GE HealthCare

Vivid™ Magazine

Sports Cardiology

Edition 5

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Dear Reader,

Nothing celebrates the love of sport like the Olympic Games. In this edition of Vivid Magazine, we recognize some of the most valuable players in athletics: sports cardiologists. While they may never stand on a podium or earn a gold medal, their inspired work is critical in maximizing athlete performance and improving safety. Within these pages, we will explore the complex subspecialty of sports cardiology, with echocardiography now emerging as one of the biggest game changers.

Leading our discussion is Prof. Sanjay Sharma of St. George's Hospital in London, who is an international expert in sudden cardiac death, cardiomyopathies, and exercise-induced cardiovascular adaptation in athletes. Prof. Sharma addresses the clinical difficulties in evaluating highly trained athletes, the potential impact of an erroneous diagnosis, and how echocardiography has been pivotal in providing confident answers.

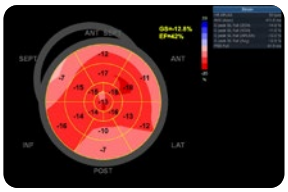
We are also proud to feature Prof. Hélder Dores of Hospital da Luz Lisboa in Portugal, who provides additional insights into leading-edge tools in echocardiographic evaluations, including the benefits of artificial intelligence. Through his lens, Dr. Dores expands the conversation on "athlete's heart" and shares his views on preparticipation screening and the value of treating recreational athletes.

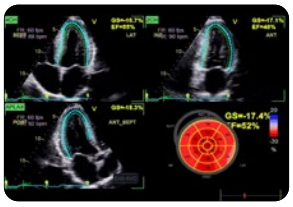
This issue also tackles the rise in anabolic steroid use and the damaging effects on the heart. Expert Dr. João Giffoni of Ipanema Health Club in Brazil shares his experience on cardiotoxicity of steroids and outlines how strain imaging and myocardial work are proving vital techniques in patient assessment.

As you will discover, innovations in the echo lab are deepening the understanding of cardiac exercise physiology and advancing evaluation, diagnosis, and treatment. GE HealthCare's Vivid team recognizes sports cardiologists as major players in this progress. Our hope is for continued partnership in what has always been a winning combination.

Dagfinn Saetre

Vivid Magazine





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Understanding the athlete's heart

Insights from echocardiography for life-changing diagnoses

Before they step onto the pitch, dive into the pool, or start pedaling, many of your favorite Olympians and professional players undergo critical cardiovascular screening. The main focus is helping these athletes maximize their performance, health, and safety. That includes preventing sudden cardiac death (SCD), the leading cause of death among young competitive athletes.[1] Crucial to this evaluation is distinguishing between normal cardiovascular adaptation to high-level exercise or 'athlete's heart' and true pathology, which places athletes at a higher risk for SCD with intense exercise. With so much at stake, some top sports cardiologists are relying on echocardiography for definitive answers.

One advocate is Prof. Sanjay Sharma, Professor of Cardiology at St. George's Hospital in London, and head of the largest sports cardiology unit in the UK. He is also a renowned expert in SCD in the young, athlete's heart, and heart muscle diseases. Professor Sharma's extensive research in this area has been pivotal in providing insights for echocardiographic assessment and critical clinical decisions.

St. George's Hospital has a busy echo lab and performs more than 30,000 echoes and 25,000 stress tests a year. Through the hospital's Inherited Cardiac Diseases and Sport Cardiology Unit, Dr. Sharma evaluates and treats hundreds of professional athletes, including Olympians, British Premier Football and Rugby League players, and members of the Lawn Tennis Association. When there's evidence of a potential cardiac abnormality during the screening process, many athletes will undergo an echo for evaluation and risk assessment.

We sat down with Prof. Sharma ahead of the Paris Olympics to learn more about identifying athlete's heart versus cardiomyopathies, and why echocardiography is a valuable tool in making a life-saving diagnosis.

What sparked your interest in sports cardiology and how has it evolved over the years?

Prof. Sharma: *I became interested in sports cardiology in 1997 after learning about the occasional football player suddenly dying on the pitch from a condition called hypertrophic cardiomyopathy. It's a disorder that is characterized by abnormal thickening of the heart muscle. Exercising regularly can also cause the heart muscle to thicken, so I started asking myself, how does one tell the difference between physiological increases in left ventricular wall thickness and hypertrophic cardiomyopathy? I knew that Saint George's Hospital had a very large cardiomyopathy center and I contacted Professor William McKenna about conducting research. I then made connections with the Lawn Tennis Association, triathlon, pentathlon, and it really grew from there.*

You are medical director of the London Marathon and work with many professional athletes, including Olympians for Team GB and Premier League players. What are your roles?

Prof. Sharma: *I've been the medical director for the London Marathon since 2017. My main job is really to enroll about 300 doctors of an appropriate skill mix to manage participants. We ensure that the race is safe and provide prompt care to get people running again or transferred to an urgent care unit.*

I also work very heavily with the Football Association and look after about 14 football clubs, including 10 Premier League clubs. I've been working with Olympians for two to three decades, including athletes competing in Paris. Whether you take triathlon or Team GB rowing, they're managed by the English Institute of Sport.

My main job with all these sporting organizations is to ensure that we have identified athletes who may be at risk of an exercise-related sudden cardiac death. That means screening those hearts to make sure they do not have any overt electrical and structural abnormalities that could result in a cardiac arrest.

What is your main objective as a sports cardiologist?

Prof. Sharma: *The main role of sports cardiology is to identify an athlete who may be harbouring a potentially serious cardiac condition, and then to provide some form of safe exercise prescription, even if we cannot cure some of the problems. We try to find the underlying cause, treat it, and preferably cure it, like Wolff-Parkinson-White syndrome or anomalous coronary artery.*

If we cannot cure, it's our job to perform risk stratification tests to identify whether some athletes may be safe enough to continue competing, despite potentially serious conditions. In some cases, an athlete must retire because the condition is quite serious. In those people, we try to provide a safe exercise prescription, which they can continue to perform without risking their lives.

Cardiac sudden death is the leading cause of death in elite athletes. Can you provide more insights about the risk?

Prof. Sharma: *I'm pleased to inform you that sudden cardiac death in young sportsmen is relatively uncommon. If we look at the overall risk of sudden death is about one in 50,000. We know that males are more prone to death than females. For males specifically, it's about one in 37,000. Athletes of African or Afro-Caribbean origin are more prone to deaths compared to white athletes. For black males participating in British football, it's about one in 4,000. If we look at black males participating in basketball in the U.S., it's also around one in 4-5,000.*[1]

We also know that sports involving dynamic start-stop nature, such as basketball and football are particularly at risk.

What are some of the cardiovascular conditions that can be linked to deaths in competitive athletes?

Prof. Sharma: *Deaths in young sportspeople (under 35 years old) are due to a diverse spectrum of cardiovascular diseases, which could have an inherited congenital or an acquired basis. The most common structural abnormality implicated in exercise-related sudden cardiac death is cardiomyopathy. Hypertrophic cardiomyopathy is the leading cause of death in the United States, whereas arrhythmogenic cardiomyopathy is the leading cause in Italy.*

> *"An erroneous diagnosis can have very serious consequences. It could jeopardize a young life if they continue to compete, or it could cost an athlete physically, psychologically, and financially if they have to give up the sport."*

Our own experience here at St. George's Hospital conducting autopsies on athletes who have succumbed during exercise, suggest that 40% of athletes actually do not have any underlying cause. When we investigate their relatives, such as their parents, we find that 40% of those individuals have an inherited electrical abnormality, such as Long QT syndrome or Brugada syndrome. Other structural causes of death include anomalous coronary arteries and valvular heart diseases. All these structural abnormalities can often be identified with echocardiography.

Why is an athlete's heart different and how does that factor into assessment?

Prof. Sharma: *People who exercise intensively for about four hours a day undergo a constellation of structural and functional changes within the heart to permit the generation of a large cardiac output for a prolonged period. That means that if you go from rest to exercise, your cardiac output increases from 5 L/per minute to between 25 and 30 L/per minute. If you're only doing this for a few minutes, the heart doesn't have to adapt. But if you're doing it for hours and hours, the heart must grow to pump a large stroke volume per beat. The heart increases in thickness by about 10 to 20% and increases in cavity size by around 10%.*

We also find that our athletes have enhanced left ventricular filling, so indices of diastolic function are supranormal. What you find with athletes with a very big heart and a very slow heart rate is that the heart fills hugely during diastole. It means the heart doesn't have to move very much to pump an adequate stroke volume to maintain a resting cardiac output of 5 L/per minute. As a result, a significant proportion of our athletes have a baseline low left ventricular ejection fraction, which can sometimes be muddled up for an early form of dilated cardiomyopathy.

Consequently, when we're faced with an elite athlete with an enlarged heart that looks as if it's just slightly bigger than what we normally expect, our differential diagnosis is between physiological cardiac enlargement at an extreme or a cardiomyopathy.

You have published extensive research on the differentiation between athlete's heart and dilated cardiomyopathy. What should clinicians consider when making assessments?

Prof. Sharma: *It's important to remember that 50% of athletes, particularly males, have a left ventricular cavity size that exceeds the upper limits for the general population. Approximately 40% of male athletes have a basal right ventricle diameter (RVD1) that exceeds that of the general population. It's also important to remember that around 12% of endurance male athletes have a borderline low left ventricular ejection fraction. Although exercise causes left ventricular hypertrophy, it's very uncommon to see a left ventricular wall thickness of more than 14 mm in a white athlete and more than 16 mm in the black athletes.*

My advice is that when you see a big ventricle that looks a bit lazy, please don't jump to a diagnosis of dilated cardiomyopathy or arrhythmogenic cardiomyopathy. Similarly, if you see a left ventricular wall thickness of more than 14 mm in a white athlete or more than 16 mm in a black athlete, do not attribute that to physiological left ventricular hypertrophy. That is hypertrophic cardiomyopathy until proven otherwise.

An erroneous diagnosis can have very serious consequences. It could jeopardize a young life if they continue to compete, or it could cost an athlete physically, psychologically, and financially if they have to give up the sport. This is why it's important that assessments are done in a very systematic way in an expert setting.

How is echocardiography part of that assessment and what are the advantages?

Prof. Sharma: *Most deaths in sport are due to a structural abnormality. Echo is an invaluable tool in identifying these abnormalities.[1] We use echo to first ascertain whether someone's got physiological changes that are compatible with athletic training. It also helps us differentiate or diagnose hypertrophic cardiomyopathy, dilated cardiomyopathy, and arrhythmogenic cardiomyopathy. It can also assess the aortic root in someone who may have aortopathy or even visualize the origins of the coronary arteries on the short axis using the aorta.*

Why is stress echo a powerful tool in sports cardiology?

Prof. Sharma: *When we try to differentiate between physiological cardiac enlargement and dilated cardiomyopathy in athletes who have big ventricles with borderline low left ventricular ejection fractions, we put them through a plethora of investigations, including biomarkers, ECG, baseline echo, stress echo, and MRI scans. We found that stress echo was by far the most superior tool in differentiating between dilated cardiomyopathy and athlete's heart.[2]*

An increase in left ventricular ejection fraction by more than 10% from baseline to peak exercise, or a peak left ventricular ejection fraction above 63% are very good discriminators for athlete's heart. Therefore, if you can increase your left ventricular ejection fraction above 10% from baseline to peak or increase your ejection fraction above 63%, that would be more in favor of physiological adaptation and allow you to safely tell the athlete to continue.

> *"Most deaths in sport are due to a structural abnormality. Echo is an invaluable tool in identifying these abnormalities. We use echo to first ascertain whether someone's got physiological changes that are compatible with athletic training."*

In addition to differentiating between athlete's heart and dilated cardiomyopathy, stress echo has a very important role in diagnosing obstructive coronary artery disease, ischemia from myocardial bridges or anomalous coronary arteries.[2] It can also identify dynamic left ventricular outflow tract obstruction in athletes who may have mild left ventricular hypertrophy with an elongated anterior mitral valve leaflet that may not show itself at baseline echo but demonstrate clear obstruction during peak exercise.

Putting athletes to the test

Focus on British Rower George Bourne

An echocardiogram and stress echo provided the answers professional rower George Bourne was hoping for. Prof. Sanjay Sharma was able to determine that the 26-year-old British rower, who was vying for the Paris Olympics, did not have a structural heart disease or other pathology that could possibly end his career.

"I came here to have my heart tested after some altitude training and getting sick with Covid. I was worried because I heard that other athletes on the team had real complications, and I was having similar symptoms to them," Bourne explained.

Bourne trains several times a day, six days a week. He acknowledged that it's a gruelling training schedule, but says it was only after the echo screening at St. George's that he could see the physical effects of intense exercise on his heart.

"Obviously we work hard, and we measure our heart rates, yet coming here to an environment like this and with all this technology, it's really cool to know how everything [in your heart] is working. And it's really reassuring to know I was getting the best tests possible," says Bourne.

While Bourne was nervous about receiving the results, he was also grateful to have the comprehensive testing available, including stress echocardiography, to rule out serious conditions.

"After all the medical tests, Professor Sharma determined it was a reaction to Covid and gave me the 'all clear' to start rowing again. I was relieved, but if I hadn't got the good news, it is still a much nicer way to find out here on this bed, rather than in a more dangerous environment," he says.

Unfortunately, Bourne missed a spot on the Olympic Team after coming up short at the final hurdle in the Men's Single Skulls at the World Rowing Final. But the determined athlete has no plans to stop competing. He is back on the water and training harder than ever (under the guidance of Prof. Sharma, of course).

> *"We found that stress echo was by far the most superior tool in differentiating between dilated cardiomyopathy and athlete's heart."*

In addition to diagnostics, how can echocardiography be used to estimate risk for cardiac conditions?

Prof. Sharma: *Echo plays a greater role than just as a screening tool. It also provides important risk assessment in many conditions. For example, let's take hypertrophic cardiomyopathy. If we look at the risk factors for hypertrophic cardiomyopathy, these include the actual maximal left ventricular wall thickness, the presence or absence of dynamic left ventricular outflow tract obstruction, or the presence of a very large left atrial diameter. All these parameters can be incorporated into the ESC risk model for hypertrophic cardiomyopathy.*

If we take an athlete who may have a low ejection fraction, we know that individuals who have dilated cardiomyopathy who have very low ejection fraction tend to do worse than individuals who've got normal ejection fractions. We also know that individuals who've got aortic roots that are approaching 50 mm are more likely to rupture their aortic root or dissect compared to individuals with a lower aortic.

What are the benefits of echocardiography over other modalities?

Prof. Sharma: *The most obvious benefits of echocardiography over other modalities, such as an ECG or an exercise stress test, is that it identifies structural heart disease. Although an ECG is an invaluable tool for someone like me, as is an exercise stress test in identifying electrical faults and exercise-induced arrhythmias, the only way we can actually diagnose structural heart disease is through an imaging test. Echocardiography is probably the most practical and pragmatic imaging test we've got available to us around the world.*

What technology is advancing the echocardiography field and allowing for more confident care?

Prof. Sharma: *There have been several advances in the technology of echocardiography machines, including GE HealthCare's Vivid machines. There have been improvements in tissue harmonics, which means that we can characterize the endocardium of the left and right ventricle and make much better measurements of the left ventricular wall thickness, the left ventricular volumes.*

And hence, we can provide a more accurate estimation of the left ventricular ejection fraction. In this respect, the 3D technology of the Vivid machines allows us to give a much better estimation of the ejection fraction.

We've got speckle tracking that gives us information on the global left ventricular longitudinal strain. And then there is tissue Doppler, which allows us to ascertain diastolic function in a much better way that we used to be able to do 20 years ago.

Is Speckle Tracking Strain imaging important in your practice?

Prof. Sharma: *There is a lot of emphasis placed on ejection fractions and strain values. It's important to remember that there is a diverse spectrum of ejection fractions that one sees in an athlete, but in general, athletes have lower ejection fractions compared to non-athletes. Our male athletes usually have a left ventricular ejection fraction below 60%. It's very difficult to comment on strain because just like our endurance athletes have low left ventricular ejection fractions, a significant proportion of our athletes also have a low global left ventricular longitudinal strain.*

> *"In this respect, the 3D technology of the Vivid machines allows us to give a much better estimation of the ejection fraction."*

I think we need to revisit the distribution of ejection fractions and also publish knowledge on a large number of athletes about the value and the cutoff values for a pathological global ventricular longitudinal strain.

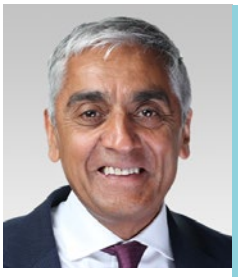
Sports cardiology is evolving. What other areas of the field need to be addressed with more research?

Prof. Sharma: *There are several knowledge gaps in sports cardiology that we need to cement. For example, I think we need more information about the impact of ethnicity on sport. Almost everything we know about sports cardiology is derived from the white population, but deaths in sport are more common in individuals of African or Afro-Caribbean origin. Asia probably contains the most athletes in the world, but we don't have data on that population.*

We also need to look at the impact of exercise on the acceleration of cardiomyopathy. We know that arrhythmogenic cardiomyopathy is made worse by exercise, but we don't have that data for hypertrophic cardiomyopathy.

What's the best part about your job and working with elite athletes?

Prof. Sharma: *It's wonderful to work with individuals that push themselves to the limits and demonstrate to us that the human body is capable of so much more than we ever imagined 20 or 30 years ago. It's just great to see that aspiration and desire, not just to do well for themselves, but to make the nation proud.* ■



Prof. Sanjay Sharma is Professor of Cardiology and lead of the Inherited Cardiomyopathies and Sports Cardiology Unit at St. George's Hospital in London. He is also the Medical Director for Virgin London Marathon, Consultant Cardiologist for the charitable organization Cardiac Risk in the Young (CRY), and Cardiologist for the English Institute of Sport, British Rugby League, and the British Lawn Tennis Association. Prof. Sharma was also lead cardiologist of the London Olympics for several events.

With more than 500 publications, Prof. Sharma has an international reputation in cardiovascular adaptation in athletes, sudden cardiac death in the young, and heart muscle diseases. His research has been key in characterizing the impact of age, sex, and ethnicity on cardiovascular adaptation to exercise and in the identification of non-invasive methods of differentiating electrocardiographic and echocardiographic manifestations of cardiomyopathy and ion channel disorders from those representing 'athlete's heart'.

1 Wasfy MM, Hutter AM, Weiner RB. Sudden Cardiac Death in Athletes. Methodist Debakey Cardiovasc J. 2016 Apr-Jun;12(2):76-80. doi: 10.14797/mdcj-12-2-76. PMID: 27486488; PMCID: PMC4969030.

2 Millar LM, Fanton Z, Finocchiaro G, Sanchez-Fernandez G, Dhutia H, Malhotra A, Merghani A, Papadakis M, Behr ER, Bunce N, Oxborough D, Reed M, O'Driscoll J, Tome Esteban MT, D'Silva A, Carr-White G, Webb J, Sharma R, Sharma S. Differentiation between athlete's heart and dilated cardiomyopathy in athletic individuals. Heart. 2020 Jul;106(14):1059-1065. doi: 10.1136/heartjnl-2019-316147. Epub 2020 Apr 27. PMID: 32341137.

Athlete's heart or dilated cardiomyopathy?

Courtesy of Prof. Sanjay Sharma, St. George's Hospital, London

Patient history/ pathology

A 23-year-old asymptomatic male underwent cardiac evaluation after his father was diagnosed with cardiomyopathy. The patient participated in the triathlon at the regional and national level. His echocardiogram revealed an enlarged left ventricle (LV) of 61 mm with mildly depressed left ventricular function (left ventricular ejection fraction (LVEF) 52%) and reduced global left ventricular longitudinal strain (-12.5%).

Challenges

A proportion of endurance male athletes reveal an enlarged LV with a mildly depressed LVEF of 48-52%, raising the differential diagnosis of dilated cardiomyopathy (DCM). The distinction between physiological cardiac enlargement with mildly depressed LVEF and DCM is crucial since DCM is implicated in exercise-related sudden cardiac death and may be exacerbated by vigorous exercise.[1] The diagnosis of DCM has further implications because it requires the initiation of prognostically important medications and regular surveillance. Dilated cardiomyopathy may also be inherited in up to 40% of cases. Given his family history, the findings on the echocardiogram could not be entirely attributed to physiological left ventricular remodelling (athlete's heart). In such cases, exercise echocardiography is important in facilitating the differentiation. An increase in LVEF <10% or a peak LVEF <63% favour DCM.

System, probe & device used

We used a Vivid E95 machine with a 4 dimensional probe (4Vc-D) to acquire LVEF using 4 dimensional full left ventricular volume analysis. The 3-4 multi-beat method was used to permit the highest possible volume rate for accurate analysis. Automated Functional Imaging (AFI) was used to measure global left ventricular longitudinal strain. Tissue Doppler was used to assess diastolic function. The scans were performed at baseline and during exercise on a supine bicycle.

Step-by-step procedure

A baseline echocardiogram, including 4D volume analysis, tissue Doppler imaging, and speckle tracking, was performed. Exercise echocardiography was conducted on a supine bicycle with an incremental ramp protocol of 20 Watts per minute. The tests revealed an increase in LVEF from 45% at baseline to 57% at peak exercise.

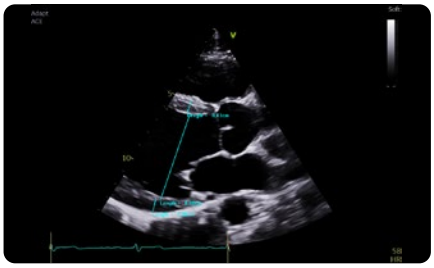
Cardiovascular Magnetic Resonance (CMR) imaging revealed enlargement of all 4 chambers and an LVEF of 52%. There were no regional wall motion abnormalities or myocardial scar.

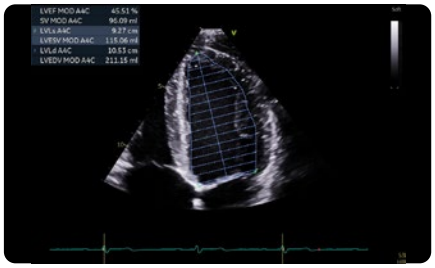
Conclusion

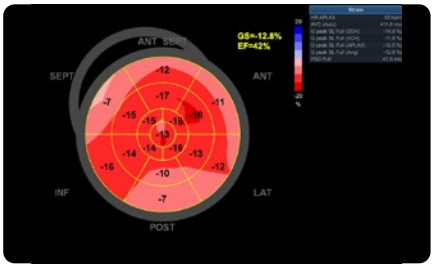
Although our athlete showed an increase in LVEF, our experience suggests that a failure to increase LVEF >10% or an increase in peak LVEF > 63% predicts DCM with a sensitivity of >80% and a specificity of >90%. We are less reliant on global left ventricular longitudinal strain (GLS) until more data is available, but our preliminary observations suggest that >70% of athletes with baseline low LVEF also have a GLS >-19%.

Imaging follow-up

The patient had genetic testing, revealing a pathogenic variant in the gene encoding titin, a recognised cause of DCM.[1] Based on the absence of symptoms, high level of fitness, only mildly depressed left ventricular function, lack of scar on the CMR, and absence of exercise-induced arrhythmias on an exercise test, he has opted to continue competitive triathlon. He is under 6 monthly assessments with resting echocardiograms, which have not revealed any deterioration in function over the past 18 months.

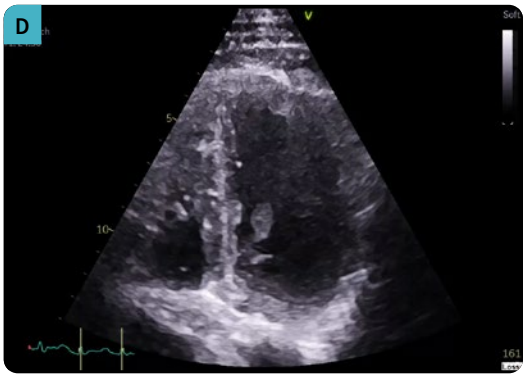






Static images reveal a dilated left ventricle with mildly reduced LVEF and reduced global longitudinal strain.

A-B) Enlarged LV with mild global hypokinesia.



C) Baseline 4-chamber left ventricular view demonstrating mild global hypokinesia.

D) Peak exercise echocardiographic 4-chamber view.

E) Baseline 2-chamber left ventricular view demonstrating mild global hypokinesia.

F) Peak exercise echocardiographic 2-chamber view.

1 Millar LM, Fanton Z, Finocchiaro G, Sanchez-Fernandez G, Dhutia H, Malhotra A, Merghani A, Papadakis M, Behr ER, Bunce N, Oxborough D, Reed M, O'Driscoll J, Tome Esteban MT, D'Silva A, Carr-White G, Webb J, Sharma R, Sharma S. Differentiation between athlete's heart and dilated cardiomyopathy in athletic individuals. Heart. 2020 Jul;106(14):1059-1065. doi: 10.1136/heartjnl-2019-316147. Epub 2020 Apr 27. PMID: 32341137.

Prof. Sanjay Sharma is a paid consultant for GE HealthCare and was compensated for his participation in this testimonial/Case study. The statements by Prof. Sanjay Sharma described here are based on his own opinions and on results that were achieved in his unique setting. Since there is no "typical" hospital/clinical setting and many variables exist, i.e. hospital size, case mix, staff expertise, etc. there can be no guarantee that others will achieve the same results.

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Advancing sports cardiology

The obstacles and opportunities that could be game changers

Sports cardiology is a growing field that continues to evolve. If you're keeping score, there have been tremendous strides in diagnostics to promote athlete safety without unnecessary limitations, but there are still gray areas contributing to continuous challenges. While more research is essential in defining future care, some experts believe emerging technologies in echocardiography will be crucial in gaining much-needed insights and providing a better understanding of the athlete's heart.

Prof. Hélder Dores is the coordinator of sports cardiology and cardiac rehabilitation at Hospital da Luz Lisboa in Portugal and a cardiologist in the Health & Performance Department of Sports Lisbon and Benfica. As a leading consultant for the most decorated football club in Portugal, Prof. Dores performs preparticipation screenings to help identify hidden cardiovascular diseases that might trigger cardiac events or sudden death.

While the preparticipation screening remains not mandatory in some countries, several scientific societies and sports federations recommend a comprehensive medical evaluation, including a 12-lead resting ECG.[1] Many physicians, including Prof. Dores, will include echocardiography when additional clinical insight is needed. As part of his practice, Prof. Dores performs transthoracic, transesophageal, and stress echoes, with Hospital da Luz Lisboa reporting more than 18,000 exams every year.

The best strategy for screening is still up for debate, but sports cardiologists are advancing the field by increasing their knowledge and understanding of the athlete's heart. Artificial intelligence and other technologies are playing a greater role in diagnostics, and helping cardiologists estimate risk and prescribe future exercise.

Prof. Dores recently shared his views on the main issues dominating modern sports cardiology, which has expanded to cover elite and recreational athletes alike.

What initially sparked your interest in sports cardiology?

Prof. Dores: *During my residency in cardiology, I developed a particular interest in exercise physiology. I was interested in cardiovascular physiological adaptations induced by exercise and also the risks and benefits of exercise in the presence of cardiovascular disease.*

Sports cardiology is a growing field with multiple possibilities to perform original investigations and also to develop these in clinical practice. Gaps and challenges surrounding screening that need to be clarified and the possibility to work with athletes in multidisciplinary teams were undoubtedly positive points that contributed to this decision.

Can you describe your position with Benfica?

Prof. Dores: *My role is in the Health and Performance Department of Benfica and is particularly relevant in preseason with cardiovascular evaluation and preparticipation screening of athletes. In addition, I perform consultations to athletes with symptoms or with abnormal findings in cardiac investigations that are recommended by my colleagues. I also perform and interpret ECGs, which are mandatory in Portugal. Additionally, I complete transthoracic echocardiograms (TTEs) in the club and integrate groups like emergency support teams.*

There are several athletes in the club that play in National teams, and it's important to work closely with the respective clinical departments. For example, regarding the Olympians and when needed, my colleagues in the clinical department of the Olympic Committee ask me for reassessments.

What are some of the most common conditions among these athletes?

Prof. Dores: *Fortunately, the main findings during athletes' evaluations are physiological adaptations and not pathological conditions. This is an important message. When discussing the abnormal findings, there are several electrocardiographic abnormal changes. For example, ventricular repolarization, especially T wave inversion, is the most common pathological finding in the ECG. In terms of structural heart conditions, we can detect cardiomyopathies, valvular heart disease, and even coronary artery disease in veteran athletes.*

What should colleagues know about sudden cardiac death?

Prof. Dores: *Sudden cardiac death in athletes is a tragic event, but uncommon. This is very important to stress considering the extremely variable incidence reflecting heterogeneity of the published data. However, sudden cardiac death is very mediatic, frequently occurring live in media and affecting apparently healthy individuals, which increases concerns. Most of the reported cases occur in male athletes with black ethnicity, mainly involved in basketball and football in the U.S. and in soccer in Europe.*[2,3,4]

While coronary artery disease is the most common cause of death in veterans, inherited conditions and sudden unexplained death cases, presumably electrical based, have been reported as the predominant causes in young individuals. Among these conditions, we have cardiomyopathies such as hypertrophic, arrhythmogenic right ventricular, or dilated cardiomyopathy. And there are primary arrhythmias like long QT syndrome, Brugada syndrome, or catecholaminergic polymorphic ventricular tachycardia.

> *"It's important to be sure that we are making the best decision for each case because the implications are not only clinical. That is why sports cardiologists need to acquire special skills beyond clinical expertise."*

It is important to highlight that there are other relevant causes of certain cardiac deaths including myocarditis and coronary origin anomalies. I also need to point out the illicit use of performance-enhancing drugs as another cause.

Why is sports cardiology a source of controversy?

Prof. Dores: *If you compare sports cardiology with other areas in cardiology or other specialties in sports, there are not a lot of randomized clinical trials. We are talking about very rare conditions. For example, sudden cardiac death is very, very rare. As a result, it's not easy to have a great experience to perform prospective studies because these will last several years.*

There are also specific considerations regarding elite athletes. There are a lot of complications if you stop the career of an athlete, including socioeconomic implications for the athlete, family, the club, and the supporters. It's important to be sure that we are making the best decision for each case because the implications are not only clinical. That is why sports cardiologists need to acquire special skills beyond clinical expertise. Developing the capacity to talk with other people and to implement a real shared decision-making process is very important in this context.

Who should undergo preparticipation screenings? Should it go beyond elite athletes?

Prof. Dores: *Regarding the evaluation of athletes, the methodology varies according to several characteristics—especially age. That's because the main causes of sudden cardiac death are different between younger athletes and veterans. The core components for younger athletes are a detailed personal and family history, physical examination, and ECG. For veteran athletes, 35 years or older, the main concern is coronary artery disease, so cardiovascular risk stratification with the application of risk scores and exercise testing are additional relevant steps. Further second-line exams, including echo, should be performed on a case-by-case basis. I think that the screening of younger athletes is fundamental for early detection of cardiac abnormalities, especially those associated with an increased risk of sudden death. In this context, mandatory screening should begin at an early age, for example 12 years old. It is controversial, but this evaluation should be repeated on a yearly basis—at least in competitive athletes. Also important, are findings that don't limit exercise, but may evolve over time, such as some congenital heart diseases, indicating that athletes should be closely monitored.*

In my opinion, the methodology and the reason to do these evaluations should include other characteristics of exercise beyond competitive level. Why? You can be a non-competitive athlete and perform a great amount of exercise per week, compared to other individuals who are competitive but don't perform the same intensity or volume of exercise. A good example is comparing a professional golfer to someone who does triathlons and Iron Man. Instead, we need to look at the overall characteristics related to the exercise and the characteristics of the person.

In younger athletes in Europe, we perform a history, physical examination, and ECG, but is that enough for an individual who performs extreme exercise (Iron Man competitions and triathlons)? Should we include an echo or other exams? In my clinical practice, I have access to all these exams, but it's not easy to implement because of the costs and financial burden so we have to integrate all the available data with specific clinical skills to detect these conditions.

What tools and technologies are most helpful in echocardiography?

Prof. Dores: *When indicated, a detailed and full echocardiographic evaluation should be performed, including all the available modalities and tools. This comprehensive evaluation is especially important in the cases that are in the gray zone due to the overlap between physiological and pathological findings. Structural evaluation is essential to evaluate for example the left ventricular wall thickness, cavity dimensions, coronary origin, valves and/or artery.*

> *"I think that echo has some advantages over other imaging modalities, particularly access, portability, and lower costs."*

The use of the conventional 2D or M mode remains relevant in this setting. The flow evaluation with color Doppler, PW, and CW, is also important, such as the tissue Doppler evaluation. Functional assessment of both left and right ventricle is very important, mainly with the calculation of left ventricular ejection fraction and the global longitudinal strain in this setting. The evaluation of the diastolic function is also very relevant in athletes because it's supernormal in a great number of them.

In short, for a more accurate athlete evaluation, I think we should use all the available echocardiographic tools with some individualized adaptations based on the clinical context.

You currently have access to many Vivid systems, ranging from the Vivid E95 to the Vivid iq. What are some of the benefits of echo versus other modalities?

Prof. Dores: *I think that echo has some advantages over other imaging modalities, particularly access, portability, and lower costs. On the other hand, with integration of different modalities and tools, I think echo allows a complete real-time evaluation of cardiac morphology and function with high spatial and temporal resolution. I believe those are the main benefits and advantages of echo versus other imaging techniques.*

Portable devices are also useful in sports cardiology and sports medicine because several times exams are performed in club facilities and not in hospitals or clinics. In my practice, I perform most of my exams at the hospital, but I have also evaluated teams using portable devices.

Do you utilize strain imaging as part of assessment?

Prof. Dores: *Strain is relevant for a more detailed evaluation of the systolic function and the most used parameter is Global Longitudinal Strain (GLS). For example, it's useful in the early detection of myocardial dysfunction. However, the interpretation of GLS in asymptomatic athletes is frequently challenging because studies have showed mildly reduced GLS at rest, especially in high-level endurance athletes.*

This topic will possibly be clarified in the near future, but integration of strain with other echo parameters, and eventually during exercise stress echo, could be helpful in athlete's evaluation.

Expand your capabilities with the Vivid Learning Academy

Take a deep dive into strain imaging in echocardiology with the Vivid Learning Academy. Check out our comprehensive episodes online.

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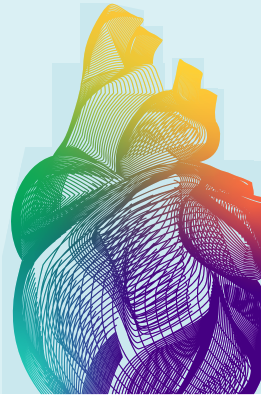

> *"Among the main advantages of these automative and AI-related tools are clearly time saving and of course, reproducibility."*

How frequently do you use artificial intelligence and automated features such as Easy AutoEF, Easy AFI?

Prof. Dores: *I utilize some AI features in practice. Auto ejection fraction and Easy AFI are the most common and useful in our standard, and I think incorporating these already validated and effective tools seem really useful. Among the main advantages of these automative and AI-related tools are clearly time saving and of course, reproducibility.*

How do you think AI will play a role in advancing sports cardiology?

Prof. Dores: *With the help of AI technologies and more robust data with large samples of individuals from multi-center practices, I think we can evolve and find answers for some controversial questions.*

Similar to how AI is impacting our daily lives, we already have evidence, tools, and devices that show the relevance of AI in sports cardiology. I believe the advantage is not only helping physicians to do exams faster, but also increasing the probability of detecting mild and early signs of abnormalities. I think there are a lot of automatic tools that can improve—and sometimes improve with more precision than the human eye—the detection of these mild changes.

So, there are many potential applications for advancing the evaluation of care of athletes, including wearable devices, and applications for automatic ECG interpretation, and analysis of echo images. Machine learning could offer opportunities to improve risk stratification, diagnosis, monitoring, and even therapeutic interventions.

Of course, it must be a balanced approach. I think combining the expertise of physicians with these technologies will lead to enhanced athlete care and better outcomes. However, we must consider ethical and legal issues at the same time.

The heart of sports cardiology and military medicine

You have extensive experience working with the military. What inspired you to work with Portuguese Army?

Prof. Dores: *One particular aspect of interest was exercise physiology, especially in extreme conditions. In fact, such as the competitive athletes, the military should be also regularly evaluated. As a military doctor of the Portuguese Army, I was involved in several real and training missions with the Special Forces, and additionally, I completed training in aeronautical medicine and was involved in the evaluation of Air Force pilots.*

The members of special forces and pilots are submitted to a more specific and deeper clinical evaluation, including some exams, namely ECG, blood tests, echo and exercise testing. At admission in the Armed Forces, the most relevant concerns are similar to those present in the preparticipation screening of young athletes, and the cardiovascular evaluation aims the early diagnosis of conditions potentially associated to sudden cardiac death. Beyond this mandatory evaluation, individual monitoring during some military activities could be important, especially in those more physically demanding or carried out in extreme conditions. These facts inspired my work in the Army.

How does sports cardiology relate to military evaluations?

Prof. Dores: *Regular exercise training induces several cardiac adaptations. This is true both in athletes and in military, mainly in the Special Forces, traditionally involved in activities characterized by exercise with high intensity and volume. These physiological adaptations that we call 'athlete's heart' would be evident at the electrical, structural, and functional level. In this setting, in the evaluation of the candidates at admission into the Portuguese Armed Forces and regularly after admission, the most relevant concerns are similar to those for young athletes, especially cardiac conditions.*

How are military soldiers screened and are there specific considerations?

Prof. Dores: *There are mandatory cardiovascular evaluations for the early diagnosis of conditions potentially associated with sudden cardiac death. Military have some particularities and are exposed to conditions that should be stressed, including emotional stress, environmental conditions, heavy equipment, and G-forces.*

As a result, the military are regularly evaluated at cardiovascular level. Beyond mandatory evaluations, individual monitoring could be important in extreme conditions and more physically demanding activities. Members of the Special Forces and Air Force are submitted to more specific and deeper clinical evaluations, including an ECG, echo and exercise testing.

You emphasize the importance of innovation in sports cardiology. What other areas need attention?

Prof. Dores: *I think that sports cardiology remains an attractive and growing field of cardiology with several controversial points that need to be clarified and research possibilities.*

As we move forward, we need to define the most appropriate methodology for athlete screening and prospective registries to avoid sudden cardiac death in sports. At a professional level, I believe sports cardiology could evolve as a subspecialty with more cardiologists integrated into clinical departments of sports federations and clubs, as well as hospitals and other health systems.

Exercise should not only be integrated in primary prevention, but also in secondary prevention, and in the treatment of patients with several conditions. That is connected to another topic that needs more attention: how to prescribe exercise.

We know there are several conditions associated with an increased risk of sudden death during exercise. While exercise is the trigger for potential arrhythmias and death, we also know that exercise could be good for some of these conditions. We need more discussion about how much exercise these people can do to have benefits and minimize risks.

You are a huge proponent of exercise to improve heart health. Can you tell us about your advocacy efforts?

Prof. Dores: *I think that exercise is medicine and it's important that people move more. Physical inactivity and sedentarism are real public health problems and affect children and adolescents. To change this, it's essential and urgent to implement measures at several levels.*

I regularly share a podcast with a colleague to educate the general population on how to have a healthier lifestyle to prevent and decrease the burden of cardiovascular disease. I am also publishing a new book on the topic and address it in papers and in the media. As a doctor, I believe I have a relevant role in this context, but I think this effort must be shared by all of us.

Dr. Hélder Dores is the coordinator of sports cardiology and cardiac rehabilitation at Hospital da Luz Lisboa in Portugal and cardiologist in the Health & Performance Department of Sport Lisbon and Benfica. Dr. Dores' areas of interest include athlete preparticipation evaluation, specifically ECG interpretation, and echocardiography as it relates to 'athlete's heart'. He has published more than 75 articles and authored two books. Dr. Dores also spent more than a decade assessing and treating members of the Portuguese Armed Forces.

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2 Chandra N, Bastiaenen R, Papadakis M, Sharma S. Sudden cardiac death in young athletes: practical challenges and diagnostic dilemmas. J Am Coll Cardiol. 2013 Mar 12;61(10):1027-40. doi: 10.1016/j.jacc.2012.08.1032. PMID: 23473408.

3 Egger F, Scharhag J, Kästner A, et al. FIFA Sudden Death Registry (FIFA-SDR): a prospective, observational study of sudden death in worldwide football from 2014 toc2018. Br J Sports Med. 2022;56(2):80.

4 Risgaard B, Winkel BG, Jabbari R, et al. Burden of sudden cardiac death in persons aged 1 to 49 years: nationwide study in Denmark. Circ Arrhythm Electrophysiol. 2014;7(2):205-11.

Left ventricular systolic dysfunction induced by androgenic anabolic steroid use

Courtesy of Dr. Hélder Dores, Coordinator of sports cardiology and cardiac rehabilitation at Hospital da Luz Lisboa, Portugal

Patient history/ pathology

Preparticipation screening: master male athlete (athletics, 100-200m sprints), 49 years old, Caucasian. Without significant personal and family history. Symptoms of fatigue and progressive reduction in sporting performance. Unremarkable physical examination.

1st step investigations: ECG without pathological findings; Cardiopulmonary Exercise Testing (CPET) showing low functional capacity (66% predicted VO2max).

Challenges

- Investigation of the potential causes for the reduction of functional capacity in this athlete
- Recognize the relevance of transthoracic echocardiogram to clarify the clinical context
- Choose the most appropriate echocardiographic tools and modalities to evaluate the cardiac morphology and function
- Understanding the role of echocardiography in the comprehensive athletes' evaluation

System, probe & device used

GE HealthCare Vivid E95, Probe 4Vc-D

Step-by-step procedure

In the setting of this preparticipation screening, echocardiogram was very important to investigate the abnormal findings present in the initial evaluation (symptoms and abnormal CPET results). This echocardiographic evaluation integrated several modalities and tools to ensure a detailed evaluation of cardiac function and structure.

Conclusion

In the evaluation of this master athlete with fatigue, progressive performance reduction and abnormal CPET, the echocardiogram was a crucial exam, revealing a dilated LV with severe systolic dysfunction, in which both LVEF and Global Longitudinal Strain (GLS) were important tools. A deeper investigation established as the most probable causes a previous abuse of anabolic-androgenic steroids or myocarditis.

During athlete's preparticipation screening, even not being a mandatory exam, echocardiogram is essential, mainly for investigation of symptomatic individuals or specific clinical contexts, such as those abusing performance-enhancing drugs.

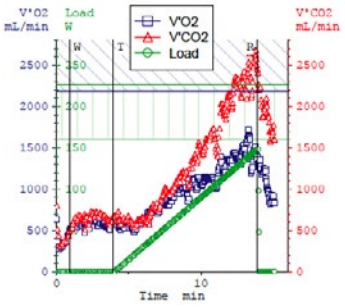
Imaging follow-up

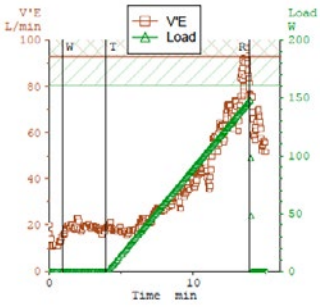
Cardiac Magnetic Resonance (CMR) was performed, showing a severe LV systolic dysfunction and extensive myocardial fibrosis.

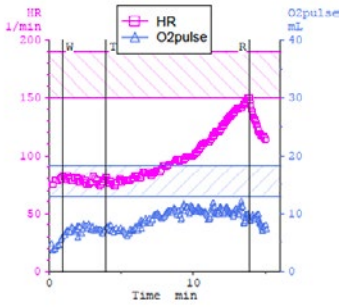
Echocardiographic revaluation 3 months after starting pharmacological therapy for heart failure.

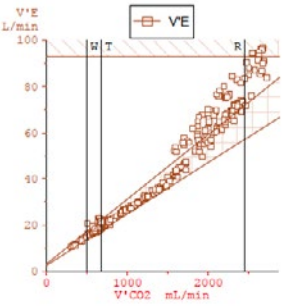
Echocardiographic follow-up at 6 and 12 months.

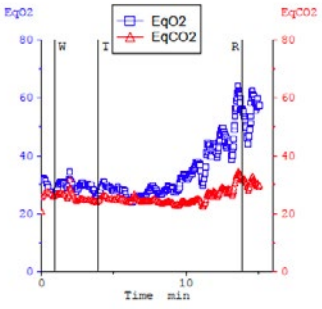
Summary (30 sec)		Rest	AT	VO2 Peak	Pred	AT/Pred (%)	VO2 Max/Pred (%)
Time	[min]	14:17	11:20	13:20	-	-	-
t-ph	[min]	00:24	07:25	09:24	-	-	-
Resposta Card. e Metabólica							
Load	[W]	0	109	139	194	56	72
RPM	[1/min]	61	63	59	-	-	-
V'O2	[mL/min]	871	1368	1725	2633	52	66
V'O2/kg	[(mL/min)/kg]	10.4	16.3	20.5	31.3	52	66
O2pulse	[mL]	6.5	11.8	12.1	15.5	76	78
HR	[1/min]	134	116	142	170	68	84
Psys	[mmHg]	170	150	160	-	-	-
Pdia	[mmHg]	80	85	85	-	-	-



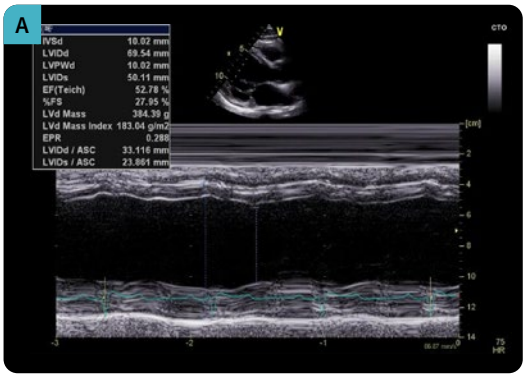


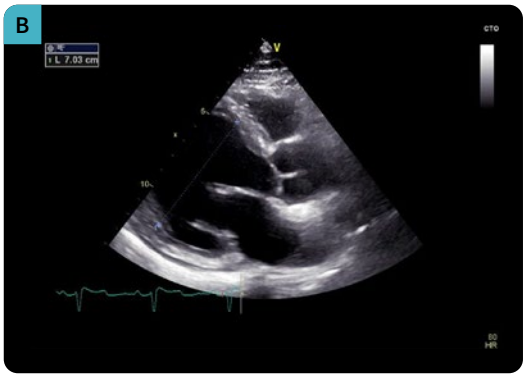




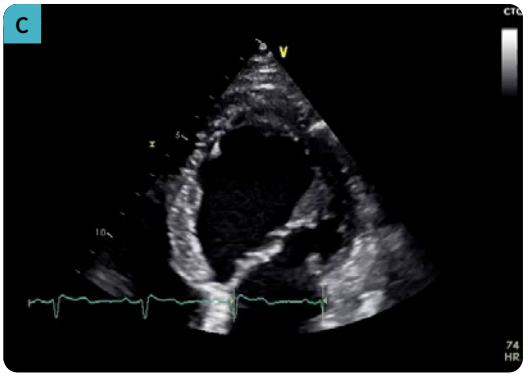


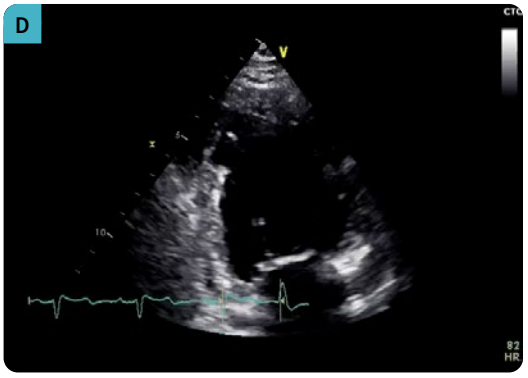
CEPT showing a reduced functional capacity with a predicted VO2max of 66%.



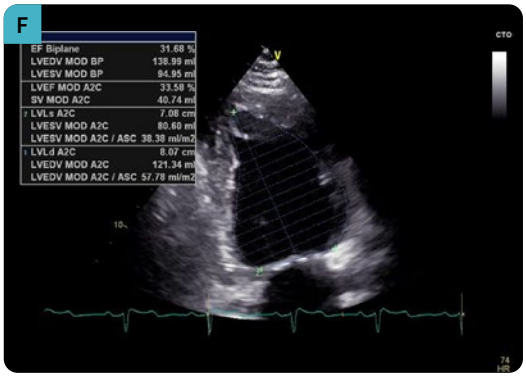


A-B) Eccentric LVH and LV dilation.

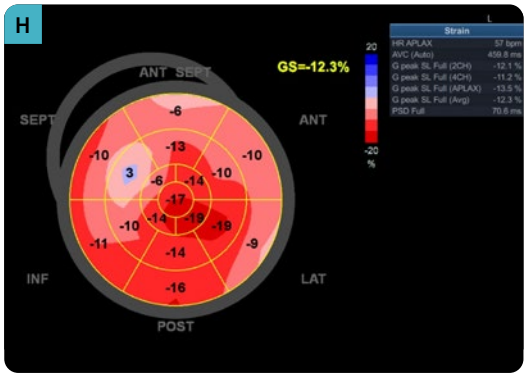


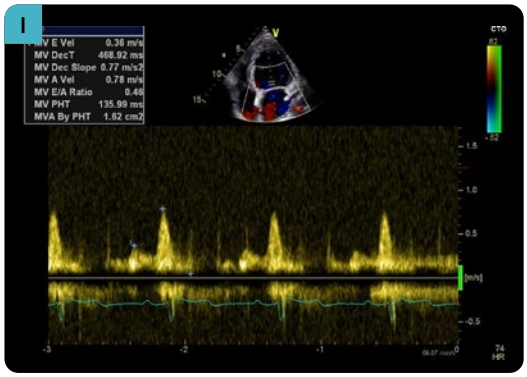


C-D) 2D 4 and 2-chamber views with dilated LV and diffuse hypokinesia.



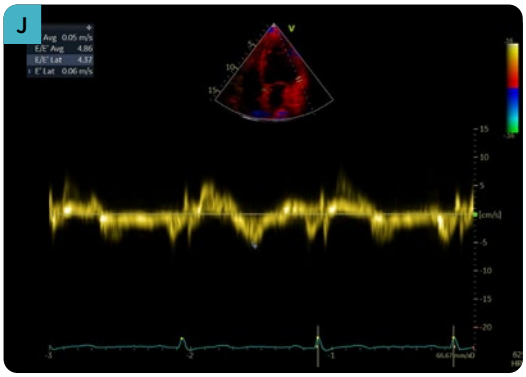
E-F) 2D showing a severe reduction in LVEF (32% by Simpson biplane).

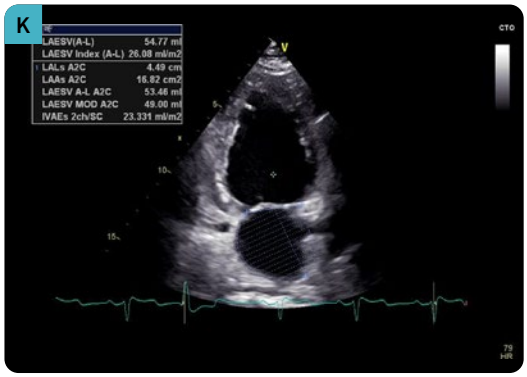


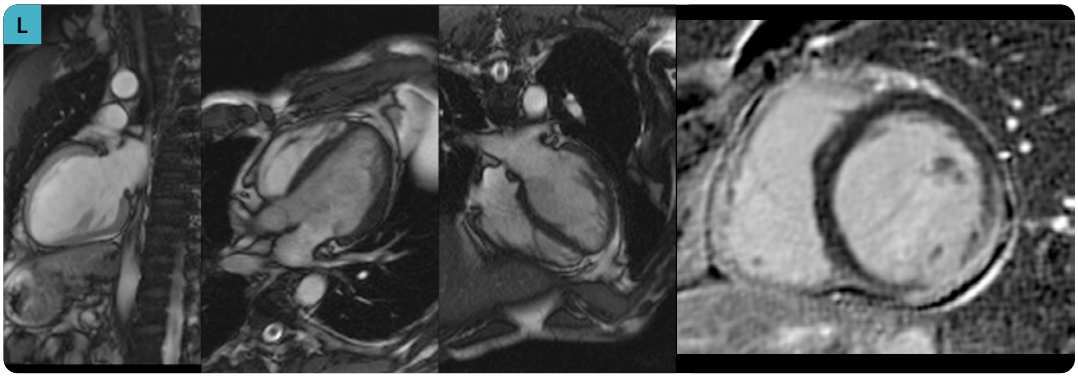


H) Speckle tracking showing a reduced GLS (-12,3%).

I-K) Additional data with a grade 1 diastolic dysfunction and dilated LA.







L) CMR showing LV dilation, systolic dysfunction (LVEF 35%) and infero-lateral subepicardial fibrosis.

Doctors are paid consultants for GE HealthCare and were compensated for participation in this article. The statements described here are based on their own opinions and on results that were achieved in their unique setting. Since there is no "typical" hospital and many variables exist, i.e. hospital size, case mix, etc., there can be no guarantee that other customers will achieve the same results.

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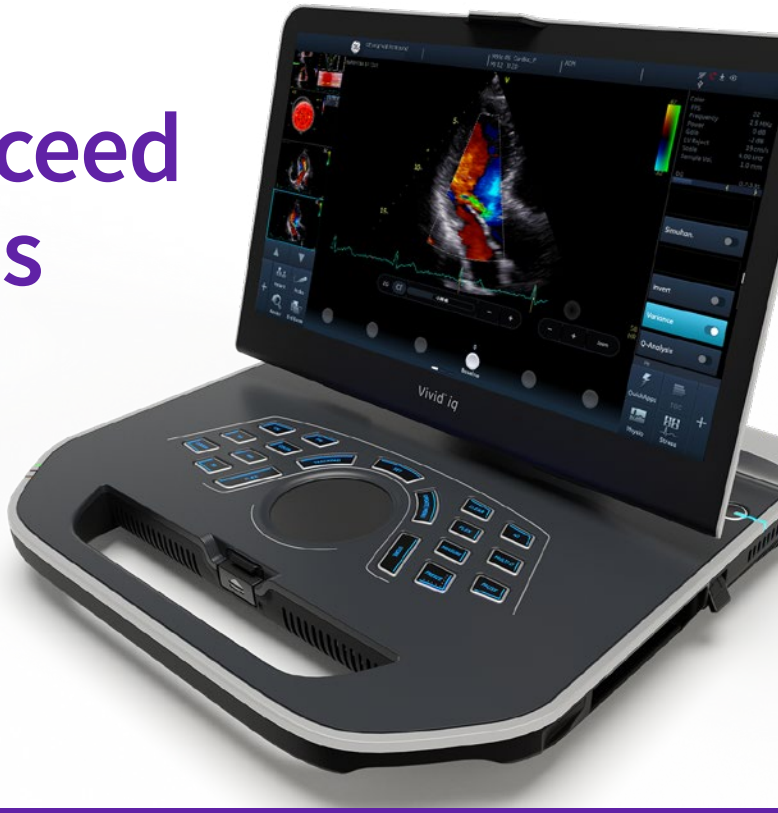

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* Ultra Edition is not a product name; it refers to the 2022 release of the Vivid portfolio.

1 Time to strain measurement result may vary with heart rate, frame rate and Vivid system. Verification of performance done by GE HealthCare clinical application specialists using Vivid system (DOC2739637).

2 Easy AutoEF is restricted for use with adult TTE on GE HealthCare raw B-mode data loops of the LV. Easy AutoEF does not support left ventricles with septal bulge.

3 L4-20t-RS only available on Vivid iq Premium, 4D, and Point of Care versions.

4 Up to 4 hours battery scan time on a cart or up to 1-hour scan time without cart.

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Building muscles shouldn't break hearts

Understanding the cardiotoxicity of steroids with advanced techniques in echocardiography

When it comes to anabolic steroids, there's one muscle that needs more attention: the heart. Prolonged steroid use has been linked to devastating cardiovascular effects.[1] With steroid use on the rise,[2] it's more important than ever to understand the effects on heart morphology and mechanics. Some of those critical answers can be found in the echo lab. However, we must delve into the details and, most importantly, incorporate advanced techniques into our analysis.

Anabolic steroids are synthetic derivatives of testosterone that are commonly used to enhance athletic performance, muscle development, and aesthetics. In sports circles, the use of performance-enhancing substances has been a contentious issue and widely debated. While steroids are commonly associated with professional sports, they are increasingly prevalent in high school locker rooms, neighborhood gyms, and fitness centers. In fact, an estimated tens of millions of people worldwide are taking steroids, and most are not competitive athletes.[3,4,5] The lifetime prevalence of ever using steroids in men (in the general population) is approximately 1% to 5%.[2,6]

Sports cardiologist Dr. João Giffoni has seen an uptick of these patients in his practice at Ipanema Health Club in Brazil. In his role as coordinator of the Advanced Imaging Center, Dr. Giffoni has conducted research on a range of steroid-induced cardiovascular complications, gaining valuable insights with advanced techniques in echocardiography. In total, his institution performs approximately 400 echocardiography exams every month, including advanced analyses (strain, myocardial work, 3D transthoracic echocardiography), vascular Doppler, cardiopulmonary exercise testing, and isometric and isotonic physical stress echocardiography.

We recently asked Dr. Giffoni to share his views on the cardiotoxicity of steroids and why he believes strain imaging and myocardial work are vital in diagnostics.

What made you want to pursue sports cardiology?

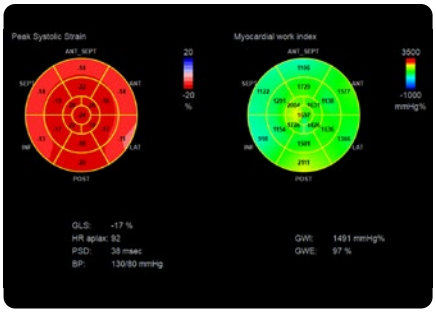
Dr. Giffoni: *I'm an athlete who enjoys sports and I have been involved in physical activities for most of my life. I've also consistently sought knowledge related to the cardiovascular performance of athletes and have an interest in assisting athletes with their performance.*

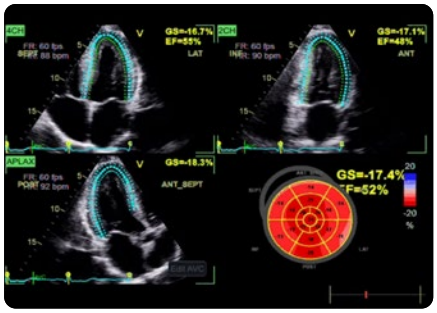
Can you describe your patient population?

Dr. Giffoni: *Our patients include regular and high-performance athletes, as well as sedentary individuals seeking longevity and beginning physical activities. We also see patients with coronary diseases or cardiomyopathies that are looking for safe exercise guidelines within their cardiac limits. For these patients, the presence of pathologies leads them to seek medical guidance, and it's our job to help them achieve high cardiovascular performance. Our role is to use cardiovascular analysis technology for the early detection and treatment of pathological conditions. For athletes, this allows for better performance. For the general population, it results in improved health and longevity.*

With current changes in sports medicine and the increasing prescription of steroid hormones, we are now facing a new condition. Patients are developing cardiac functional changes due to the use of anabolic steroids and other stimulating substances. Patients frequently use these substances in pursuit of a 'perfect body' and enhanced performance.

> *"Using echocardiographic techniques like strain and myocardial work, we can differentiate between cardiac adaptations to physical training and significant pathological conditions, such as HCM."*





Research shows steroid use is widespread and increasing. What are some of the factors contributing to the rise in numbers?

Dr. Giffoni: *There has been a rapid growth in fitness and bodybuilding culture. There is a positive side, including training, discipline, and healthier eating habits. However, there is also a dark side to the indiscriminate use of steroids—all of which is amplified by the media.*[6]

Currently, the use of steroids has become common. In today's culture, there is a certain glamour associated with their use. This is especially true here in Brazil,[7] *but I believe it's the same for Europe and the United States.*

Statistically, in the last decade, there has been an exponential increase in steroid use associated with increased prescriptions by doctors. The main reason is the relentless pursuit of a perfect physique. Notably, steroid use has expanded beyond the realm of high-performance sports, entering gyms and the offices of integrative medicine, endocrinology, and sports medicine.

Steroids have become a cornerstone of various medical treatments for libido, sarcopenia, obesity, osteoporosis, and primary and secondary hypogonadism, as well as for aesthetic purposes.

How do anabolic steroids impact cardiac function?

Dr. Giffoni: *We know anabolic steroids harm the heart muscle through direct aggression. There are two main mechanisms: genomic and non-genomic pathways. Both have been studied extensively in the literature. These mechanisms cause direct aggression to cardiomyocytes, leading to myocardial dysfunction, changes in the contractile pattern, increased left ventricular mass, and alterations in ventricular relaxation.*[1,8]

The use of anabolic steroids opens a new scenario as it increases the prevalence of adverse cardiovascular conditions such as hypertension, coagulation disorders, and changes in lipid profiles. These situations need to be analyzed as additional risk factors.

Why is echocardiography so important in sports cardiology?

Dr. Giffoni: *Echocardiography is fundamental in sports because it allows us to evaluate the presence of pathological conditions potentially associated with cardiovascular events that could be exacerbated by physical activity. Using echocardiographic techniques like strain and myocardial work, we can differentiate between cardiac adaptations to physical training and significant pathological conditions, such as Hypertrophic Cardiomyopathy (HCM). This reduces the so-called gray zone.*

In my practice, we use advanced tools daily. Not only for faster information that facilitates interpretation, but also for providing greater diagnostic possibilities. Most importantly, these tools help us better understand cardiac mechanics.

Through education, we have already managed to plant the seed of change in the national scenario where sports doctors now understand cardiotoxicity in a different way. They understand the need to perform echocardiograms with advanced techniques—introducing the use of myocardial work, in addition to isometric stress tests. Until recently, this was unthinkable.

> *"Without the use of advanced echocardiographic technology and stress analysis, it is highly likely that conventional echocardiographic evaluations will appear normal, leading to a loss of diagnostic time."*

What is the value of strain imaging in evaluating the impact of steroids on the heart?

Dr. Giffoni: *Depending on cardiac changes, patients will present with alterations in longitudinal strain, left ventricular twisting, and left atrial function. Without the use of advanced echocardiographic technology and*

stress analysis, it is highly likely that conventional echocardiographic evaluations will appear normal, leading to a loss of diagnostic time. That is why the use of strain imaging becomes mandatory in this group of patients. Additionally, there are alterations in myocardial work, with an increase in wasted work and a loss of efficiency.

Do you see any benefit of using RV and/or LA strain in addition to LV strain in athletes?

Dr. Giffoni: *Yes, both RV and LA strain are key for different reasons. We cannot consider the left ventricle without associating it with left atrial function. Proper ventricular function depends on good ventricular filling, which involves atrial function. When we talk about athletes, we refer to cardiopulmonary capacity. In this sense, we already know that the longitudinal strain of the right ventricle is closely related to cardiopulmonary capacity.*

For example, a right ventricular strain of less than 15% indicates significantly reduced cardiopulmonary capacity in anabolic steroid users.[8]

> *"Saving time is very helpful, especially in daily routines. However, reproducibility is essential because a technique must be reproducible to be used on a larger scale."*

How is strain helpful in other aspects of sports cardiology?

Dr. Giffoni: *I have incorporated strain into my clinical practice since 2009. From the beginning, I understood that it enables earlier diagnoses. We have observed significant technological advancements over time, allowing us to expand our capabilities beyond diagnostics.*

When studying the athlete's heart, we can now develop projects with sports trainers on cardiovascular performance, helping fine-tune the cardiac machine. That means understanding the right balance between contraction and relaxation, understanding contractility, the twisting mechanism, and how this impacts myocardial work, which influences cardiac efficiency.

For athletes and sports enthusiasts, details make a huge difference. These details can only be seen with the use of all the variables that echocardiographic tools like strain and myocardial work allow.

You utilize Easy AFI and Auto EF in your practice. What is the value of artificial intelligence in echocardiography?

Dr. Giffoni: *Saving time is very helpful, especially in daily routines. However, reproducibility is essential because a technique must be reproducible to be used on a larger scale. I particularly notice this when using Easy AFI and Auto EF. Looking forward, I believe that artificial intelligence will soon assist in defining important diagnostic patterns and conditions associated with specific clinical conditions, predicting the development of specific pathological phenotypes.*

What are some of the current gaps in sports cardiology and where could innovation make an impact?

Dr. Giffoni: *Sports cardiology is a rapidly growing field that is gaining attention as clinical cardiologists recognize the need to understand these patients differently. In this scenario, I see an increasing need for technology to understand the functional changes occurring in our patients' bodies (athletes or high-performance athletes,*

especially those using anabolic steroids), particularly in the cardiovascular system. This includes understanding the changes brought about by physical training and the effects on patients who resort to new medical therapies in the relentless pursuit of beauty and youth.

What steps are you taking to advance the field and help others understand the effects of steroids on the heart?

Dr. Giffoni: *We have been studying and researching the use of steroid hormones and their interaction with the cardiovascular system for several years, presenting our findings at national and international conferences. We are also participating in podcasts and educating doctors in various courses and lectures throughout Brazil. We are currently part of the faculty of the first postgraduate course in sports cardiology in Brasil, coordinated by Dr. Renata Castro. Additionally, we are pioneers in sports echocardiography with a course held at ECOPE, the School of Echocardiography in Pernambuco.*

We are contributing to a book set to be released later in 2024, focusing on cardiac strain. In this book, we discuss the cardiotoxicity of steroid use and the application of myocardial work. This panorama reflects immense growth in the country. I believe that the technology of myocardial work is now being used extensively by all our students, mainly because of the cardiotoxicity caused by steroid use.

How are you trying to educate the public on the dangers of anabolic steroids?

Dr. Giffoni: *We work daily to try to raise awareness among people on social media. I also think we should have more presence at fitness fairs. We need to do more to reach the primary audience, which is influential and generates a lot of content on social media. This sparks debate and drives doctors to seek out the content inversely. In other words, the public brings the information to doctors who feel the need to stay informed.* ■

Dr. João Giffoni is the coordinator of the Advanced Imaging Center at Ipanema Health Club. He specializes in sports medicine, cardiology, and echocardiography. The sports cardiologist combines academic research with clinical practice, investigating the impact of steroids on athletes' hearts. Dr. Giffoni has published articles and various papers at congresses in Brazil, the American College, and ESC on the subject. He also shares a passion for sports, including bodybuilding, boxing and jiu-jitsu.

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Assessment of myocardial dysfunction in anabolic steroid users

Courtesy of Dr. João Giffoni, Coordinator, the Advanced Imaging Center, Ipanema Health Club, Specialist in Sports Medicine, Brazil

Patient history/ pathology

33 year old male, 175 cm, 87 kg, bodybuilder. Reports a decline in physical performance with decreased training loads, experiencing dyspnea at rest. Has no prior history of cardiovascular diseases, normotensive. Using testosterone on a weekly basis, and anabolic steroids daily for the past 6 months.

Challenges

The challenges include the need for an assessment using advanced echocardiographic techniques both at rest and during isometric exercise to determine the presence of myocardial function alterations, considering that the use of two-dimensional echocardiography does not reveal functional changes.

System, probe & device used

The Vivid E95 echocardiography system with the 4Vc-D phased array probe was used for image acquisition. Image post-analysis was conducted on the EchoPAC™ software only version 206. This analysis was performed both at rest and during isometric exertion using a leg press.

Step-by-step procedure

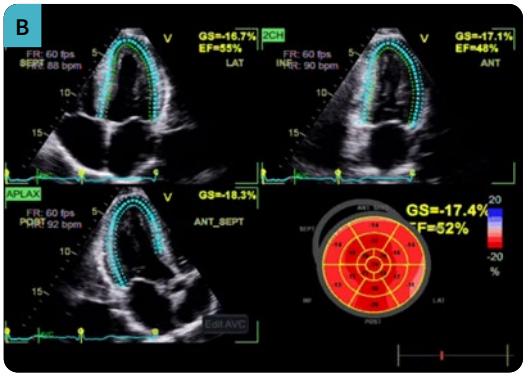
An echocardiographic analysis was performed both at rest and during isometric exercise on an extensor chair. The following measurements from two-dimensional echocardiography were analyzed: left ventricular end-diastolic diameter (LVEDD), left ventricular end-systolic diameter (LVESD), inferolateral wall thickness and anterior septal thickness, left ventricular ejection fraction (LVEF), left ventricular diastolic function, global longitudinal strain (GLS) of the left ventricle, myocardial work with all its variables, constructive work, wasted work, and myocardial efficiency.

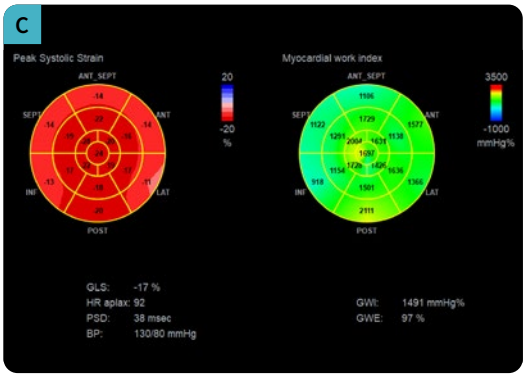
Conclusion

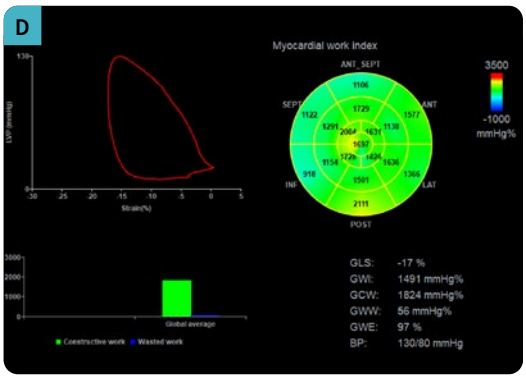
We identified the need to use advanced echocardiographic techniques to detect myocardial dysfunction in users of anabolic steroids. Additionally, we found that specific analyses simulating the athletes' training efforts are required, as myocardial dysfunction often becomes apparent only under physical stress. Consequently, we observed a significant increase in deconstructive work, which defines a decrease in myocardial efficiency.

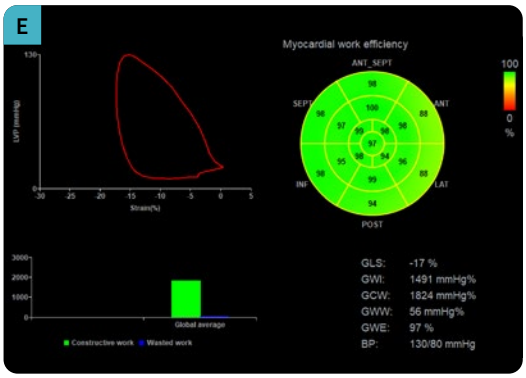
Imaging follow-up

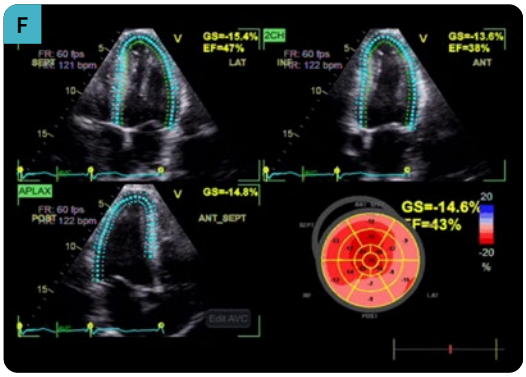
We emphasize the importance of analyzing left ventricular strain and myocardial work both at rest and during isometric exertion. This approach shows a significant decrease in myocardial efficiency, which cannot be detected through conventional two-dimensional echocardiography.

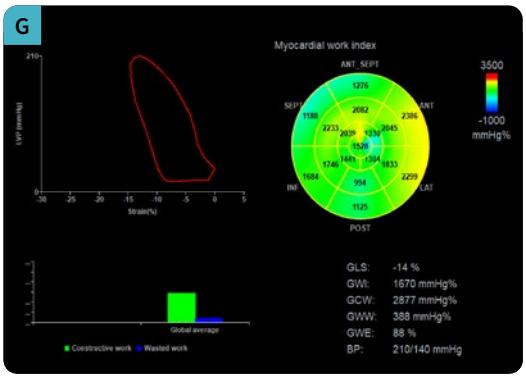


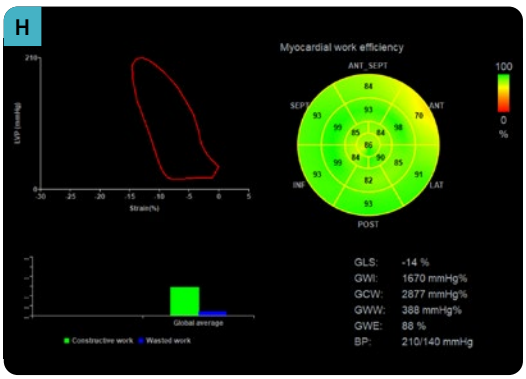












A) Analysis of left ventricular ejection fraction by Simpson.

B) Analysis of longitudinal strain at rest by AFI, observing the 4-chamber, 2-chamber and 3-chamber views.

C) Analysis of longitudinal strain and myocardial work at rest.

D) Analysis of myocardial work at rest.

E) Analysis of myocardial efficiency at rest using myocardial work tool.

F) Analysis of longitudinal strain by AFI during isometric exertion in leg press, observing 4-chamber, 2-chamber and 3-chamber views.

G) Evaluation of myocardial work during isometric exertion in leg press, demonstrating a significant increase in deconstructive work and a decrease in efficiency.

H) Analysis of myocardial efficiency by using myocardial work tool during isometric exertion.

Doctors are paid consultants for GE HealthCare and were compensated for participation in this article. The statements described here are based on their own opinions and on results that were achieved in their unique setting. Since there is no "typical" hospital and many variables exist, i.e. hospital size, case mix, etc., there can be no guarantee that other customers will achieve the same results.

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