New Concepts in *cardiac imaging* 1986

New Concepts in
cardiac imaging 1986

Editorial Board

Gerald M. Pohost, M.D., Editor-in-Chief
Professor of Medicine and Radiology
Director, Division of Cardiology
University of Alabama at Birmingham School of Medicine
Birmingham, Alabama

Charles B. Higgins, M.D.
Professor of Radiology
Chief, Magnetic Resonance Imaging Section
Department of Radiology
University of California at San Francisco School of Medicine
San Francisco, California

Joel Morganroth, M.D.
Professor of Medicine and Pharmacology
Director, Sudden Death Prevention Program
The Likoff Cardiovascular Institute
Hahnemann University
Philadelphia, Pennsylvania

James L. Ritchie, M.D.
Professor of Medicine
University of Washington School of Medicine
Chief, Division of Cardiology
Veterans Administration Medical Center
Seattle, Washington

Heinrich R. Schelbert, M.D.
Professor of Radiological Sciences
Division of Nuclear Medicine and Biophysics
Department of Radiological Sciences
UCLA School of Medicine
Los Angeles, California

YEAR BOOK MEDICAL PUBLISHERS, INC.
Chicago • London

0 9 8 7 6 5 4 3 2 1

International Standard Serial Number: 0743-9237
International Standard Book Number: 0-8151-5949-8

Sponsoring Editor: Elizabeth Sugg
Manager, Copyediting Services: Frances M. Perveiler
Production Manager: Henry E. Nielsen
Proofroom Supervisor: Shirley E. Taylor

Contributors

James A. Balschi, Ph.D.
Harvard Medical School
NMR Laboratory
Department of Medicine
Brigham and Women's Hospital
Boston, Massachusetts

George A. Beller, M.D.
Professor of Medicine
Director, Division of Cardiology
University of Virginia School of Medicine
Charlottesville, Virginia

Douglas P. Boyd, Ph.D.
Professor of Radiology (Physics)
University of California at San Francisco School of Medicine
San Francisco, California

Madeleine Fisher, M.D.
Department of Radiology
Northwestern University Medical Center
Chicago, Illinois

Julius M. Gardin, M.D.
Division of Cardiology
Department of Medicine
University of California, Irvine Medical Center
Orange, California
Long Beach Veterans Administration Medical Center
Long Beach, California

Robert S. Gibson, M.D.
Associate Professor of Medicine
Director, Cardiac Noninvasive Laboratory
University of Virginia School of Medicine
Charlottesville, Virginia

Robert J. Herfkens, M.D.
Assistant Professor
Department of Radiology
Duke University Medical Center
Durham, North Carolina

Charles B. Higgins, M.D.
Professor of Radiology
Chief, Magnetic Resonance Imaging Section
Department of Radiology
University of California at San Francisco School of Medicine
San Francisco, California

Joanne S. Ingwall, Ph.D.
Harvard Medical School
NMR Laboratory
Department of Medicine
Brigham and Women's Hospital
Boston, Massachusetts

Martin J. Lipton, M.D.
Professor of Radiology and Medicine
Chief, Cardiovascular Imaging Section
Department of Radiology
University of California at San Francisco School of Medicine
San Francisco, California

Debabrata Maulik, M.D., Ph.D.
Associate Professor and Chief
Division of Obstetrics and Perinatology
Department of Obstetrics and Gynecology
University of Missouri–Kansas City Medical School
Kansas City, Missouri

Joel Morganroth, M.D.
Professor of Medicine and Pharmacology
Director, Sudden Death Prevention Program
The Likoff Cardiovascular Institute
Hahnemann University
Philadelphia, Pennsylvania

Navin C. Nanda, M.D.
Professor of Medicine
Director, Heart Station and Echocardiography–Graphics Laboratories
Division of Cardiology
University of Alabama at Birmingham School of Medicine
Birmingham, Alabama

Ioannis P. Panidis, M.D.
Cardiac Ultrasound Laboratory
The Likoff Cardiovascular Institute
Hahnemann University
Philadelphia, Pennsylvania

James L. Ritchie, M.D.
Professor of Medicine
University of Washington School of Medicine
Chief, Division of Cardiology
Veterans Administration Medical Center
Seattle, Washington

Heinrich R. Schelbert, M.D.
Professor of Radiological Sciences
Division of Nuclear Medicine and Biophysics
Department of Radiological Sciences
UCLA School of Medicine
Los Angeles, California

William A. Schiavone, D.O.
Department of Cardiology
The Cleveland Clinic Foundation
Cleveland, Ohio

Markus Schwaiger, M.D.
Assistant Professor of Radiological Sciences
Division of Nuclear Medicine and Biophysics
Department of Radiological Sciences
UCLA School of Medicine
Los Angeles, California

Michael L. Stadius, M.D.
Acting Instructor
Division of Cardiology
Veterans Administration Medical Center
Seattle, Washington

Earl P. Steinberg, M.D., M.P.P.
Assistant Professor of Medicine
Division of Internal Medicine
The Johns Hopkins Hospital
Joint Appointment, Department of Health Policy and Management
The Johns Hopkins School of Hygiene and Public Health
Baltimore, Maryland

William J. Stewart, M.D.
Department of Cardiology
The Cleveland Clinic Foundation
Cleveland, Ohio

Donald F. Switzer, M.D.
Fellow, Division of Cardiovascular Diseases
University of Alabama at Birmingham School of Medicine
Birmingham, Alabama

Robert A. Vogel, M.D.
Chief, Cardiology Section
Veterans Administration Medical Center
Professor of Medicine
University of Michigan Medical School
Ann Arbor, Michigan

Preface

NEW CONCEPTS IN CARDIAC IMAGING 1986 (NCCI), like the first volume, provides the reader with timely and critical reviews of state-of-the-art diagnostic methods on a regular, annual basis. These articles, written by internationally-known experts, provide clinical and technical information to help clinicians, scientists, and students keep abreast of developments in this rapidly changing and important area of medical practice.

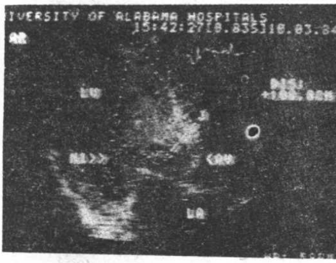
NEW CONCEPTS IN CARDIAC IMAGING is again organized into four sections according to methodology: ultrasound, radionuclide, x-ray, and magnetic. Contributors have used illustrations extensively (including color photographs) to make their presentations most effective. Our readers can count on the Editorial Board to encourage authors to take full advantage of illustrative materials in future volumes of NCCI as well.

A new feature in this series is the "lead article" on a topic relevant to all aspects of cardiac imaging. In the inaugural lead article, Dr. Earl P. Steinberg discusses the impact of cost-containment and DRG-based prospective payment. Dr. Steinberg, well known for his thoughtful in-depth analyses of cost-containment issues, examines recent health care cost-containment initiatives and their potential impact on cardiac imaging and coronary angiography. The discussion applies not only to cardiac imaging, but also more generally to other aspects of medical technologies and practices. He points out most definitely that evolving reimbursement policies will become more dependent on cost effectiveness of a given modality and will discourage the use of multiple modality or serial studies when gains from the second study are considered marginal. Obviously it is becoming essential that physicians who order the tests need to become increasingly conversant with the technology and its relative cost effectiveness.

Among the topics you can look forward to in subsequent volumes are: applications of laser techniques, the value of the computer in echocardiography, myocardial perfusion assessment strategies with NMR imaging, and many others. While it is natural to emphasize methods that prove successful and those that appear most promising, it is also important to indicate when methods have not proved the test of time. When such instances occur, you can be confident that they will be covered in NCCI.

The Editors are quite pleased with the evolution of NCCI as demonstrated by NCCI 1986. We believe that the addition of the lead article enhances the value of the content, as does the continued liberal use of illustrations, including those in full color. We will continue to provide you with discussions of a critical nature so that the efficacy of these techniques is communicated most effectively, and we hope that you enjoy this volume as well as the entire series. We welcome your suggestions, including recommendations of future topics.

GERALD M. POHOST, M.D.
EDITOR-IN-CHIEF



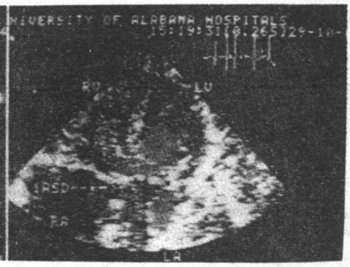


Plate 1 (left).—Color Doppler of aortic insufficiency. In this diastolic frame of a low parasternal view, the regurgitant jet *(J)* is seen extending from the aortic valve *(AV)* into the left ventricular outflow tract and is clearly differentiated from the simultaneous mitral inflow *(MI)*. The jet is relatively thin and does not reach beyond the tip of the anterior mitral leaflet, and would therefore be graded as mild. *LA* indicates left atrium; *LV*, left ventricle.

Plate 2 (right).—Atrioventricular canal defect. In this four chamber view, the 2-D image shows an ostium primum atrial septal defect *(ASD)* and a ventricular septal defect. With the superimposed color flow imaging, systolic flow is clearly seen extending through both defects in a left to right direction. With ECG gating to specific points in the cardiac cycle, any significant right-to-left shunting can also be detected (as in Plate 3). *LA* indicates left atrium; *RA*, right atrium; *LV*, left ventricle; *RV*, right ventricle.

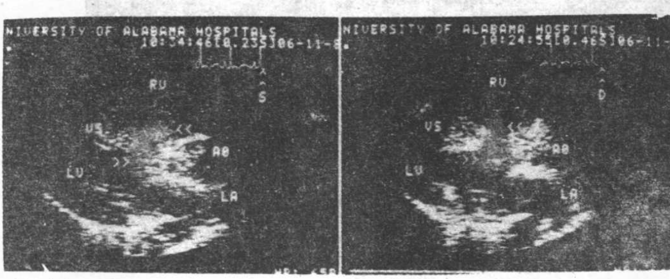


Plate 3.—Large ventricular septal defect *(VSD)* with pulmonary hypertension and bidirectional shunting. Long-axis view shows a large VSD. The color Doppler documents the presence of bidirectional flow through the VSD. A, the flow is directed into the right ventricle during systole, shown as red with a central blue area due to aliasing. B, during diastole, the flow reverses from right to left *(blue area)*.

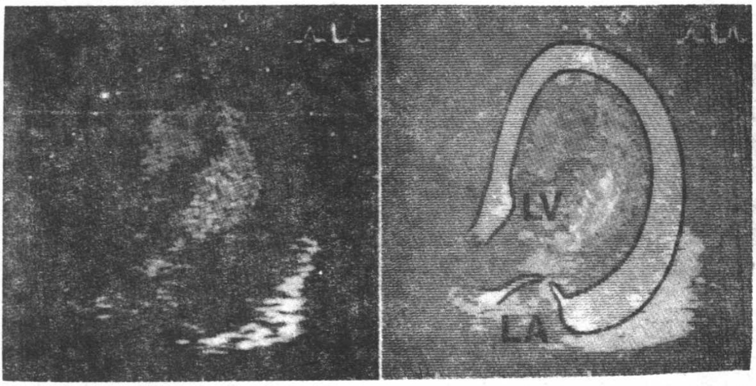


Plate 4.—Color-coded 2-D Doppler echocardiogram, parasternal long-axis view, of a patient with valvular mitral stenosis. The transmitral jet is shown in color. *LV* indicates left ventricle; *LA*, left atrium.

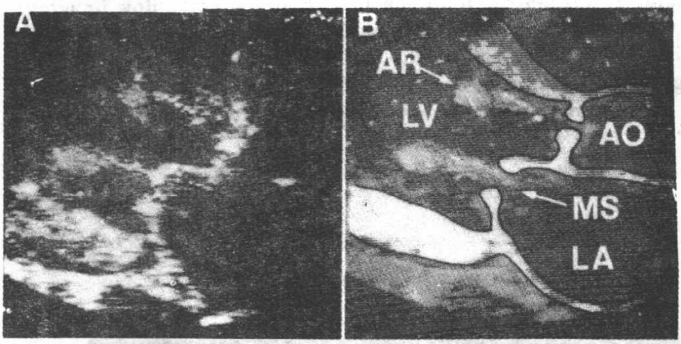


Plate 5.—Color-coded 2-D Doppler image (A) and drawing (B) from a patient with aortic regurgitation *(AR)* and mitral stenosis *(MS)* in a parasternal long-axis view. Mitral and aortic diastolic flow are shown in color. *LV* indicates left ventricle; *AO*, aorta, *LA*, left atrium.

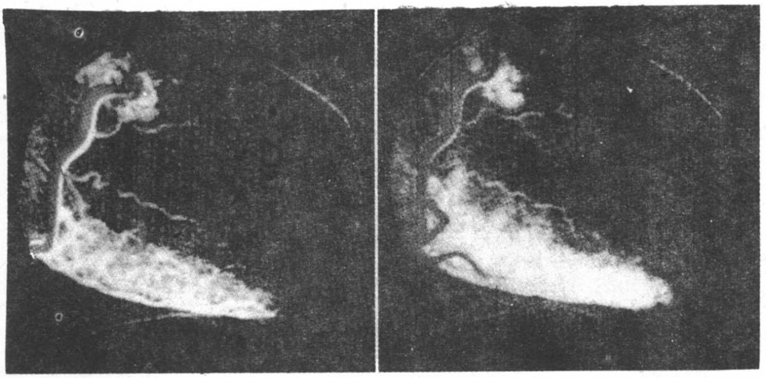


Plate 6.—Functional images depicting relative coronary flow of a normal right coronary artery obtained in the right anterior oblique projection are shown under baseline *(left)* and hyperemic *(right)* conditions. A significant increase in hyperemic flow is seen as earlier colors and greater intensity of the pixels within the region of perfusion of the hyperemic compared with the baseline study.

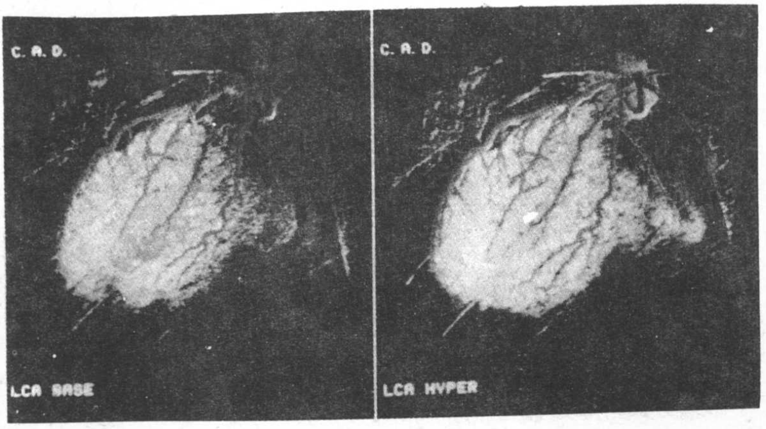


Plate 7.—Functional images depicting relative coronary flow of a left coronary artery with 75% stenoses obtained in the left posterior oblique projection are shown under baseline *(left)* and hyperemic *(right)* conditions. A low coronary flow reserve is visually apparent from the small change in pixel color and intensity within the region of perfusion.

Contents

0743-9237/86/0002-0001-0016-$04.00

1

The Impact of Cost-Containment and DRG-Based Prospective Payment on Cardiac Imaging*

EARL P. STEINBERG, M.D., M.P.P.

Assistant Professor of Medicine, Division of Internal Medicine, Johns Hopkins Hospital; Joint Appointment, Department of Health Policy and Management, Johns Hopkins School of Hygiene and Public Health, Baltimore, Maryland

TREMENDOUS PROGRESS has been made over the past decade in cardiac imaging techniques, providing an increasingly exciting and at times perplexing array of alternative means of evaluating the cardiovascular system. Coincident with these technological developments, there has been a steady 10% to 15% per year rise in health care costs in this country. By 1983, expenditures on personal health care in the United States had risen to $313.3 billion per year, approximately 10% of the Gross National Product.[1] With federal health care expenditures amounting to $92 billion per year[1] and a budget deficit of approximately $200 billion, the federal government has been looking increasingly to reductions in health care spending as a means of cutting its deficit. Such cost-cutting efforts will undoubtedly affect not only the use of existing cardiac imaging techniques, but also the number and types of new techniques developed in the future.

The purpose of this chapter is to examine recent health care cost-containment efforts and to consider their potential impacts on the field of cardiac imaging. The chapter will focus on federal cost-containment initiatives. Although these have by no means been the only cost-containment programs established over the past few years, undoubtedly they have been the most

*This work was supported in part by a grant from the Robert Wood Johnson Foundation. Dr. Steinberg is a Henry J. Kaiser Family Foundation Faculty Scholar in General Internal Medicine.

important. Moreover, many of the implications of federal policies for cardiac imaging are true for other cost-containment efforts as well.

The chapter is organized as follows: The first section describes historical trends in the use of the various types of cardiac imaging modalities. The second section provides an overview of the three major pieces of federal health care cost-related legislation that have been implemented over the past three years. The third section considers the potential impact that legislation is likely to have on the use of cardiac imaging modalities over the next several years.

HISTORICAL TRENDS IN CARDIAC IMAGING UTILIZATION

According to the American Heart Association, approximately $52 billion (16% of total national health expenditures) were spent on the diagnosis and treatment of cardiovascular diseases in 1984.[2] As can be seen from Table 1, almost 9% of all hospitalizations are related to heart disease. Among those 65 years of age or older, heart disease–related hospitalizations are even more common. The extent to which cardiovascular disease contributes to national health care expenditures can be expected to increase as the American population ages over the next several decades.

To provide some idea of the extent to which the use of cardiac imaging modalities contributes to these health care costs, data regarding the acquisition costs of various types of cardiac imaging equipment, representative charges for different types of imaging studies, and estimates of the annual volume of utilization of various types of cardiac imaging studies are presented in Tables 2 through 4. Utilization trend data for various

TABLE 1.—Heart Disease Discharges by Age, 1979–98*

	No. of discharges related to heart disease (in thousands)			Corresponding percentage of all hospital discharges		
Age, yr	1979	1980	1981	1979	1980	1981
All	3,070	3,201	3,339	8.3	8.5	8.7
<15	30	26	26	.8	.7	.7
15–44	241	239	240	1.6	1.5	1.5
45–64	1,114	1,127	1,157	13.1	13.0	13.3
65+	1,685	1,808	1,916	18.6	18.3	18.4

*Source for 1979 data, reference 3; for 1980, reference 4; for 1981, reference 5.

TABLE 2.—CARDIAC IMAGING EQUIPMENT COSTS

MODALITY	AVERAGE PRICE (DOLLARS)	PRICE RANGE (DOLLARS)
Echocardiography		
M-Mode	$ 17,000[4]	$ 15,000–20,000[6]
2-D sector scanner	60,000[6]	30,000–120,000[7]
2-D with Doppler	90,000[6]	75,000–100,000[6]
Electronic phased array	100,000[6]	80,000–125,000[6]
Nuclear Studies		100,000–174,000[7,8]
Catheterization		
Single-plane equipment		490,000–600,000[9]
Complex laboratory		625,000–875,000[9]
Digital subtraction angiography		400,000–700,000[7]
X-ray CT scanners		
Standard	1.0 million[7]	
Dynamic spatial reconstruction	2.0 million[7]	
Cine-CT scanner	1.6 million[10]	
Magnetic resonance imaging	1.5 million[11]	800,000–2.5 million[11]
Positron emission tomography		
Imaging unit	325,000[12]	
Medical cyclotron	399,500[12]	

types of cardiac imaging modalities at Johns Hopkins Hospital are presented in Figure 1. Noninvasive as well as invasive imaging of cardiac structures and coronary arteries have clearly become increasingly integral parts of the management of patients with known or suspected cardiac disease.

TABLE 3.—ESTIMATED CHARGES PER IMAGING STUDY*

MODALITY	AVERAGE CHARGE (DOLLARS)	CHARGE RANGE (DOLLARS)
Echocardiography		
M-Mode	$163[13] (h + md)	$ 75–85[14] (h)
2-D		120–130[14] (h)
2-D with Doppler		190–210[14] (h)
Nuclear Studies		
Thallium-201		
Rest	248[15] (h)	140–500[15,16] (h)
Exercise	307[15] (h)	200–470[15] (h)
Exercise-redistribution	405[8] (h + md)	315–495[8] (h + md)
First-pass		
Rest	155[15] (h)	95–275[15] (h)
Rest and exercise	395[8] (h + md)	315–475[8] (h + md)
MUGA		
Rest	243[8] (h + md)	225–260[8] (h + md)
Rest and exercise	350[8] (h + md)	315–385[8] (h + md)
Infarct imaging	240[15] (h)	143–300[15] (h)
Cardiac Catheterization	760[17] (h)	307–1,470[17] (h)
	640[9] (md)	200–1,200[9] (md)
Cine-CT		300–750[10] (h)

*h indicates hospital charge; md, professional fee; (h + md), hospital charge plus professional fee.

TABLE 4.—ESTIMATED ANNUAL VOLUME OF CARDIAC IMAGING STUDIES IN THE UNITED STATES BY MODALITY

	NO. OF STUDIES* (IN THOUSANDS)				
IMAGING MODALITY	1979	1980	1981	1982	1983
Echocardiograms		1,355[18] 1,500[19]		3,491[14]	
Cardiac Nuclear Studies					
Nonspecified	396[15]	558[18] 550[19]	629[15]		714[15]
Thallium-201				800[6]	
Gated blood pool				500[6]	
Cardiac catheterizations		348[20]	414[2]	471[20]	
Heart CT scans					20[20]

*Within year estimates vary due to differences in sampling and estimation methodologies.

RECENT LEGISLATION

Until recently, hospitals were paid under a cost-based system of reimbursement. That is, a hospital's charges (and revenues) were based on the costs it incurred in the process of providing care to a patient. It is now generally believed that such a system, which pays hospitals and physicians more for doing more, has provided little incentive for health care providers to consider cost-benefit tradeoffs in the provision of care, and thus has contributed to the rise in health care costs that we have witnessed over the past 20 years.

Pressed by an enormous budget deficit, the federal government began in 1982 to change the system under which it paid for inpatient care provided to Medicare beneficiaries.* The intent of these changes was quite simple—namely, to slow the rate of rise in federal health care expenditures. Because the care provided to Medicare beneficiaries in acute care hospitals accounts for about 35% to 40% of all hospital revenues, these changes in the way the federal government pays for health care services provided to Medicare beneficiaries are of great importance to hospitals and to health care in general. In order to understand the health care implications of recent federal cost-containment efforts, it is essential to have some familiarity with three major pieces of federal legislation that have been enacted over the past three years.

*Medicare beneficiaries include individuals who are 65 years of age and older, disabled, or who have end-stage renal disease.

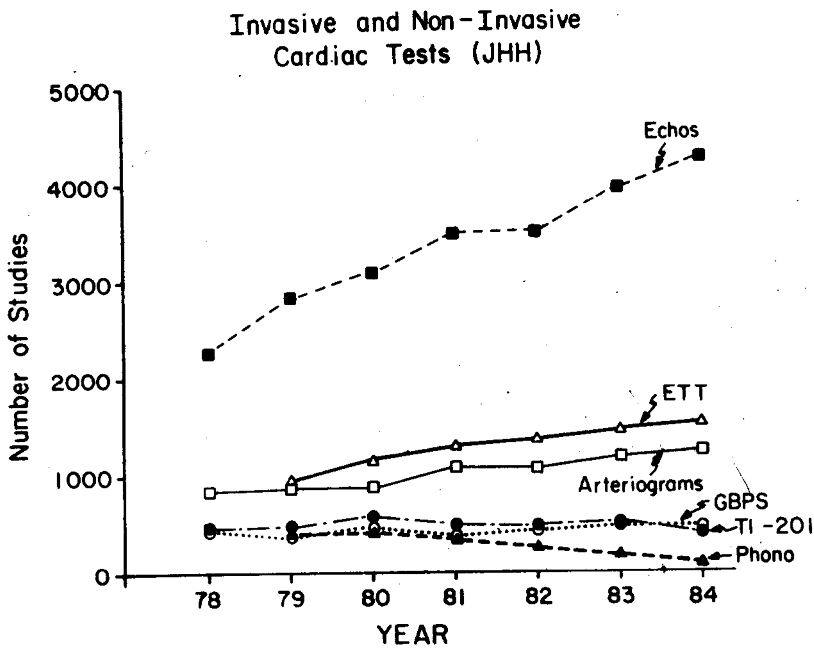


Fig 1.—Utilization trends for cardiac tests at Johns Hopkins Hospital, 1978 to 1984. *Echos* indicates echocardiograms; *ETT*, exercise ECG tolerance test; *arteriograms*, coronary angiograms; *GBPS*, gated blood pool scans; *Tl*-201, thallium-201 rest and/or rest and redistribution scans; *Phono*, phonocardiograms.

The Tax Equity and Fiscal Responsibility Act of 1982

The first piece of legislation, entitled the Tax Equity and Fiscal Responsibility Act (TEFRA) of 1982, made two important changes in the way the federal Health Care Financing Administration (HCFA) pays hospitals for providing care to Medicare beneficiaries. In the first change, TEFRA established a ceiling on the amount HCFA would pay a hospital for caring for a particular type of patient. Type of patient was defined on the basis of the now-familiar 467 diagnosis-related groups (DRGs), and the ceiling was set equal to 120% of the average national cost of providing care to patients within a particular DRG. Of fundamental importance was the fact that the ceiling was set equal to 120% of *total* costs, thus encompassing not only routine costs (e.g., room, board, and nursing), but also ancillary costs (e.g., laboratory and imaging tests).

TEFRA contained a second important provision aimed at slowing the rate of rise of federal payments to hospitals—c limit on the allowance paid to hospitals for increases over time in the "intensity" of medical care provided during a hospitalization. Increases in federal payments to hospitals over time can be attributed to three factors: inflation in the prices of goods and services utilized by hospitals (the "hospital market basket"), population growth, and greater "intensity" of care during a hospitalization. The latter factor, which includes increases in the number and types of manpower, services, and techniques employed in patient care, has historically risen at an annual rate of 4% to 5%.[21] With passage of TEFRA, the allowance for increases in intensity of care was limited to 1% per year. This decrease, significant by any standard, has obvious implications for growth in the use of services such as cardiac imaging modalities.

The Social Security Amendments of 1983—DRG-based Prospective Payment

The second major piece of legislation which has tremendous implications for the cost and quality of health care in this country is the Social Security Amendments (SSA) of 1983. Several provisions of the SSA require explanation.

The most major change brought about by the SSA was that, beginning in fiscal year 1984,* HCFA began paying hospitals a fixed price for caring for patients with particular diagnoses, regardless of the number and types of services provided during a hospitalization. Four hundred sixty-seven different DRG-specific payment rates were established in this new "prospective payment system," each based on the costs and patterns of medical care provided to patients in fiscal year 1981.† The 43 cardiovascular disease-related DRGs are listed in Table 5.

Under the prospective payment system, hospitals are permitted to retain any savings that derive from a hospitalization that generates patient-care costs that are less than the DRG

*Since different hospitals have different accounting fiscal years, not all hospitals started getting paid under the prospective payment system at the same time. Approximately one third of hospitals came under prospective payment in October 1983, one third in January 1984, and one third in July 1984.

†DRG-specific payment rates will be phased in over a four-year period. During this phase-in period, actual payment rates will be a blend of the DRG-specific payment rate, an individual hospital's historical cost of providing care within a specific DRG, and an interim regional average DRG-specific payment rate.