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DEVELOPMENT OF NONINVASIVE CARDIOLOGY DIAGNOSIS AT BJELOVAR GENERAL HOSPITAL 1975-2005

Mario Ivanuša

Department of Medicine, Bjelovar General Hospital, Bjelovar, Croatia

SUMMARY – The rising tendency of cardiovascular disease morbidity and mortality has entailed an increased demand of noninvasive cardiology diagnostic procedures. The aim of this study was to analyze the number of procedures performed at Cardiology Laboratory, Bjelovar General Hospital, in order to emphasize the role of education of all personnel involved in the process of organization, prevention, diagnosis and treatment of cardiovascular disease, substantiated by our own experience in the field. From May 15, 1975 till December 31, 2004, a total of 32,026 diagnostic procedures were performed, with a predominance of exercise test (52%), followed by 24-h electrocardiography (26%), transthoracic echocardiography (18%), 24-h ambulatory blood pressure monitoring (3%), and lower extremity arterial and venous Doppler (<1%). During 1995-2004 period, 2074 procedures were performed *per* year on an average, yielding a 12-fold increase relative to the first ten years of work. The use of an integrated software system enables efficient processing of medical documentation thus produced, along with its professional, scientific and economic evaluation. The experience acquired should be communicated not only to medical professionals from the Hospital catchment area but also to the community at large, in the form of lectures and continuous publication of results in scientific and professional periodicals. Evaluation of the results and continuing education of all medical personnel, along with appropriate education of the general population are the basis of successful management and prevention of cardiovascular disease.

Key words: *Cardiovascular diseases – diagnosis; Diagnostic techniques, cardiovascular – methods; Diagnostic techniques, cardiovascular – history; Internal department, hospital; Croatia*

Introduction

Cardiovascular diseases are the leading cause of morbidity, mortality and hospitalization, and the second most common diagnosis recorded in general practitioner (GP) offices in the Republic of Croatia[1]. Over the last three decades, the morbidity and mortality of cardiovascular disease, coronary heart disease in particular, have been on a continuous increase in the Bjelovar-Bilogora County as well as in all other Croatian counties[2-5]. In the Bjelovar-Bilogora County with an area of 2637 km^2 and 144,042 inhabitants according to the last census, cardiovascular diseases account for the highest proportion of deaths (61%), along with the highest age adjusted mortality rates of cardiovascular disease (668,8/100,000 inhabitants) and heart failure (149,2/100,000 inhabitants) relative to other parts of Croatia[1,2,5]. Besides thorough history, clinical examination and electrocardiogram (ECG), the diagnosis of cardiovascular disease, especially coronary heart disease, usually requires the use of single or multiple noninvasive cardiology diagnostic procedures. Exercise test, transthoracic echocardiography (TTE), 24-h electrocardiogram (Holter ECG), and continuous 24-h ambulatory blood pressure monitoring (ABPM) are noninvasive diagnostic procedures that are now available in the majority of hospitals. These diagnostic methods play a crucial role in the evaluation of therapeutic success, scheduling of invasive diagnostic and/or therapeutic procedures required, and assessment of the cardiologic patient working ability. Continuing education of all medical personnel, education of patients and their family members in treatment proce-

Correspondence to: *Mario Ivanuša, MD, F.E.S.C.*, Department of Medicine, Bjelovar General Hospital, Mihanovićeva 8, HR-43000 Bjelovar, Croatia

E-mail: mivanusa@vip.hr

dures and potential complications, and systematic recording, reporting and evaluation of daily clinical practice for continuous upgrading of care quality should be considered as integral parts of health care for cardiovascular patients[4-10].

The aim of this report is to analyze the cardiology diagnostic procedures performed at the Unit of Noninvasive and Functional Diagnosis of Cardiovascular Disease, Department of Medicine, Bjelovar General Hospital (Cardiology Laboratory) during the past 30 years of its work. With this presentation of our own experience we want to emphasize the importance of appropriate education of not only the population at large and patient groups at risk in particular, but also of all medical and nonmedical personnel involved in the process of organization, prevention, diagnosis and management of cardiovascular disease.

Development of Cardiology Laboratory

Specialist internist service was established as early as 1925 by Head Doctor Franjo Fanton, MD, at the then Bjelovar District Hospital[4,11]. The first noninvasive cardiology diagnostic instrument, single-lead electrocardiograph, was purchased in 1957, owing to the efforts of Bruno Kristić, MD. Merits for the foundation of the first Coronary Unit at Department of Internal Medicine of the then Bjelovar Medical Center, on June 17, 1974, go to Josip Šurmanović, MD, as its initiator, along with Head Doctor Rudolf Miculinić, MD, and Head Doctor Stipe Brzović, MD, MS. However, the foundation of Coronary Unit soon called for establishment of a laboratory of cardiology. The first noninvasive exercise test by fast climbing the staircase with ECG recording before and after exercise was performed on May 15, 1975, the date being taken as the formal beginning of the work of the Cardiology Laboratory[5]. Over the next three years, the two-stair exercise test according to Master was occasionally performed. On October 6, 1978, the bicycle ergometer exercise test with the use of a three-lead ECG recording instrument and monitor was introduced (Fig. 1). Since 1985, the treadmill ergometer exercise test has been available (Fig. 2), however, it has been used in daily routine only since September 14, 1998, due to unjustified fear from potential complications. Since then, all ergometer exercise tests have been performed on a treadmill with monitoring on a 12-lead ECG device. The quality of testing has considerably improved since May 24, 2004, when a new ECG instrument was supplied by donations, and especially since May 31, 2005, when a new ergometer exercise test device was purchased. Now, a computerized ECG signal can be transferred to a computer, where it can be stored, printed by use of an economical laser printer, and transmitted across the hospital network. All findings are readily available, which is of utmost importance in daily routine[5,12,13].

Transthoracic echocardiography (TEE) is available since June 1, 1987, when the first cardiologic ultrasound device was purchased. After its daily usage for ten years, a new, universal ultrasound device was purchased in 1997. Doppler diagnosis of lower extremity arterial and venous diseases on the same instrument has been performed since May 15, 2001. The broad spectrum of the instrument operation and a relatively short life of the device of only six years influenced its availability for the diagnosis of gynecologic, surgical and neurologic disor-

Fig. 1. Bicycle ergometer (Instrumenten Lode B.V.), instruments for monitoring (Philips MM 409) and three-lead ECG recording (Philips Cardiopan CR 300) from 1978.

Fig. 2. Treadmill (Quinton Q 55) from 1985, and 12-lead ECG with monitor (Ergoline ergoscript EK 3012).

Fig. 3. Size comparison of the 24-h ECG device Oxford Medilog 4000 from 1988 and Medilog FD-5 from 2003.

ders; thus, the device was for some time used by as many as eleven physicians. A modern echocardiography instrument with complete cardiologic program, including stress echocardiography, image and short film transfer *via* DICOM to computer was mounted on February 16, 2005. Holter ECG has been available since July 13, 1988 (Fig. 3). The most recent procedure available at Cardiology Laboratory is ABPM, introduced in daily clinical use on October 4, 2001.

In addition to usual equipment for emergency interventions, the safety of our patients is now supported by a new defibrillator offering the option of transitory transcutaneous electrostimulation. This device allows for safe intervention in all types of arrhythmia, which is of great importance considering the fact that Cardiology Laboratory is dislocated from the ward[5].

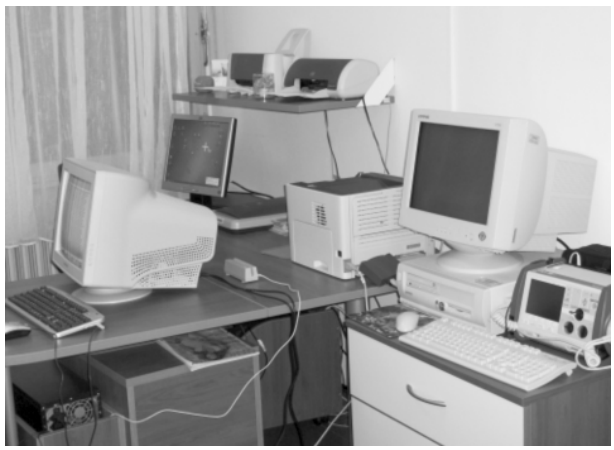

Fig. 4. The Cardiology Laboratory interior as redesigned and computerized during the 2002-2005 period.

Since 2002, the interior of the Cardiology Laboratory has been gradually renewed, along with continuous process of computerization, also under way at other divisions of the Department of Medicine (Fig. 4). Since the beginning of 2002, when the first PC was supplied, the majority of patient findings have been issued as hard copies and stored in the computer.

The ever growing influx of patients, the shortage of personnel, especially physicians, and inadequate room to store voluminous medical files have stimulated us to invest additional efforts to upgrade our daily routine[5]. In doing so, we were additionally motivated by daily encountering fragmentary files due to inadequate patient motivation for the process of diagnosis and treatment. Now, using the upgraded integrated InternPol software for the creation, processing and analysis of medical documentation, we have substantially improved the quality of daily work. Since October 2004, all findings obtained by noninvasive diagnostic methods at Cardiology Laboratory are directly entered in the electronic medical record identified by the patient's identification number and printed by laser printers. The software has proved to be the best solution for being able to cover all specificities of individual patients and processes of medical documentation generation, while being time-saving, reducing the time needed for particular medical service and decision making, and enabling appropriate evaluation of daily activities[12,13].

However, it should be borne in mind that besides high-quality devices that are in good repair and regularly maintained, the major factor of efficient work is properly equipped medical personnel offered all opportunities for continuing education. During the 30-year work of the Cardiology Laboratory, a great number of secondary school and college level nurses/medical technicians, all cardiologists, the majority of internists and residents in internal medicine and other related specialties took part in the Laboratory daily routine (Table 1). The problem of inadequate staff members has appeared in the last few years. Besides quite slow replacement of the worn out equipment with the new one, it is a minor cause of the long waiting lists for all diagnostic procedures. The other, major cause is the enormous influx of patients, frequently referred for noninvasive cardiology diagnosis without previous specialist consultation and clear indication for such a procedure.

In the light of the announced restriction of funds for polyclinic-specialist service and current shortage of both

Table 1. Cardiology Laboratory personnel 1975-2005

Nurses and medical technicians	Physicians
Marija Horvat, RN	Head Doctor Rudolf Miculinić, MD, internist, cardiologist
Zlatko Žiberna, med. technician	Head Doctor Stipe Brzović, MD, MS, internist, cardiologist
Zlata Šestani, nurse	Željko Šebek, MD, internist, cardiologist
Zdenka Pašalić, nurse	†Božo Kelava, MD, internist
Terezija Marušić, nurse	Boris Kudumija, MD, internist
Marija Rogić, nurse	Marina Premužić, MD, internist
Jasminka Krčma, nurse	Ljiljana Pleskalt, MD, internist
Ksenija Đurđek, nurse	Mario Ivanuša, MD, internist, European cardiologist, F.E.S.C.
Jasminka Hađasija, nurse	Željko Lepoglavec, MD, internist
Vlasta Henc, nurse	Dražen Šebetić, MD, internist
Ružica Ćurković, RN	Saša Magaš, MD, internist
	Jasna Čerkez-Habek, MD, MS, internist
	Mislav Klobučić, MD, internist
	Vlasta Soukup-Podravec, MD, resident in internal medicine
	Marin Deškin, MD, resident in internal medicine
	Marinko Lukić, MD, resident in internal medicine
	Andreja Čleković-Kovačić, MD, resident in internal medicine
	Renata Ivanac, MD, resident in internal medicine
	Tomislav Trumbetaš, MD, resident in internal medicine
	Goran Povh, MD, secondary physician

room and manpower, the patient pressure for reduction of waiting lists for diagnostic procedures is expected to further increase. Therefore, shift work and/or introduction of afternoon cardiologic diagnosis for patients who can afford paying full price of the procedure should be taken in consideration[5].

Analysis of Cardiology Diagnostic Procedures Performed During the Past Thirty Years

Data on all diagnostic procedures performed in both inpatients and outpatients from May 15, 1975 till December 31, 2004 were analyzed. There were a total of 32,026 diagnostic procedures (Table 2). Exercise tests predominated (n=16,628), accounting for 52% of all tests performed, followed by Holter ECG (n=8466; 26%), TTE (n=5730; 18%), ABPM (n=1100; 3%), and lower extremity arterial and venous Doppler (n=102; <1%). During the first ten-year period (1975-1984), 180 diagnostic procedures were performed *per* year on an average, to increase to 946 procedures *per* year in the second ten-year period (1985-1994) and to an average of 2074 procedures *per* year in the third ten-year period (1995-2004), yielding a 12-fold increase from the first ten-year period. The highest rise in the number of procedures was recorded in exercise tests and Holter ECG.

Analysis of the Experience Acquired During the Last Ten Years

The role of education of the population at large and patient groups at risk

Knowing and following epidemiologic situation in the area, the Bjelovar cardiologists have long realized that cardiovascular diseases are the main health problem in the Bjelovar-Bilogora County, and have therefore decided to take a more active part in the public health activities. On April 22, 1996, a Society of Cardiovascular Protection named *Srce* (Heart) was established in Bjelovar, led by Head Doctor Stipe Brzović, MD, MS, internist-cardiologist, intended to assemble patients diagnosed with coronary heart disease and all those interested. The Society's motto, "To fight cardiovascular disease with prevention", was best illustrated by the publication of a booklet entitled Prevention of Coronary Disease in the Bjelovar-Bilogora County in 1998[3].

The World Heart Day was celebrated in 2003, 2004 and 2005, and World Day of Hypertension in 2005, in collaboration with the Bjelovar-Bilogora County government, Croatian Society of Cardiology, Croatian Society of Hypertension, and Bjelovar General Hospital. The anniversaries of the Coronary Unit and Cardiology Labo-

ratory were celebrated by a ceremony on July 1, 2004, expressing due thanks to donators and issuing a booklet on the 30-year work of the Cardiology Laboratory[5]. On several occasions attended by local political authorities involved in designing the policy of health structure and financing in the County, in the presence of mass media, at Bjelovar General Hospital and County government premises as well as at lectures held at Croatian Medical Association – Bjelovar Branch, we had opportunities to point to the significant role of cardiovascular risk factors on the one hand, and of rational but timely diagnosis of cardiovascular disease on the other hand. The magnitude of the leading cardiologic problems and possible modes of solving them were elaborated in live radio broadcasts (Bjelovar-Bilogora radio station, Radio Čazma, Radio Grubišno Polje), a number of short TV reports (HTV, NET), and in daily and weekly newspapers (Večernji list, Bjelovarac). The following issues have been highlighted:

Table 2. Noninvasive diagnostic procedures performed at Cardiology Laboratory 1975-2004

Year	Exercise test	Holter ECG	TTE[1]	ABPM	AVD[2]	Total
May 15 - Dec 31, 1975	26					26
1976	86					86
1977	44					44
1978	45					45
1979	86					86
1980	173					173
1981	235					235
1982	323					323
1983	362					362
1984	424					424
1985	463					463
1986	556					556
1987	533		83			616
1988	520	89	375			984
1989	558	237	230			1025
1990	586	292	324			1202
1991	624	290	252			1166
1992	589	312	261			1162
1993	623	425	270			1318
1994	442	393	149			984
1995	696	476	224			1396
1996	836	693	298			1827
1997	978	602	250			1830
1998	949	595	360			1904
1999	886	634	693			2213
2000	765	708	534			2007
2001	1023	687	494	44	66	2314
2002	919	541	451	166	36	2113
2003	1140	510	289	414	—	2353
2004	1138	982	193	476	—	2789
Total 1975-2004	16,628	8466	5730	1100	102	32,206

[1]TTE=transthoracic echocardiography; [2]AVD=lower extremity arterial and venous Doppler

a) public health consequences of cardiovascular risk factors;
b) timely diagnosis and treatment of coronary heart disease;
c) prevention and appropriate education of cardiovascular patients; and
d) inequality in the availability of appropriate treatment, one of the pressing problems of Croatian cardiology, could be reduced by a more efficient organization of health care with the use of modern sophisticated methods (computers, telemedicine, GSM, ADSL), which is of utmost importance in the management of patients with acute myocardial infarction[8,14-18].

The role of education and evaluation of health professional daily work

The awareness that health care digitalization has become an indispensable measure that will upgrade the quality of health care provided was during 2001 extrapolated into Microsoft Access databases entitled Bjelovar Registry of Acute Myocardial Infarction and Registry of Acute Cerebrovascular Disease. Developed on the Cardiology Laboratory computers, both these databases have been used for professional and scientific evaluation of the prevalence of particular risk factors and therapeutic outcomes in this north-west part of Croatia. Towards the end of 2003, a computer database of ABPM procedures performed by then was established for a more precise analysis of the issue. ECG recordings of our patients suffering from cardiac diseases and serious arrhythmias have been stored in the computer since 2004[5-7,13].

Our long-lasting experience collected by daily use of noninvasive cardiology diagnostic methods and in the management of patients with cardiovascular diseases has been translated into a number of papers published in Croatian and international indexed journals, presented at professional sessions at Bjelovar General Hospital and Croatian Medical Association – Bjelovar Branch, and at symposia and congresses in Croatia and abroad, always emphasizing the crucial role of a more efficient health care organization[2,17,19-25]. Among the papers generated at Cardiology Laboratory on the topic of noninvasive cardiology diagnosis, mention should be made of the reports presented at the European Congress on Hypertension (Paris, France, 2004)[19], and two papers presented at the 11th Congress of the International Society of Holter and Noninvasive Electrocardiography (Gdansk, Poland, 2005)[20,21]. The first study performed in a sample of 260 patients found that there was no statistically significant difference in the rate of artifacts occurring on ABPM, indicating that there was no difference in the ABPM performance between outpatients and inpatients[19]. The other two studies pointed to the great role of properly educated nurse and standardized procedure of ABPM placement[20] and to the fact that ABPM performance is not sex dependent[21].

During the 1997-2005 period, more than 30 sponsored lectures in the field of cardiology were held for specialists and residents, GPs, nurses and pharmacists from the Bjelovar General Hospital catchment area, with valuable support from pharmaceutical industries. The lectures were delivered by renowned experts from Zagreb University Departments as well as by physicians from the Bjelovar General Hospital. Several educative lectures were held for physicians from the Croatian Medical Association – Bjelovar Branch (e.g., Continuous arterial pressure measurement – when, who and why?; Are there some novelties on arterial hypertension in Croatia?; Echocardiography in practice; Indications for and interpretation of exercise test results), with the aim to emphasize justifiability of the rational choice of (expensive) noninvasive cardiology diagnostic procedures. We also participated in the education on resuscitation and electrocardiography for the professionals from Emergency Department of the Bjelovar-Bilogora County Health Center.

Conclusion

The growing tendency of the cardiovascular disease morbidity and mortality recorded in Croatia over the last thirty years has been especially evident in the Bjelovar-Bilogora County in the last decade, reflecting in the ever increasing demand for noninvasive cardiology diagnostic procedures. During the study period, more than 32,000 procedures were performed, predominantly exercise test and Holter ECG, corresponding to nearly one-fourth of the County population.

The experience acquired during the 30-year work indicates that providing quality noninvasive cardiology diagnosis requires numerous and diverse laboratory techniques, thereby keeping pace with advancements in clinical medicine, medical technique and growing requirements of medical computerization. Due to the great number of patients, the process of medical documentation generation, processing and filing should be so adjusted as to enable rapid and functional search and anal-

ysis of medical data. Professional, scientific and economic evaluation of own results makes the basis of successful education of all health care professionals and population alike, which is of special importance for those patients who have sustained an atherothrombotic event, which has interfered with their quality of life and life prognosis.

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Sažetak

RAZVOJ NEINVAZIVNE KARDIOLOŠKE DIJAGNOSTIKE U OPĆOJ BOLNICI BJELOVAR OD 1975. DO 2005. GODINE

M. Ivanuša

Rastući trend pobola i smrtnosti od srčanožilnih bolesti očituje se u povećanim zahtjevima za neinvazivne kardiološke dijagnostičke postupke. Cilj ovoga prikaza je analiza broja učinjenih postupaka u Kardiološkom laboratoriju Opće bolnice Bjelovar. Prikazom vlastitih iskustava želi se naglasiti važnost izobrazbe svih djelatnika koji sudjeluju u procesima organizacije, prevencije, dijagnostike i zbrinjavanja srčanožilnih bolesti. U razdoblju od 15. svibnja 1975. do 31. prosinca 2004. godine učinjeno je 32.026 dijagnostičkih postupaka. Najviše je bilo ergometrija (52%), slijede 24-satno snimanje elektrokardiograma (26%), transtorakalna ehokardiografija (18%), 24-satno kontinuirano mjerenje arterijskog tlaka (3%), te Doppler arterija i vena donjih ekstremiteta (<1%). U odnosu na prvih deset godina rada, od 1995. do kraja 2004. godine prosječno je učinjeno 2.074 postupaka na godinu, što čini porast broja pretraga za 12 puta. Učinkovitu obradu nastale medicinske dokumentacije i njenu procjenu u stručnom, znanstvenom i ekonomskom smislu omogućuje primjena integriranog softverskog sustava. O stečenim iskustvima treba obavijestiti ne samo krug liječnika koji gravitira bolnici, nego i širu zajednicu, i to kroz predavanja i stalno objavljivanje rezultata u znanstvenim i stručnim časopisima. Procjenjivanje vlastitih rezultata rada i stalna medicinska izobrazba svih zdravstvenih djelatnika, ali i cjelokupnog stanovništva čine temelj uspješnog liječenja i prevencije srčanožilnih bolesti.

Ključne riječi: *Srčanožilne bolesti – dijagnosika; Dijagnostičke tehnike, srčanožilne – metode; Dijagnostičke tehnike, srčanožilne – povijest; Odjel za unutarnje bolesti, bolnica; Hrvatska*