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Gated SPECT perfuzijska scintigrafija miokarda

Gated SPECT myocardial perfusion scintigraphy

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SAŽETAK: *Cilj rada je predstaviti dijagnostičke i prognostičke mogućnosti nove nuklearno-kardiološke tehnike: Gated (EKG sinhronizirane) SPECT (Single Photon Emission Computed Tomography) perfuzijske scintigrafije miokarda (GSPECT). Ova tehnika predstavlja* state of the art *slikovnu metodu za neinvazivnu procjenu perfuzije i funkcije miokarda lijeve klijetke. Zahvaljujući tehnološkom i znanstvenom razvoju ova metoda ujedinjuje dvije već etablirane nuklearno-kardiološke tehnike: perfuzijsku scintigrafiju miokarda i radionuklidnu ventrikulografiju. Takvim pristupom pojednostavljuje i pojeftinjuje se neinvazivna kardiološka dijagnostička obrada bolesnika, što je prepoznato u razvijenim zemljama svijeta gdje se GSPECT primjenjuje znatno češće nego u Republici Hrvatskoj. Neinvazivna procjena prohodnosti stenta, preoperativna procjena vijabilnosti miokarda, postintervencijska (dilatacija i stent) i postoperativna (aortokoronarno premoštenje) evaluacija postignutih rezultata, kao i procjena nužnosti za invazivnom kardiološkom obradom, samo su neki od razloga koji čine ovu dijagnostičku tehniku nezaobilaznim dijelom modernog pristupa kardiovaskularnim bolesnicima.*

KLJUČNE RIJEČI: *Gated SPECT perfuzijska scintigrafija miokarda, nuklearna kardiologija, neinvazivna kardiološka dijagnostika.*

UDK *616.1-073.9=163.42=111*

SUMMARY: *The goal of the article is to present the diagnostic and prognostic capabilities of the new nuclear cardiology technique: Gated (synchronized ECG) SPECT (Single Photon Emission Computed Tomography) myocardial perfusion scintigraphy (GSPECT). This multidisciplinary technique represents the state-of-the-art imaging method for noninvasive evaluation of perfusion and the left ventricular myocardial function. Owing to the technological and scientific development, this method combines two already established nuclear cardiac techniques: myocardial perfusion scintigraphy and radionuclide ventriculography. This approach can simplify and make the noninvasive cardiac diagnostics of patients cheaper, which has been recognized by developed countries of the world where GSPECT is used much more often than in the Republic of Croatia. The non-invasive evaluation of coronary artery stent patency, the preoperative evaluation of myocardial viability, the postinterventional (dilatation and stent) and postoperative (aortocoronary bypass) evaluation of obtained results, as well as the evaluation of the necessity for invasive cardiac management, are just some of the reasons that make this diagnostic technique an unavoidable part of the modern approach in treating cardiovascular patients.*

KEYWORDS: *Gated SPECT myocardial perfusion scintigraphy, nuclear cardiology, noninvasive cardiac diagnostics.*

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Cilj rada je predstaviti dijagnostičke i prognostičke mogućnostima nove nuklearno-kardiološke neinvazivne slikovne tehnike: GATED (EKG sinhronizirane) SPECT (*Single Photon Emission Computed Tomography*) perfuzijske scintigrafije miokarda (GSPECT).

U visoko razvijenim zemljama svijeta nuklearna kardiologija zauzima važno mjesto u dijagnostičkom algoritmu kardiovaskularnih bolesti[1]. Perfuzijska scintigrafija miokarda s Tc-99m označenim radiofarmacima: Tc-99-sestamibi (MIBI) i Tc-99m-Tetrofosmin, rutinski se koristi u dijagnostici i prognozi budućih događanja kod bolesnika s koronarnom bolesti srca (KBS)[2]. Klinička praksa zahtjeva veliko znanje operatora, što podrazumijeva i racionalnu odluku o izboru najboljeg dijagnostičkog testa u konkretnoj kliničkoj situaciji. Ispravnim korištenjem neinvazivnih nuklearno-kardioloških tehnika nastupaju značajne uštede, tj. značajno se smanjuje potreba za puno skupljim i invazivnim kardiološkim zahvatima[3,4]. Nažalost, u manje razvijenim zemljama svijeta, pa tako i kod nas, nuklearno-kardiološke tehnike se primjenjuju znatno rjeđe. Nekoliko je razloga zašto se perfuzijska scintigrafija miokarda pomoću Tc-99m označenih farmaka (Tc-99-MIBI i Tc-99m-Tetro-

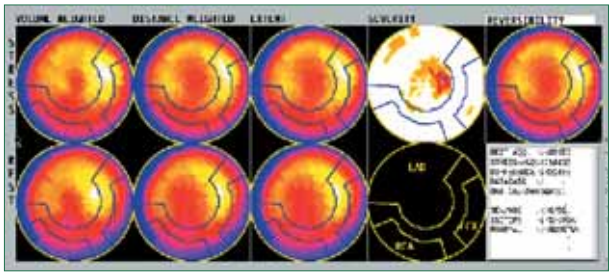

Figure 1a. *Normal result of myocardial perfusion scintigraphy during stress and rest performed with the SPECT imaging technique after injecting Tc-99m MIBI ("Polyclinic Dr. Lacić" database).*

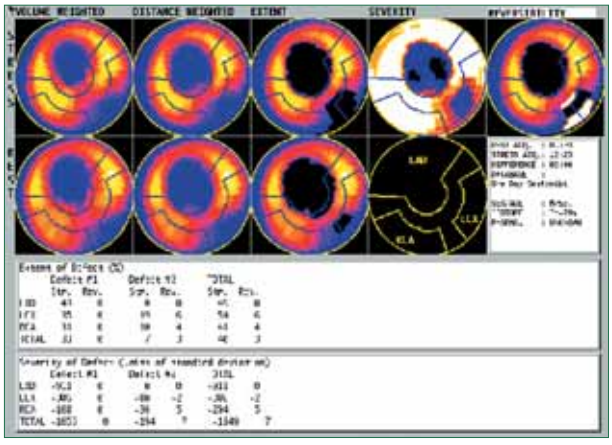

Figure 2a. *The results of the stress and rest myocardial perfusion scintigraphy performed with the SPECT imaging technique after injection of Tc-99m MIBI show extensive scar changes in the LAD area (approximately 50% of the area affected by infarction) and less extensive scar and ischemic infero-lateral-posterior changes ("Polyclinic Dr. Lacić" database).*

The goal of the article is to present the diagnostic and prognostic capabilities of the new nuclear cardiac technique: Gated (synchronized ECG) SPECT (*Single Photon Emission Computed Tomography*) myocardial perfusion scintigraphy (GSPECT).

In the highly developed countries the nuclear cardiology takes a very important position in the diagnostic algorithm of cardiovascular diseases[1]. Myocardial perfusion scintigraphy with Tc-99m labeled radiopharmaceuticals: Tc-99-sestamibi (MIBI) and Tc-99m-Tetrofosmin are routinely used in the diagnostics and prediction of future events in coronary heart disease (CHD) patients[2]. Clinical practice requires a high level of knowledge from the operator, which also implies a rational decision in choosing the best diagnostic test in a specific clinical case. The proper use of noninvasive nuclear cardiac techniques brings significant savings, i.e. significant reduction in the necessity for more expensive and invasive cardiac procedures[3,4]. Unfortunately, in less developed countries, and therefore in our country, nuclear cardiac techniques are used much less. There are several reasons why myocardial perfusion scintigraphy using Tc-99m labeled radiopharmaceuticals

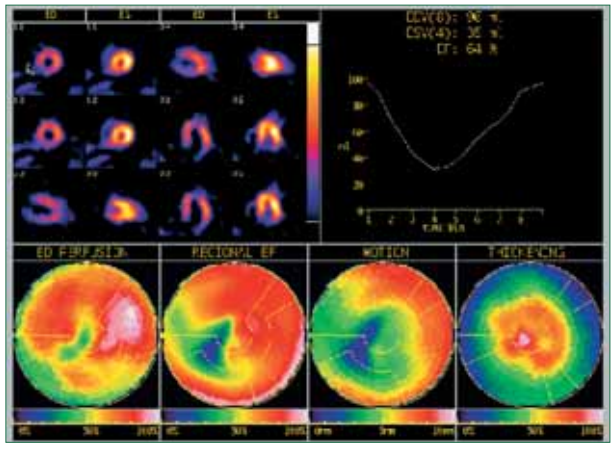

Figure 1b. *Gated SPECT of the same patient from Figure 1a. Normal result of perfusion and left ventricular function, with normal contraction of all left ventricular myocardial segments ("Polyclinic Dr. Lacić" database).*

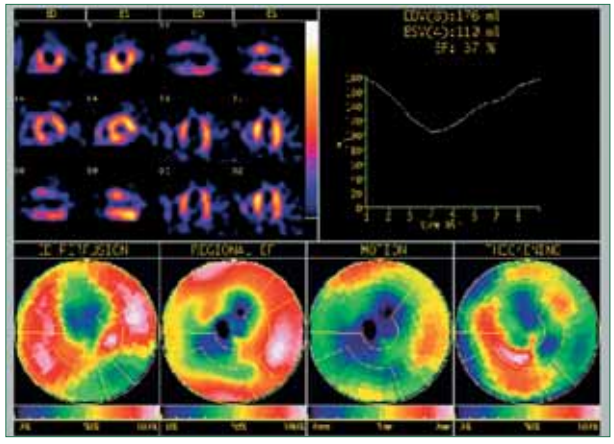

Figure 2b. *Gated SPECT of the same patient from Figure 2a. Clearly reduced perfusion and left ventricular function (EF 37%) with akinesis of antero-apical septal wall and hypokinesis of infero-lateral-posterior wall ("Polyclinic Dr. Lacić" database).*

fosmin) nedovoljno često radi u manje razvijenim zemljama. Prvi i najvažniji razlog je što ne postoji timska suradnja između kardiologa i specijalista nuklearne medicine. Naime, da bi se postigli dobri rezultati u nuklearnoj kardiologiji, odnosno da bi test perfuzijske scintigrafije miokarda u opterećenju bio reprezentativan, potrebno je bolesnika adekvatno opteretiti. Jasno je da će maksimalni stupanj opterećenja, bilo fizičkog ili farmakološkog, najbolje napraviti kardiolog koji prati bolesnika. Drugi razlog je adekvatna tehnološka potpora, koja danas nameće potrebu korištenja GSPECT tehnologije pri procjeni perfuzije miokarda. Ovom tehnikom snimanja se istovremeno dobivaju informacije o perfuziji miokarda lijeve klijetke (LK) u mirovanju i opterećenju (**Slika 1a**), kod nas je ta informacija vezana uz pojam talij — perfuzijska scintigrafija miokarda, kao i funkciji LK (**Slika 1b**), kod nas je ta informacija vezana uz pojam tehnecij — radionuklidna ventrikulografija. Štoviše, ukoliko u istog bolesnika eventualno postoji potreba i za procjenom postojanja srčanih grešaka ("shunt") radionuklidna angiokardiografija se može učiniti tijekom perfuzijske scintigrafije miokarda u mirovanju, čime se mogu učiniti značajne uštede, kako u vremenu snimanja tako i u količini injiciranih radiofarmaka, a onda posljedično i u dozi ozračivanja pacijenata i financijskim sredstvima. Govoreći jednostavnim riječnikom tri temeljne nuklearno-kardiološke pretrage (radionuklidna angiokardiografija, radionuklidna ventrikulografija i perfuzijska scintigrafija miokarda) su spojene u jednu GSPECT.

Perfuzijska scintigrafija miokarda pomoću Tl-201 (talij 201) uvedena je u kliničku praksu u ranim sedamdesetim godinama prošlog stoljeća. Dugi niz godina koristila se isključivo tehnika planarnog snimanja. Razvojem, prvenstveno, informatičke tehnologije omogućeno je dobivanje funkcionalnih tomografskih snimaka (*Single Photon Emission Computed Tomography* — SPECT) perfuzije miokarda. SPECT u odnosu na planarne snimke perfuzije miokarda LK predstavlja isto što i kompjutorizirana tomografija u odnosu na planarne radiološke snimke određenog organa, uz važnu napomenu da nema bitne razlike u dozi ozračivanja pacijenta kod primjene SPECT i planarne tehnike snimanja. Osim razvoja SPECT tehnologije, medicinska informatika je zaslužna i za razvoj snažnih programskih rješenja u kvantifikaciji, tj. objektiviziranju nuklearno-medicinskih pa tako i nuklearno-kardioloških studija[5]. Došlo je do mogućnosti stvaranja baza podataka normalnih vrijednosti koje su se onda mogle lako uspoređivati s dobivenim rezultatima studije kod određenog pacijenta i na taj način objektivno procjenjivati opseg i intenzitet patološkog procesa[6]. Paralelno s ovim napretkom na fizikalnom polju, došlo je i do napretka na području kemije te su razvijeni novi, bolji, spojevi za procjenu perfuzije miokarda. Premda je Tl-201, kao analog kalija, imao dobre kemijske osobine, njegove nuklearno-fizikalne karakteristike, niska energija gama zraka i dug poluživot, činile su ga manje poželjnim od kemijskih spojeva koje bismo mogli označiti sa Tc-99m pertehnetatom. Početkom devedesetih godina prošlog stoljeća pojavila su se dva preparata s takvim osobinama: Tc-99m sestamibi (MIBI) i Tc-99m tetrofosmin i gotovo u potpunosti zamijenili Tl-201. Time su se otvorila vrata širokoj kliničkoj primjeni SPECT perfuzijske scintigrafije miokarda. Perfuzijska scintigrafija miokarda. premda se može raditi i samo u mirovanju kada je u pitanju isključivo vijabilnost miokarda, najčešće se radi kao pro-

(Tc-99-MIBI and Tc-99m-Tetrofosmin) is not used more frequently in the less developed countries. The first and foremost, the reason for this is that there is no team collaboration between cardiologists and the nuclear medicine specialists. Namely, to achieve good results in nuclear cardiology, that is, in order to make the stress myocardial perfusion scintigraphy test representative, the patient should be adequately stressed. It is clear that it is the best for the maximum stress level, whether physical or pharmacological, to be achieved by the cardiologist monitoring the patient. The other reason is the appropriate technological support, which today imposes the need for the use of GSPECT technology in the evaluation of the myocardial perfusion. This imaging technique simultaneously gives information on the left ventricular (LV) myocardial perfusion during rest and stress (**Figure 1a**), this information is related to thalium — myocardial perfusion scintigraphy, as well on the LV function (**Figure 1b**), this information is related to technetium — radionuclide ventriculography. Moreover, if for the same patient there is also a potential need for evaluating the existence of cardiac shunt, radionuclide angiography can be performed with myocardial perfusion scintigraphy during rest, which can bring significant savings of imaging time and the quantity of injected radiopharmaceuticals, and consequentially in the patient radiation dose and funds. Using layman's terms, three basic nuclear-cardiologic tests (radionuclide angiography, radionuclide ventriculography and myocardial perfusion scintigraphy) are merged into one GSPECT.

Myocardial perfusion scintigraphy using Tl-201 (thallium 201) was introduced into clinical practice during the early seventies of the last century. For many years the technique of planar imaging was exclusively used. The development, primarily, of information technology enabled the functional tomographic myocardial perfusion imaging (*Single Photon Emission Computed Tomography* — SPECT). Compared to planar LV myocardial perfusion imaging, SPECT is what computerized tomography is compared to planar radiology imaging of certain organs, with one important note that there is no significant difference in the patient radiation dose when using SPECT and planar imaging techniques. Besides the development of SPECT technology, medical informatics is also responsible for the development of powerful program solutions in quantification, i.e. objectification of studies in nuclear medicine and therefore in nuclear cardiology[5]. The possibility for creating databases with normal values emerged, and those values could then be easily compared with the study results obtained from a specific patient and in that way objectively evaluating the extent and the intensity of the pathological process[6]. Parallel to this advancement in the physical scope, there also occurred advancement in chemistry with the development of new and better compounds for the evaluation of myocardial perfusion. Although Tl-201, as an analogue of potassium, had good chemical properties, its nuclear-physical properties, low energy of gamma rays and the long half-life, made it less desirable than the chemical compounds which could be marked with Tc-99m pertechnetate. Two products with these properties appeared at the beginning of the nineties in the last century: Tc-99m sestamibi (MIBI) and Tc-99m tetrofosmin and they almost completely replaced Tl-201. This opened the doors to wide clinical application of SPECT myocardial perfusion scintigraphy. Myocardial perfusion scintigraphy, although it can be performed only during rest when only the myocardial viability is concerned, most often it is performed as a pro-

tokol sa studijama u opterećenju i mirovanju. Usporedbom studija dobivaju se odgovori o postojanju ožiljnog (infarkt) i/ili ishemijskog dijela segmenata miokarda. Premda se opterećenje na pokretnoj traci primjenjuje uvijek kad je to moguće, sve češće se primjenjuju i farmakološki testovi opterećenja primjenom dipiridamola, adenozina i dobutamina.

GSPECT tehnologija ulazi u kliničku praksu početkom ovog stoljeća i omogućuje istovremeno dobivanje informacija o perfuziji i funkciji miokarda LK, čime se perfuzijska scintigrafija miokarda i radionuklidna ventrikulografija stapaju u jednu[7]. Mogućnost kvantifikacije podataka, određivanje pripadnosti defekta perfuzije opskrbnom području određene koronarne arterije, zahvaćenost jedne ili više žila bolešću, veličina defekta, jačina defekta (usporedba s normalnom bazom podataka), dinamika promjena u stresu i mirovanju te njihovo longitudinalno praćenje kod određenog pacijenta značajno doprinose načinu i rezultatima liječenja bolesnika s KBS (**Slika 2a**)[8]. EKG sinhronizacija omogućuje podjelu svakog srčanog ciklusa u 8-16 vremenskih slika. Tako dobiveni podaci omogućuju, uz procjenu perfuzije miokarda LK, prikaz informacija o regionalnoj gibljivosti segmenata LK, njezinom zadebljanju prilikom kontrakcija, izračunu ukupne i regionalne ejekcijske frakcije, kao i mjerenje volumena LK, odnosno prikaza volumne krivulje LK (**Slika 2b**). Činjenica da uredan nalaz GSPECT znači izrazito nisku (<1%) vjerojatnost koronarnog događaja u sljedećih godinu dana, daje prednost ovoj tehnici u procjeni rizika KBS[9]. Metoda se pokazala naročito korisnom kod pacijenata sa slikom bloka lijeve grane u 12-kanalnom EKG-u, kod kojih ergometrijsko testiranje ne donosi značajnu dijagnostičku dobrobit. Nadalje, ovom tehnikom u mogućnosti smo razlikovati pacijente visokog rizika koji zahtijevaju daljnju žurnu kardiološku obradu, od onih kojima se može pomoći konzervativnim postupcima[10-12]. Neinvazivna procjena prohodnosti stenta, preoperativna procjena vijabilnosti miokarda, postintervencijska (dilatacija, stent) i postoperativna (aortokoronarno premoštenje) evaluacija postignutih rezultata, kao i procjena potrebe za invazivnom kardiološkom obradom čini ovu tehniku nezaobilaznim dijelom modernog pristupa kardiovaskularnim bolesnicima[13,14]. Sve su to razlozi da se danas GSPECT smatra *state of the art* nuklearno-kardiološkom tehnikom za neinvazivnu procjenu perfuzije miokarda LK. Planarna perfuzijska scintigrafija miokarda kao i obična SPECT perfuzijska scintigrafija miokarda su tehnike koje bi, ukoliko je moguće, trebalo zamijeniti metodom GSPECT.

Zbog svega prethodno spomenutog, metoda GSPECT se u razvijenim zemljama svijeta danas puno više koristi nego kod nas. Usporedbe radi u Singapuru, koji je po broju stanovnika sličan Hrvatskoj, samo u Nacionalnom centru za srčane bolesti godišnje se radi preko 7.000 GSPECT pretraga. Dr. Felix Keng, nuklearni kardiolog koji vodi ovaj centar, zahvaljujući primjeni GSPECT znatno rjeđe koristi MSCT koronarografiju u evaluaciji svojih pacijenata[15]. Poznata je činjenica da je u Sjedinjenim Američkim Državama zabilježen sedmerostruki porast u broju učinjenih perfuzijskih scintigrafija miokarda nakon što su američki kardiolozi ušli u svijet nuklearne kardiologije i uočili prednosti ove neinvazivne slikovne tehnike. Najnovije zajedničko izvješće Njemačkog kardiološkog i Njemačkog nuklearno medicinskog društva, izvješćuje da je tijekom 2008. godine u toj zemlji učinjeno 98.947 perfuzijskih scintigrafija

tocol with studies during stress and rest. Comparing the studies we get answers about the existence of scared (infarction) and/or ishaemic part of the myocardial segments. Although stress achieved by walking on a treadmill is used whenever possible, more often we can also see the use of pharmacological stress tests using dipyridamole, adenosine and dobutamine.

The GSPECT technology entered into clinical practice during the beginning of this century and simultaneously enabled the gathering of information on perfusion and LV myocardial function, whereby myocardial perfusion scintigraphy and radionuclide ventriculography merge[7]. The possibility for quantifying data, determining to which coronary artery supply area the perfusion defect belongs, extent of disease to one or more arteries, the size of the defect, the severity of the defect (compared with the normal database), dynamics of change during stress and rest and their longitudinal monitoring on a specific patient, all considerably contribute to the method and the results of treating patients with CHD (**Figure 2a**)[8]. ECG synchronization enables the division of every cardiac cycle into 8-16 time frames. The data gathered in this way enables, with the evaluation of LV myocardial perfusion, the presentation of information in regional segmental motion of LV, its thickening during contractions, calculation of the total and regional ejection fraction, as well as the measuring of the LV volume, i.e. the representation of the LV volume curve (**Figure 2b**). The fact that a normal GSPECT result means exceptionally low (<1%) probability of a coronary event in the next year is an advantage of this technique for the evaluation of the CHD risk[9]. This method has proved to be especially useful in patients with left bundle branch block in standard 12-lead ECG, who have no significant diagnostic advantage from ergometry. Furthermore, with this technique we may distinguish between high risk patients who need further emergency cardiac treatment and those who can be helped with conservative approach[10-12]. The noninvasive evaluation of coronary artery stent patency, the preoperative evaluation of myocardial viability, the postinterventional (dilatation and stent) and postoperative (aortocoronary bypass) evaluation of obtained results, as well as the evaluation of the necessity for invasive cardiac treatment, are just some of the reasons which make this diagnostic technique an unavoidable part of the modern approach of treating cardiovascular patients[13,14]. All this are reasons why GSPECT is today considered the state-of-the-art nuclear cardiac technique for noninvasive evaluation of LV myocardial perfusion. The planar myocardial perfusion scintigraphy as well as the common SPECT myocardial perfusion scintigraphy are techniques which should, if possible, be replaced by the GSPECT method.

Because of everything mentioned earlier, the GSPECT method is today much more used in the developed countries than in our country. For the sake of comparison, in Singapore, with similar population to that of Croatia, only the National Centre for Heart Disease performs over 7,000 GSPECT tests annually. Dr Felix Keng, nuclear cardiologist who is the head of this centre, owing to the use o GSPECT rarely uses the MSCT coronarography in the evaluation of his patients[15]. A well known fact is that United States have seen a sevenfold increase of the number of myocardial perfusion scintigraphies since American cardiologists entered into the world of nuclear cardiology and noticed the advantages of this imaging technique. The most recent joint

miokarda, od čega 77% u vanbolničkim poliklinič kim ustanovama[16]. Zajednička preporuka ova dva društva je da se u svih pacijenata obavezno radi GSPECT u mirovanju i opterećenju te da se dobiveni podaci obavezno kvantificiraju, tj. uspoređuju s normalnim bazama podataka.

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report by the German Cardiac Society and the German Society of Nuclear Medicine, reports that there were 98,947 myocardial perfusion scintigraphies performed in that country during 2008, out of which 77% was in outpatient polyclinic institutions[16]. The joint message of these two societies is that stress and rest GSPECT is mandatory for all patients and that the obtained data must be quantified, i.e. compared to normal databases.

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