DOI: 10.5644/PI2021.199.02

UPDATE IN DIAGNOSTICS CARDIOLOGY

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Submitted: 2021, accepted: 2021, published: 2021

Abstract

Cardiovascular medicine is an area of clinical practice with a continually rapid expansion of knowledge, guidelines, best practices and new technology in adult cardiovascular medicine as well as in paediatric cardiology medicine. Cardiovascular diseases (CVD) are the leading cause of mortality in the world and cause major costs for the health sector and economy. Cardiovascular imaging indices have a significant impact on the prevention, diagnosis, and treatment of cardiac diseases. Advanced imaging technologies have dramatically improved our ability to detect and treat cardiovascular disease at an early stage. Multimodality imaging techniques - echocardiogram, cardiac computerized tomography, magnetic resonance imaging, simulation 3D models, artificial intelligence - are being used more frequently as their utility is better appreciated.

Coronavirus disease 2019 (COVID-19) exerts an unprecedented global impact on public health and health care delivery. Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) causing COVID-19 has reached pandemic levels since March 2020. Patients with cardiovascular (CV) risk factors and established CVD represent a vulnerable population when suffering from COVID-19, and have an increased risk of morbidity and mortality. Severe COVID-19 infection is associated with myocardial damage and cardiac arrhythmia. Diagnostic workup during SARS infection revealed electrocardiographic changes, sub-clinical left ventricular (LV) diastolic impairment and troponin elevation.

All professionals in cardiovascular medicine, as a part of lifelong learning process, have the continuous imperative in reviewing novelties, with results data from numerous researches in order to treat all patients according to best practices and evidence-based medicine, especially on this journey through corona pandemic.

Key words: diagnostics, cardiology, up to date

Cardiovascular medicine is an area of clinical practice with a continually rapid expansion of knowledge, guidelines, best practices and new technology in adult cardiovascular medicine as well as in paediatric cardiology medicine (1). Cardiovascular diseases (CVD) are the leading cause of mortality in the world and cause major costs for the health sector and economy. Although during the last two decades rates of cardiovascular mortality declined in many developed countries, they have grown in low- and middle-income countries. Primary care clinicians are challenged to optimally manage a multitude of diseases involving the cardiovascular system, including the heart failure, arrhythmias and the circulation affected by abnormal cholesterol metabolism and hypertension. The majority of CVDs can be prevented by addressing behavioural risk factors such as tobacco use, unhealthy diets and obesity, physical inactivity and harmful use of alcohol, using a population wide strategy (2). *Innovative technologies* in the world of cardiovascular medicine are expanding every day such as: wearable computing technologies, bioresorbable stents, leadless pacemaker, valve-in-valve procedure, protein patch for heart muscle growth and others (3).

In the section of *Adult Cardiology,* we are going *to review* a few novelties which would be of interest *for primary care practitioners*.

Artificial intelligence (AI) is defined as the ability of computer systems to perform tasks humans usually perform. Machine learning, while often used interchangeably with AI, is actually a subset of AI in which algorithms, mathematical models and/or computer systems are used to optimize the performance of a given task (4). The *Six broad* areas in which AI will advance the cardiovascular field are: *1. Novel drug discovery/development*. AI is increasingly being used to refine the selection of potential therapies by searching for patterns in molecular biology, structure-function, and clinical trial databases; *2. Precision medicine.* With AI, genetic information, environment and lifestyle can be quickly assessed to determine who is most likely to benefit from certain interventions; *3. Integration of data from varied sources*. AI enables data from varied sources, such as wearables, social media, the electronic health record, to be integrated into models that can predict the trajectory of both health and disease; *4. Improved efficiency.* AI can help reduce provider dissatisfaction and burnout by minimizing repetitive tasks, prioritizing HER (Health Electronic Record) - based alerts or messages, improving and automating image interpretation in the catheterization or echocardiography laboratory, and presenting a "preferred" treatment plan based on integration of varied data sources; *5. Remote monitoring*. AI can strain out clinically actionable data from the trillions of data bytes wearable devices collect; *6. Increasing the value of delivered care*. Artificial intelligence is an ideal population tool, given its ability to better predict individuals at greater or lesser risk of developing chronic diseases or related complications, tailoring preventive therapies and allocating limited resources to those most likely to benefit from them. No emerging technology has more promise than AI. There are dozens of articles about the potential for AI in health care and an increasing number of scientific publications. But, overall, almost nothing has yet made its way into clinical practice. One likely reason is that many start-up and established tech companies underestimated the complexity of health care data and the need to provide strong evidence that the use of AI would improve efficiency and outcomes. It's therefore important that clinicians insist on strong data before relying on AI.

Another aspect of novelty in cardiovascular diagnostics medicine that has been discussed is *Patient-Generated Data:* The first "wearable" in cardiovascular medicine dates back to the 1800s, when a watch with a second hand was used to measure heart rate (4). Today, however, wearables are more likely to be patient initiated, measuring everything from heart rate and rhythm to blood pressure, sleep quality and duration, and physical activity (5,6). There is particular interest in the ability of wearables to affect clinical outcomes in cardiovascular disease. A major trial evaluating the potential of specialized software for the Apple Watch to detect abnormal heart rhythms is underway. The Apple Heart Study, a virtual, prospective, single-arm pragmatic study has enrolled more than 400.000 participants. The primary outcome is the proportion of participants with an irregular pulse detected by the watch who are diagnosed with AF on subsequent ambulatory ECG patch monitoring. A secondary outcome is to estimate the rate of initial contact with a healthcare provider within three months after the patient is notified of a pulse irregularity (8). To date, data on clinical outcomes from mHealth devices are primarily based on case studies. For instance, Martin and his colleagues recently reported on the case of a woman with paroxysmal AFib whose Apple Watch/Cardia Band detected tachycardiomyopathy, enabling early identification and treatment and likely preventing significant morbidity (7,8,9). This represents the beginnings of mHealth being integrated into clinical care.

Acute myocarditis has been evaluated in the section of *cardiovascular imaging techniques*, discussing several points: the challenge to diagnose acute myocarditis given its varied clinical manifestations. *Cardiovascular magnetic resonance (CMR)* is a key noninvasive test for acute myocarditis as it enables identification of the location and extent of myocardial involvement, but the optimum CMR protocol for identification of acute myocarditis has not been established. A systematic review and meta-analysis included 22 studies comparing the diagnostic accuracy of CMR techniques for acute myocarditis (10). These findings will help refine CMR protocols for the diagnosis of acute myocarditis. Limited data are available on the agreement between left ventricular ejection fraction (LVEF) measurements by various cardiac imaging modalities. The largest available study of *intermodality variability of LVEF* analysed core lab data from an international trial enrolling patients with coronary artery disease and reduced LVEF including *echocardiograms, single-photon emission computed tomography, and cardiac magnetic resonance (CMR) imaging* (11). Correlation between LVEF determined by quantitative versus visual echocardiographic methods was greater than the correlation between LVEF assessed by different modalities (such as biplane echocardiography versus CMR). In paired comparisons of LVEF by differing imaging modalities, approximately half fell within a range of five absolute percentage points. These observations demonstrate a significant limitation of using LVEF thresholds to guide clinical management and suggest that serial follow-up of a given patient may be best accomplished using a consistent imaging modality. Most published studies suggest that *coronary computed tomography angiography (CCTA) and stress testing (with stress imaging)* are associated with comparable long-term clinical outcomes in stable patients with suspected coronary artery disease (CAD) and in patients with acute chest pain. In the SCOT-HEART trial, which compared standard care (contemporary medical therapy and diagnostic testing at the discretion of the treating physician) with standard care plus CCTA in over 4100 patients with stable chest pain, patients randomized to CCTA with standard care had a reduction in the primary endpoint of CAD death or non-fatal myocardial infarction (2.3 versus 3.9 percent) over an average follow-up of 4.8 years (12). In contrast to prior studies comparing CCTA with stress testing, however, 85% of patients underwent stress electrocardiography (ECG) alone, with only 9 percent subsequently undergoing a stress test with imaging. Ongoing studies of CCTA should provide additional guidance regarding its optimal role in the diagnosis of patients with chest pain and suspected CAD.

Hypertension is one of the risk factors for development of cardiovascular diseases. Numerous epidemiological studies have found an association between incrementally higher blood pressure in middle-aged and older adults and the risk of cardiovascular disease in middle-aged and older adults; fewer data are available for the outcomes of *high blood pressure among young adults.* Two large prospective cohort studies of adults younger than 40 years at baseline found that increments in blood pressures >120/>80 mmHg, compared with a blood pressure <120/<80 mmHg, were associated with increasing risk for coronary heart disease and stroke later in life (13,14). These studies support that hypertension, defined by the 2017 ACC/AHA guidelines as blood pressure ≥130/≥80 mmHg, is an important risk factor for cardiovascular disease, including in young adults. The American Heart Association updated their statement on detection, evaluation, and management of *resistant hypertension* (uncontrolled hypertension despite prescription of three or more antihypertensive medications) (14). The most notable change from prior guidelines relates to the diagnosis of true resistant hypertension. True resistance must be distinguished from pseudo resistance by confirming that blood pressure is above goal when measured in the office using proper technique, by then confirming uncontrolled hypertension with out-of-office measurements (i.e., ambulatory blood pressure monitoring or home blood pressure monitoring), and by considering and excluding nonadherence to antihypertensive therapy.

In the current era, *multimodality imaging techniques* are being used more frequently as their utility is better appreciated (15). Echocardiography has been the mainstay approach, cardiac computerized tomography and magnetic resonance imaging provide a good imaging alternative for patients with multiple complex surgeries. 3D printing has seen a rapid growth in use for planning treatments for patients with congenital heart disease. Simulation using 3D models is emerging as a fundamental resource for teaching procedural techniques and a new standard of care.

Cardiac imaging has a significant influence on the science and practice of paediatric cardiology. Cardiac imaging changed the face of paediatric cardiology. The improvements in the diagnostic modalities of congenital heart disease, especially imaging techniques, surgical and interventional approaches as well as postoperative intensive cardiac therapy and care, have contributed to the significant reduction of prenatal morbidity which is one of the major indicators of the state and level of development of a country. Cardiac catheterization was the first technique which allowed imaging of the heart and extracardiac vessels by angiography. The development and improvements made in non-invasive imaging techniques, like echocardiography and cardiac magnetic resonance imaging (MRI), have been extremely important. Technical advancements in the field of medical imaging are quickly being made. Techniques such as intracardiac echocardiography, 3D echocardiography, and tissue Doppler imaging are relatively new echocardiographic techniques, which further optimize the anatomical and functional aspects of congenital heart disease. As more information is gathered using these techniques, and is correlated with clinical, hemodynamic and angiographic findings, non-invasive cardiologists have gained greater confidence in understanding images that are viewed. These imagining techniques give a rare satisfaction to those who master them and understand them, resulting in the timely diagnosis and adequate selection of the treatment of congenital heart anomalies.

Cardiac Magnetic Resonance Imaging (MRI) is rapidly developing and is currently becoming increasingly accepted as an important imaging tool in paediatric cardiology. The indications are situated in areas where echocardiography cannot answer clinical questions. A first common indication for the use of cardiac MRI is for better visualisation of extracardiac anatomic structures including the pulmonary arteries with the distal branches, the aorta, the pulmonary veins, and the systemic veins. If there is any doubt about these structures which can be difficult/impossible to visualize using echocardiography because of the interposition of the lungs, MRI is a good alternative to cardiac catheterisation with a high spatial resolution. *Important challenges:* Imaging techniques are changing very quickly and this represents a real challenge for the users of this technology. Training and, afterwards, maintaining competence have become a real challenge. In order to guide training in cardiac imaging, the Association for European Paediatric Cardiology published training guidelines for paediatric echocardiography and cardiac MRI (16,17). Developing competence in paediatric echocardiography is a complex process. A solid foundation is essential to build core knowledge that evolves throughout fellowship, with equal emphasis on both procedural and interpretive skills. Hands-on training through an echo boot camp allows fellows to build a foundation for their procedural skills. An online learning platform develops interpretative skills, it can be accessed by multiple learners irrespective of their location, and is easy to implement once developed and can be user adaptive. The goals of paediatric cardiology training include the acquisition of cognitive and procedural expertise needed to provide high-quality care to the fetus, infant, and child with congenital and acquired cardiovascular disease and the adult with congenital heart disease, along with the acquisition of the academic skills to make meaningful scholarly contributions to the specialty and to develop the capacity for career-long self-education beyond the years of formal training. No doubt the use of complex tools to refine our diagnostic accuracy will lead us toward the delivery of more sophisticated or patient-specific prevention strategies or therapies. An important consideration for today's imaging innovations is whether a new technique can offer substantial improvements in outcome, safety, or cost. 3D printing has seen a rapid growth in use for planning treatments for patients with congenital heart disease and carries hope in improving quality, efficiency and outcomes of these procedures. The current paradigm of the practice is to identify patients with complex anatomy who may require repeated procedures that carry significant risk. Life-size models by 3D printing using different materials can be used by the surgeon who can then immediately contemplate the approach and the technical feasibility of the anticipated procedure. The use of 3D-printed models can be used to tailor education to different learners, to effectively teach complex cardiac anatomy to radiology, cardiology and cardiovascular surgery fellows. Simulation using 3D models is emerging as a fundamental resource for teaching procedural techniques for trainees acquiring advanced skill sets in the field and is similarly being used within practice as a new standard of care. 3D-printed models are also effective *tools for communication* within health care teams and with patients. Within the practice, specific 3D models used to explain disease processes and planned procedures enhance patient understanding and facilitate shared decision-making and informed consent, which ultimately improves patient satisfaction (18).

The *advances in imaging techniques* (CT, MRI, and echocardiography) that include 3-dimensional imaging and the ability to print models and evaluate anatomy in a virtual environment allow a more thorough preparation for a complex intervention. In addition, the ability to practice the actual procedure in advance of the operation provides an effective model for education and may help reduce morbidity and mortality for complex or infrequently performed percutaneous or open surgical procedures. Imaging and diagnostic capabilities have revolutionized the capacity to care for patients with CHD of all ages. Increasingly the diagnosis of CHD is made during gestation. With increased resolution in imaging, identification of certain features, such as a restrictive or intact atrial septum in hypoplastic left heart syndrome, can be anticipated and intervened on soon after delivery at centres with expertise in this area, improving outcomes. Advances in imaging and systematic study of quantified parameters, such as indexed right ventricular volumes on magnetic resonance imaging, have helped define thresholds for surgical intervention and improved outcomes. Development of diagnostic parameters such as liver stiffness has assisted the ability to evaluate patients for sequelae of CHD. Additionally, 3D modelling now aids in preoperative planning for patients with complex lesions. This modelling can be particularly helpful *in adult patients with CHD* who have had multiple previous repairs, not infrequently involving surgical techniques that are now extinct. Virtual reality opens another world of possibility in both preoperative planning and education. The complex 3D structure of congenital heart defects can be more completely understood by walking through them and examining every angle. Diagnostic capabilities will also improve with increasing use of molecular and genetic markers, allowing earlier detection and earlier intervention when appropriate. Such advances will make possible personalized treatment based on the molecular fingerprint of the patient›s disease process.

Devices and technology: Current state-of-the-art care of CHD includes a close collaboration between surgeons and interventional cardiologists, with transcatheter interventions assisting before and after surgical interventions, as well as being performed with surgery in hybrid procedures (19). Advances in devices and technology for transcatheter approaches now allow ductal stents as opposed to surgical shunts, percutaneous closure of certain atrial septal defects and percutaneous valve replacements in select patients. Refinement of cardiopulmonary bypass machines, including alterations in oxygenators, safety alarms, and tubing and priming to minimize systemic response to bypass, have improved outcomes. Ventricular assist devices have progressed to become smaller and optimize long-term support, and they are now available for children and even infants. Technological innovations have also led to minimal access surgery and robot-assisted surgery that can be applied in certain teenagers and adults with CHD. Now more than ever a multidisciplinary approach is needed for the care of patients with CHD, with a team of specialists determining the best combination of treatment strategies. On the horizon are further advances in the areas of devices and technology. A subset of CHD progresses during gestation, worsening the severity of the condition and the prognosis for the baby after birth. Fetal cardiac intervention, however, gives the opportunity to stop or slow such progression, thereby improving the patient's overall prognosis. With technological advancements and refinement of interventional techniques such as ex utero intrapartum treatment, a subset of patients with hypoplastic left heart syndrome have undergone fetal cardiac interventions with evidence of improvement compared with similar patients without intervention. Other congenital cardiac anomalies have the potential of benefiting from fetal cardiac intervention with further study and experience in this burgeoning realm. Other technology and device developments are on the horizon with the potential to significantly improve the ability to care for patients: refinement in transcatheter technology will enable smaller delivery systems-particularly important in small patients with CHD; biomaterials development will lead to implanted materials with fewer issues related to clotting and scarring, with the potential for drug elution technology for specific diseases; tissue engineering is also on the horizon, including biodegradable scaffolds and materials with the potential to grow with the patient; robot-assisted technology will continue to evolve, allowing the potential for use in smaller patients and even in remote surgeries; continued development in assist devices will create implantable devices (as opposed to extracorporeal devices) and smaller devices for the unique CHD anatomy and physiology. Data related to health care will only increase in ensuing years. Artificial intelligence and machine learning will be critical in optimizing the use of such data in the care of patients. In the near future, real-time analysis of patient-specific data will alert physicians of impending physiological compromise before hemodynamic change is apparent to the patient or the physician. Artificial intelligence and machine learning will also become fundamental in the diagnosis of conditions. Remote monitoring, both for perioperative care that decreases hospital stays and in the intermittent or continuous monitoring and management of chronic conditions, will become routine.

In the second part of this review paper, we are going to evaluate the diagnostics in COVID-19 cardiac patients.

Coronavirus disease 2019 (COVID-19) exerts an unprecedented global impact on public health and health care delivery. Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) causing COVID-19 has reached pandemic levels since March 2020 (20). Patients with cardiovascular (CV) risk factors and established CVD represent a vulnerable population when suffering from COVID-19, and have an increased risk of morbidity and mortality. Severe COVID-19 infection is associated with myocardial damage and cardiac arrhythmia. Common cardiac complications in SARS were: hypotension, myocarditis, arrhythmias, and sudden cardiac death (SCD) (21, 22). The European Society for Cardiology evaluated this global health problem and gave the *ESC Guidance for the Diagnosis and Management of CV Disease during the COVID-19 Pandemic*, so in the following lines are some diagnostic criteria for cardiovascular diseases in scenario of Covid 19 (23).

Diagnostic workup during SARS infection revealed electrocardiographic changes, sub-clinical left ventricular (LV) diastolic impairment and troponin elevation. Monitoring of cardiac toxicity of antiviral drugs is recommended. SARS-CoV-2 not only causes viral pneumonia but has major implications for the CV system. Patients with CV risk factors including male sex, advanced age, diabetes, hypertension and obesity as well as patients with established CV and cerebrovascular disease have been identified as particularly vulnerable populations with increased morbidity and mortality when suffering from COVID-19. Moreover, a considerable proportion of patients may develop cardiac injury in the context of COVID-19 which portends an increased risk of in-hospital mortality. Aside from arterial and venous thrombotic complications presenting as acute coronary syndromes (ACS) and venous thromboembolism (VTE), myocarditis plays an important role in patients with acute heart failure (HF). A wide range of arrhythmias has been reported to complicate the course of COVID-19 including potential pro-arrhythmic effects of medical treatment targeted at COVID-19 and associated diseases. *Strategies for Diagnosing SARS-CoV-2*: Diagnosis of COVID-19 relies on a combination of epidemiological criteria (contact within incubation period), presence of clinical symptoms as well as laboratory testing (nucleic acid amplification tests) and clinical imaging based tests. Antibody and SARS-CoV-2 antigen based enzyme-linked immunosorbent assay (ELISA) tests are under development and are not yet fully validated. Widespread testing proves efficient in the containment phase of the epidemic. Quality of sample collection (deep nasal swab) and transport (time) to laboratories are essential to avoid false negative outcomes. Lung computed tomography (CT) imaging may be used as a diagnostic test in COVID 19.

Diagnosis of Cardiovascular Conditions in COVID-19 Patients: Chest pain and breathlessness is a frequent symptom in COVID-19 infection. Chronic and acute coronary syndrome presentations can be associated with respiratory symptoms. In COVID-19 patients with impaired end-organ perfusion at risk of cardiogenic shock (CS) (e.g., large acute myocardial infarction

[AMI]), consider also sepsis as possible or mixed aetiology. Myocarditis should be considered as precipitating cause of CS. The same ECG diagnostic criteria for cardiac conditions apply in patients affected by the SARS-CoV-2 infection and in the general population. *Biomarkers:* Cardiomyocyte injury, as quantified by cardiac troponin T/I concentrations, and haemodynamic stress, as quantified by B-type natriuretic peptide (BNP) and N-terminal B type natriuretic peptide (NT-proBNP) concentrations, may occur in COVID-19 infections as in other pneumonias. The level of those biomarkers correlates with disease severity and mortality; Cardiac troponin T/I and BNP/NT-proBNP concentrations should be interpreted as quantitative variables. D-Dimers quantify activated coagulation, a prominent feature in COVID-19. Due to the central role of endothelitis and VTE /Venous thromboembolism/ in COVID-19, serial measurements of D-dimers may help in the selection of patients for VTE-imaging and/or the use of higher than prophylactic doses of anticoagulation. *Cardiac Troponin I/T:* COVID-19 is a viral pneumonia that may result in severe systemic inflammation and ARDS (Acute respiratory distress syndrome), and both conditions have profound effects on the heart. As a quantitative marker of cardiomyocyte injury, the concentrations of cardiac troponin I/T in a patient with COVID-19 should be seen as the combination of the presence/extent of pre-existing cardiac disease and the acute injury related to COVID-19 (23, 24, 25). *B-Type Natriuretic Peptide/N-Terminal B-Type Natriuretic Peptide:* BNP/NT-proBNP as quantitative biomarkers of haemodynamic myocardial stress and HF (Heart failure) are frequently elevated among patients with severe inflammatory and/or respiratory illnesses (26, 27). While experience in patients with COVID-19 is limited, very likely the experience from other pneumonias can be extrapolated to COVID-19. Dimers should be monitored routinely. In particular, elevations of D-Dimers have been associated with poor outcome (28). *Non-Invasive Imaging:* In patients with suspected or confirmed COVID-19, contamination from patient to other patients, imagers and imaging equipment should be prevented. Imaging studies should be performed in patients with suspected or confirmed COVID-19 only if the management is likely to be impacted by imaging results. Re-evaluate which imaging technique is best for patients both in terms of diagnostic yield and infectious risk for the environment. The imaging protocols should be kept as short as possible. *Transthoracic (TTE) and Transoesophageal Echocardiography (TEE).* Performing transthoracic, transoesophageal and stress echocardiograms should be avoided in patients in which test results are unlikely to change the management strategy. TEE carries increased risks of spread of COVID-19 due to exposure of HCP (Healthcare personnel) to aerosolization of large viral load and should not be performed if an alternative imaging modality is available. In COVID-19 infected patients, the echocardiogram could be performed focusing solely on the acquisition of images needed to answer the clinical question in order to reduce patient contact with the machine and the HCP performing the test. Point of care focused ultrasound (POCUS), focused cardiac ultrasound study (FoCUS) and critical care echocardiography performed at bedside are effective options to screen for CV complications of COVID-19 infection. *Echocardiography* can be performed bedside to screen for CV complications and guide treatment. POCUS, FoCUS and critical care echocardiography are probably the preferred modalities to image patients with COVID-19. Limited evidence exists for the use of lung ultrasound to differentiate acute respiratory distress syndrome - ARDS (single and/or confluent vertical artefacts, small white lung regions) from HF. The presence of dilated right ventricle and pulmonary hypertension may indicate contrast CT to rule out PE (Pulmonary embolism). In COVID-19 infected patients, echocardiography should focus solely on the acquisition of images needed to answer the clinical question in order to reduce patient contact with the machine and HCP. *Cardiac CT* should be performed when there is a potential impact on clinical management, including evaluation of symptomatic suspected CAD (Coronary artery disease), acute symptomatic heart valve dysfunction, left ventricular assist device (LVAD) dysfunction, PE pulmonary embolism, and urgent structural intervention (29). Cardiac CT is preferred to TEE to rule out the presence of intracardiac thrombus. In patients with acute chest pain and suspected obstructive CAD, CCTA (Coronary computed tomography angiogram/angiography) is the preferred non-invasive imaging modality since it is accurate, fast and minimizes the exposure of patients. In patients with respiratory distress, lung CT is recommended to evaluate imaging features typical of COVID-19 and differentiate from other causes (HF, PE) (30). However, it should not be used to screen for or as a first-line test to diagnose COVID-19 and should be reserved for hospitalized patients. A dedicated CT scanner for patients with suspected or confirmed COVID-19 is preferred. As in other imaging modalities, local standards for prevention of virus spread and protection of personnel should be followed.

Nuclear cardiology should be performed only in specific indications and when no other imaging modalities can be performed. The shortest duration of scan time and exposure should be used. Standard dose imaging with rapid protocols of data acquisition are recommended. Positron emission tomography (PET) minimizes the acquisition times. *Cardiac Magnetic Resonance* (CMR) protocols are focused to address the clinical problem.

Performance of *exercise testing* (either conventional, Echo or nuclear) has major limitations in the COVID-19 era. During exercise, the patient increases respiration rate and the amount of aerosol or droplets production, even if wearing a surgical mask (that could strongly affect his/her exercise capacity). This problem is further increased since rooms of outpatient clinics are rarely large and well aerated. Performance of exercise testing is discouraged in COVID-19 suspect or positive patients and, in general, in every patient in COVID-19 epidemic or potentially epidemic areas. Alterative diagnostic methods for CAD not requiring exercise should be used as an alternative to exercise testing whenever possible. The presence of COVID-19 infection should not preclude a systematic search for CV events, including ACS (Acute coronary syndrome). COVID-19 infection-related injury should be kept in mind as differential diagnosis. Other manifestations and complications of COVID-19 infection mimicking heart disease should also have been ruled out. No doubt the use of complex tools to refine our diagnostic accuracy will lead us toward the delivery of more sophisticated or patient-specific prevention strategies or therapies.

Conclusion

As a part of lifelong learning process for all professionals in cardiovascular medicine, the imperative is to have continuity of reviewing novelties, with research results in order to treat patient according to best practices and evidence-based medicine. All professionals in cardiovascular medicine, as a part of lifelong learning process, have the continuous imperative in reviewing novelties, with resulting data from numerous researches in order to treat all patients according to best practices and evidence-based medicine, especially on this journey through corona pandemic.

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NOVOSTI U DIJAGNOSTIČKOJ KARDIOLOGIJI

Apstrakt

Kardiovaskularna medicina je područje kliničke prakse s kontinuirano brzim širenjem znanja, smjernica, najboljih praksi i novih tehnologija u kardiovaskularnoj medicini odraslih, kao i u dječjoj kardiološkoj medicini. Kardiovaskularne bolesti (KVB) su vodeći uzrok smrtnosti u svijetu i uzrokuju velike troškove za zdravstveni sektor i ekonomiju. Indeksi kardiovaskularnog snimanja imaju značajan utjecaj na prevenciju, dijagnozu i liječenje srčanih bolesti. Napredne tehnologije snimanja dramatično su poboljšale našu sposobnost otkrivanja i liječenja kardiovaskularnih bolesti u ranoj fazi. Multimodalne tehnike snimanja: ehokardiogram, kompjuterska tomografija srca, snimanje magnetnom rezonancom, simulacijski 3D modeli, umjetna inteligencija se koriste sve češće, jer se njihova korisnost sve više cijeni.
Globalni utjecaj koji koronavirusna bolest 2019 (COVID-19) ima na javno zdravlje i pružanje zdravstvene njege je bez presedana. Teški akutni respiratorni sindrom koronavirus 2 (SARS-CoV-2) koji uzrokuje COVID-19 dosegao je nivo pandemije u martu 2020. godine. Pacijenti s kardiovaskularnim (CV) faktorima rizika i ustanovljenim KVB-om predstavljaju ranjivu populaciju od COVID-19 te imaju povećan rizik od morbiditeta i mortaliteta. Teška COVID-19 infekcija povezuje se s oštećenjem miokarda i srčanom aritmijom. Dijagnostički pregledi tokom SARS infekcije otkrili su elektrokardiografske promjene, subkliničko dijastoličko oštećenje lijeve ventrikule (LV) i povišenje troponina.
Svi stručnjaci u kardiovaskularnoj medicini, u sklopu procesa cjeloživotnog učenja, imaju kontinuirani imperativ praćenja noviteta, uključujući rezultate brojnih istraživanja, kako bi svi pacijenti bili liječeni prema najboljim praksama i medicini zasnovanoj na dokazima, posebno na ovom putu kroz pandemiju koronavirusa.

Ključne riječi: dijagnostika, kardiologija, ažuriranje