the patient's overcoming SCD in the context of an OHCA, and finally an optimal use of the AED.

ACKNOWLEDGEMENT

Acknowledgment to Dra. Lillian Hernandez Garcia for assisting in the review and translation of the manuscript.

REFERENCES

1. Gallagher EJ, Lombardi G, Gennis P. Effectiveness of bystander cardiopulmonary resuscitation and survival following out-of-hospital cardiac arrest. JAMA. 1995; 274 (24): 1922-1925.
2. Nichol G, Laupacis A, Stiell IG, O'Rourke K, Anis A, Bolley H et al. Cost-effectiveness analysis of potential improvements to emergency medical services for victims of out-of-hospital cardiac arrest. Ann Emerg Med. 1996; 27 (6): 711-720.
3. Dami F, Carron PN, Praz L, Fuchs V, Yersin B. Why bystanders decline telephone cardiac resuscitation advice. Acad Emerg Med. 2010; 17 (9): 1012-1015.
4. Rea TD, Eisenberg MS, Culley LL, Becker L. Dispatcher-assisted cardiopulmonary resuscitation and survival in cardiac arrest. Circulation. 2001; 104 (21): 2513-2516.
5. Kim F, Nichol G, Maynard C, Hallstrom A, Kudenchuk PJ, Rea T et al. Effect of prehospital induction of mild hypothermia on survival and neurological status among adults with cardiac arrest: a randomized clinical trial. Jama. 2014; 311 (1): 45-52.
6. Vaillancourt C, Verma A, Trickett J, Crete D, Beaudoin T, Nesbitt L et al. Evaluating the effectiveness of dispatch-assisted cardiopulmonary resuscitation instructions. Acad Emerg Med. 2007; 14 (10): 877-883.
7. Berg RA, Hemphill R, Abella BS, Aufderheide TP, Cave DM, Hazinski MF et al. Part 5: adult basic life support: 2010 American Heart Association Guidelines for Cardiopulmonary resuscitation and Emergency Cardiovascular Care. Circulation. 2010; 122 (18 Suppl 3): S685-S705.
8. Blom MT, Beesems SG, Homma PC, Zijlstra JA, Hulleman M, van Hoeijen DA et al. Improved survival after out-of-hospital cardiac arrest and use of automated external defibrillators. Circulation. 2014; 130: 1868-1875. doi: 10.1161/CIRCULATIONAHA.114.010905.
9. Zijlstra JA, Koster RW, Blom MT, Lippert FK, Svensson L, Herlitz J et al. Different defibrillation strategies in survivors after out-of-hospital cardiac arrest. Heart. 2018; 104: 1929-1936. doi: 10.1136/heartjnl-2017-312622.
10. Nichol G, Thomas E, Callaway CW, Hedges J, Powell JL, Aufderheide TP et al. Regional variation in out-of-hospital cardiac arrest incidence and outcome. JAMA. 2008; 300 (12): 1423-1431.

11. Ong ME, Shin SD, De Souza NN, Tanaka H, Nishiuchi T, Song KJ et al. Outcomes for out-of-hospital cardiac arrests across 7 countries in Asia: The Pan Asian Resuscitation Outcomes Study (PAROS). Resuscitation. 2015; 96: 100-108.
12. Cummins RO, Ornato JP, Thies WH, Pepe PE. Improving survival from sudden cardiac arrest: the "chain of survival" concept. A statement for health professionals from the Advanced Cardiac Life Support Subcommittee and the Emergency Cardiac Care Committee, American Heart Association. Circulation. 1991; 83 (5): 1832-1847.
13. Ebunlomo EO, Gerik L, Ramon R. Save a life: implementation and evaluation of a community-focused CPR education program in Houston, Texas. J Prim Care Community Health. 2021; 12: 2150132721998249.
14. Homma PCM, de Graaf C, Tan HL, Hulleman M, Koster RW, Beesems SG et al. Transfer of essential AED information to treating hospital (TREAT). Resuscitation. 2020; 149: 47-52. doi: 10.1016/j.resuscitation.2020.01.033.
15. Hulleman M, Blom MT, Bardai A, Tan HL, Koster RW. Atrial fibrillation mimicking ventricular fibrillation confuses an automated external defibrillator. Neth Heart J. 2018; 26: 281-282. doi: 10.1007/s12471-018-1098-0.
16. Martínez-Duncker RD, Urzúa-González AR, Aguilera-Mora LF, Laínez-Zelaya JS, Álvarez de la Cadena-Sillas J et al. Espacios cardioprotegidos en México: acciones para prevenir la muerte súbita cardiaca. Una postura de profesionales de la salud. Salud Pública Mex. 2023; 65 (4): 407-415.
17. Waalewijn RA, de Vos R, Koster RW. Out-of-hospital cardiac arrests in Amsterdam and its surrounding areas: results from the Amsterdam resuscitation study (ARREST) in 'Utstein' style. Resuscitation. 1998; 38 (3): 157-167. doi: 10.1016/s0300-9572(98)00102-6.
18. Van Alem AP, Vrenken R, de Vos R, Koster RW. The use of an automatic external defibrillator by the police: the Amsterdam resuscitation study (ARREST 4) [Abstract]. Circulation. 2001; 104: 17ll-400: 1905.
19. Hansen MB, Nielsen AM. ECGs from deployed AEDs: a neglected resource? Resuscitation. 2014; 85: e79-e80. doi: 10.1016/j.resuscitation.2014.02.003.
20. Ley Federal de Protección de Datos Personales en Posesión de los Particulares. Texto vigente. Nueva Ley publicada en el Diario Oficial de la Federación el 5 de julio de 2010.
21. Urzúa-González A, Álvarez de la Cadena-Sillas JE, Martínez-Duncker D, Celaya-Cota MJ, Aguilera-Mora LF et al. Suggested protocol for certification as a cardio protected areas in México. Positioning of a group of experts. Cardiovasc Metab Sci. 2024; 35 (1): 31-36.
22. Álvarez de la Cadena-Sillas J, Asensio-La Fuente E, Martínez-Duncker D, Urzua-González D, Celaya-Cota M, Aguilera-Mora LF et al. Out of hospital Cardiac Arrest.First steps to know and follow in Mexico to have Cardioprotected territories. A point of view of a group of experts. Arch Cardiol Mex. 2023; 93 (4): 1-7.
23. Wierda E, Eindhoven DC, Schalij MJ, Borleffs CJW, Amoroso G, van Veghel D et al. Privacy of patient data in quality-of-care registries in cardiology and cardiothoracic surgery: the impact of the new general data protection regulation EU-law. Eur Heart J Qual Care Clin Outcomes. 2018; 4: 239-245. doi: 10.1093/ehjqcco/qcy034.
24. Eindhoven DC, van Staveren LN, van Erkelens JA et al. Nationwide claims data validated for quality assessments in acute myocardial infarction in the Netherlands. Neth Heart J. 2018; 26: 13-20. doi: 10.1007/s12471-017-1055-3.
25. Urzúa-González AR, Rivera-Chávez MJ, Zapién-Villegas R, Huaracha-López PA. Cardio protected areas in México. Arch Cardiol Mex (Eng). 2020; 90 (2): 207-215.
26. Rodríguez-Reyes H, Muñoz-Gutiérrez M, Asensio-Lafuente E. Hands-only cardiopulmonary resuscitation and public access defibrillation, the need for cardio-protected areas implementation in Mexico. Cardiovasc Metab Sci. 2019; 30 (4): 143-146.

Funding: no financial support was received for this study.
Declaration of interests: the authors declare no conflict of interest.

Correspondence:
Jorge Álvarez-de la Cadena-Sillas
E-mail: jalvarezdelacadena@gmail.com

The *Cardiovascular and Metabolic Science* (before *Revista Mexicana de Cardiología)* is the official entity of the National Association of Cardiologists of Mexico, the Society of Interventional Cardiology of Mexico, the National Association of Cardiologists of the Medical Center La Raza AC, the National Association of Cardiologists Serving State Workers AC, the Mexican Association for the prevention of Atherosclerosis and its complications AC, the Mexican Society of Preventive Cardiology, the Alliance for a Healthy Heart, the Mexican Society of Cardiac Pacing and Electrophysiology, Medical Association of the Hospital of Cardiology Medical Center S. XXI. The Journal is currently indexed in Scopus, EBSCO, Scielo, Latindex, Medigraphic, LILACS, BVS, Google Scholar and others. Its scopes include original papers related to disease heart, blood vessels and related health sciences. The Journal publishes original research articles (experimental investigation) both clinical and preclinical, epidemiological papers, review topics, clinical case, corners of science, editorials (usually by invitation), letters to the editor and news of various associations.

In order to be accepted, all manuscripts are initially evaluated by at least two peer reviewers and finally sanctioned by the Editorial Committee. The Journal accepts, in general terms, the stated guidelines by the International Committee of Medical Journal Editors. Manuscripts should be prepared according to the Requirements of Uniforms for Submission of Manuscripts to Biomedical Journals. The updated version is available at: www.icmje.org.

All submissions should be made on line at the Journal's site. New users must first create an account. Once logged in, submission should be made via the Author Center. https://cardiovascularandmetabolicscience.org.mx/publicar.php or https://revision.medigraphic.com/RevisionCms/revistas/revista5/index.php If you experience any problem with your submission, please contact the editors at revmexcardiol@gmail.com

Submitted manuscripts should not be under review in any other journal. Moreover, all submissions must include full disclosure of all relationships that could be viewed as presenting a potential conflict of interest. If there are no conflicts of interest, authors should state that there are none.

Accepted papers will be owned by the Journal and may not be published (either whole or partial) elsewhere without written permission of the publisher.

Checklist

Check when each section has been duly completed in accordance with specified. Papers will not be accepted for a review if they do not include any (s) of the points previously mentioned.

General aspects

( ) Articles must be submitted electronically. https://cardiovascularandmetabolicscience.org.mx/publicar.php or https://revision.medigraphic.com/RevisionCms/revistas/revista5/index.php

( ) Manuscripts should be written in American English.

( ) The item must be written with a minimum font size 10 double space (28 x 21 cm), with margins of 2.5 cm on each side. The words in another language must be submitted Italicized. Avoid the use of «he, she, they, we» could be exchanged for nouns (doctor (s), patient (s), client (s), whenever possible, to seek gender neutrality.

( ) The text should be presented as follows: 1) page title, 2) abstracts and key words, 3) introduction,

4) materials/patients and methods; 5) results, 6) discussion, 7) conclusions, 8) acknowledgments, 9) references, 10) appendices, 11) text boxes, 12) figure captions. Each section will begin in different sheet. The format can be altered in review articles, clinical case, corners of science, if considered necessary.

( ) All authors should have made intellectual participation in the manuscript (conception or design of the work, taking responsibility for the data acquisition and analysis, and conclusions). Authors should revise the CRediT 'Contributor Roles Taxonomy' to detail authors' contributions (https://credit.niso.org/). Add a description of each author's role.

( ) Considering the type of article to publish (original research articles, clinical and preclinical, multicenter studies, epidemiological papers, review topics), the number of authors depends on the type of study, topic complexity, number of participating centers and sample size.

( ) No more than five authors in corners of science.

( ) List the name, address, telephone number and e-mail of three suggested reviewers who are not members of your workgroup, so they can be considered as potential peer-evaluation candidates.

Text

Title page

( ) Includes: a) title with a maximum of 15 words, b) name(s) of the authors in the order in which will be published; if the paternal and maternal surnames are recorded, linked them with a hyphen, c) degrees of the authors, d) affiliations and institution(s) where was the work performed, e) complete address, telephone, fax and e-mail address of the corresponding author.

Abstract

( ) Both in English and Spanish; with a maximum of 250 words. Structured according to the order of information in the text: 1) Introduction, 2) objectives, 3) material and methods, 4) results and 5) conclusions.

( ) 3-5 Key words.

Text

( ) Divided into subtitles that facilitate the reading: 1) introduction, 2) objectives, 3) material and methods, 4) results, 5) discussion, 6) conclusions.

( ) The names, initials or numbers of the patients studied record should be omitted.

( ) Abbreviations are accepted, but must be preceded for what they mean the first time that they are cited, according to the international units of measurement.

( ) Medicines, drugs and chemicals should be called by its generic name, dosage and route of administration, indicating the international nomenclature.

( ) The statistical methods used should be described at the end of the material and methods section.

Acknowledgements

( ) Acknowledgements should be considerate to scientific assistance, contributors to the acquisition of funding, figures or illustrations acquisition, general supervision, writing assistance, technical editing, administrative support, language editing, or proofreading.

( ) The acknowledgments and details on supports, drug (s) and team (s) provided (s) should be cited before the references.

References

( ) Vancouver style citation is required. (https://guides.lib.monash.edu/citing-referencing/vancouver).

( ) Identified in the text with Arabic numbers and superindex in progressive order of appearance.

( ) Personal communications and unpublished data will be cited unnumbered in a footnote.

Examples of journal articles:

Ohlsson J, Wranne B. Noninvasive assessment of valve area in aortic stenosis patients with. J Am Coll Cardiol 1986; 7: 501-508.

Six or more authors

San-Luis R, Munayer J, Aldana T, et al. Venous connection total anomalous pulmonary. Five years of experience. Rev Mex Cardiol 1995; 6: 109-16.

Books

Myerowitz PD. Heart transplantation. New York: Futura Publishing; 1987: 20-31.

Book chapters

Hardesty R, Griffi th B. Combined heart-lung trans plantation. In: Myerowitz PD. Heart transplantation. New York: Futura Publishing; 1987: 125-140.

Tables

( ) None.

( ) Yes.
Quantity (with letters): ________________

( ) The authors declare that all tables in the manuscript are entirely original and do not require reprint permission.
( ) The information provided is not repeated in the text or in Figures. Maximum allowed is the 50 percent plus one of the text sheet.
( ) Tables are preceded by the title and numbered progressively in Arabic numerals as they appear in the text.
( ) The title of each table alone explains its contents and allows correlate with limited text.
( ) Allowed formats: PDF, JPG, DOC or XLS. The file must be larger than 7 Kb and less than 4.2 Mb.

Figures

( ) None
( ) Yes
Quantity (with letters): ________________

( ) The authors declare that all illustrations and figures in the manuscript are entirely original and do not require reprint permission.
( ) Photographs, drawings, graphs, and diagrams are considered figures. All drawings must be professionally designed. The maximum allowed is 50 percent of one of each sheet of text.
( ) The information provided is not repeated in the text or tables.
( ) The figures are progressively identified with Arabic numbers according to the order in which they appear in the text, bearing in mind that the numbering includes the photographs, drawings, graphs and diagrams.
( ) Separately attached in formats: PDF, JPG, DOC or XLS. The file must be larger than 7 Kb and less than 4.2 Mb.
( ) The titles and explanations are presented separately
( ) Photographs that enables the people´s identification are accompanied by consent letters.
( ) Color illustrations are accepted and thus will appear online, but if authors wanted to be published in color of the printed version, must cover the proportional cost of printing.

Figure captions

Quantity (with letter): ________________

( ) The figure captions are marked with Arabic numerals according to the overall sequence corresponding to them.

Digital resources

( ) None
( ) Yes
Quantity (with letters): ________________

( ) The authors declare that all digital resources of the manuscript are entirely original and do not require reprint permission.
( ) Animations, video and audio recordings are considered digital resources. Professionals must design layouts.
( ) The information provided is not repeated in the text or tables.
( ) Please note that they are progressively identified with Arabic numerals according to the order of appearance in the text.
( ) Separately attached in formats: mp3 or mp4. The file must be larger than 7 Kb and less than 8 Mb. The titles and explanations are presented separately.

Digital source captions

Quantity (with letter): ________________
( ) Captions are added according to the sequence of Arabic numbers that corresponds to them.

Ethical aspects

( ) The human procedures must conform with the Ethical Standards of the Declaration of Helsinki of 1975 and the 1989 amendments to the agreement about ; issued by the Ministry of Health, published on January 26, 1982, and the Scientific Committee and Ethics institution where they were first performed.
( ) The informed consent was attached.
( ) The clinical trial registry number has been added to the manuscript body.
( ) The authors declare that they have followed their workplace protocols for using patient data. Also, they certify that the patient has received sufficient information and has given written informed consent for his/her/their images and other clinical information to be reported in the journal, without names or initials, to protect the right to privacy.
( ) Animal experiments conform to the rules of the National Research Council and the institution where they were performed.
( ) Any other situation that may interest must be notified in writing to publishers.

Transfer of Copyright

Article title:

Names of the main author and co-authors, and their emails:

All authors contributions (revise the CRediT, https://credit.niso.org/):

The authors certify that the above-mentioned article is original work and has not previously been published except in abstract form; all tables, illustrations, and figures in the manuscript are entirely original and do not require reprint permission. Additionally, the authors attest that no form of generative artificial intelligence was employed in the preparation of this manuscript or in the creation of figures, graphs, tables, or their corresponding captions or legends. Once accepted for publication in the *Cardiovascular and Metabolic Science*, copyright will be transferred to the latter. They also state that it has not been sent simultaneously for publication in another journal. The authors agree that, if necessary, this article would be included in the electronic media that the editors of the *Cardiovascular and Metabolic Science* consider appropriate.

The authors report that the order in which their names are mentioned in the article have been agreed between them and is a product of the proportion in which they participated in the elaboration of the work.

Signature of all authors

Location and date:

Asociación Nacional de Cardiólogos de México

PREVENIR ES NUESTRA META

XXI CONGRESO NACIONAL DE CARDIOLOGÍA

ABORDAJE MULTIDISCIPLINARIO DE UN MISMO PROBLEMA

EACVI European Association of Cardiovascular Imaging

ASE American Society of Echocardiography — Sound Saves Lives

5TH WORLD SUMMIT ON ECHOCARDIOGRAPHY

GUADALAJARA, JAL. MÉXICO

30 DE OCTUBRE AL 2 DE NOVIEMBRE 2024

Expo Guadalajara