Computed Tomography, Ultrasound and X-Ray: An Integrated Approach 1980

Edited by

ALBERT A. MOSS, M.D.

HENRY I. GOLDBERG, M.D.

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ALBERT A. MOSS, M.D.
Associate Professor of Radiology
Chief of Computed Body Tomography
University of California, San Francisco

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Preface

Computed Tomography, Ultrasound and X-Ray: An Integrated Approach is a postgraduate course presented by the Radiology Research and Education Foundation in association with the Department of Radiology and the University of California, San Francisco. In this course we have selected current problems in clinical medicine and have updated and re-evaluated the principles, advantages and disadvantages of the available imaging modalities as they pertain to particular clinical situations.

This year's postgraduate course in Diagnostic Imaging takes note of the ever-advancing fields of CT, Ultrasound and Nuclear Medicine by featuring some of the newer applications of these modalities. For example, the first part of the course concentrates on the newer techniques such as CT angiography, and needle biopsy of lesions guided by Ultrasound and CT. Cross-sectional imaging of the neck and larynx is also featured, as this represents recently described areas of normal cross-sectional anatomy and pathologic processes. The newer uses of CT for evaluating abdominal trauma are also discussed. Our postgraduate course encompasses a review of comparative diagnostic imaging modalities in evaluating familiar problems of the liver, pancreas, retroperitoneum, musculoskeletal system, and central nervous system, as well as giving attention to the most recent advances in these areas.

ALBERT A. MOSS, M.D.

HENRY I. GOLDBERG, M.D.

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Contributors

ELIAS H. BOTVINICK, M.D., Assistant Professor of Radiology and Medicine University of California, San Francisco, California

ROBERT C. BRASCH, M.D., Assistant Professor of Radiology, University of California, San Francisco, California

PETER W. CALLEN, M.D., Assistant Professor of Radiology, University of California, San Francisco, California

MICHAEL D. F. DECK, M.D., B.S., Associate Professor of Radiology, Cornell University Medical College; Chief of Neuroradiology, Memorial Sloane Kettering Cancer Center, New York, New York

DIETER R. ENZMANN, M.D., Assistant Professor of Neuroradiology, Division of Diagnostic Radiology, Stanford University School of Medicine, Stanford, California

MICHAEL P. FEDERLE, M.D., Assistant Professor of Radiology, San Francisco General Hospital, San Francisco, California

ROY A. FILLY, M.D., Associate Professor of Radiology; Chief of Diagnostic Ultrasound, University of California, San Francisco, California

GORDON GAMSU, M.D., Associate Professor of Radiology; Chief of Chest Radiology, University of California, San Francisco, California

HARRY K. GENANT, M.D., Professor of Radiology; Chief of Bone Radiology, University of California, San Francisco, California

LOUIS A. GILULA, M.D., Associate Professor of Radiology; Co-Chief, Musculoskeletal Section, Washington University, Mallinckrodt Institute of Radiology, St. Louis, Missouri

HENRY I. GOLDBERG, M.D., Professor of Radiology; Chief, Diagnostic Radiology Research Laboratory; Chief of Gastrointestinal Radiology, University of California, San Francisco, California

CHARLES A. GOODING, M.D., Professor of Radiology and Pediatrics; Vice-Chairman, Department of Radiology, University of California, San Francisco, California

VICTOR M. HAUGHTON, M.D., Associate Professor of Radiology, Medical College of Wisconsin; Chief of Neuroradiology, Milwaukee County Medical Complex, Milwaukee, Wisconsin

ELIAS KAZAM, M.D., Assistant Professor of Radiology; Head of the Division of Ultrasound and Computed Tomography, New York Hospital, Cornell Medical Center, New York, New York

FAYE C. LAING, M.D., Assistant Professor of Radiology; Chief of Diagnostic Ultrasound, San Francisco General Hospital, San Francisco, California

BARTON LANE, M.D., Assistant Clinical Professor of Radiology, University of California; Assistant Chief, Department of Radiology, Mt. Zion Hospital, San Francisco, California

MARTIN J. LIPTON, M.D., Associate Professor of Radiology and CVRI, University of California, San Francisco, California

JAY C. MALL, M.D., Assistant Clinical Professor of Radiology, University of California, San Francisco, California

ANTHONY A. MANCUSO, M.D., Assistant Professor of Radiology, University of California School of Medicine, Los Angeles, California

ALEXANDER R. MARGULIS, M.D., Professor and Chairman, Department of Radiology, University of California, San Francisco, California

EDWARD M. MILLER, M.D., Assistant Professor of Radiology; Chief of Neuroradiology, San Francisco General Hospital, San Francisco, California

ALBERT A. MOSS, M.D., Associate Professor of Radiology; Chief of Computed Body Tomography, University of California, San Francisco, California

THOMAS P. NAIDICH, M.D., Associate Professor of Radiology, Washington University School of Medicine, St. Louis, Missouri

THOMAS H. NEWTON, M.D., Professor of Radiology, Neurology and Neurosurgery; Chief of Neuroradiology, University of California, San Francisco, California

DAVID NORMAN, M.D., Associate Professor of Radiology, University of California, San Francisco, California

STEVEN H. OMINSKY, M.D., Assistant Clinical Professor of Radiology; Chief of Ambulatory Care Radiology, University of California, San Francisco, California

DAVID C. PRICE, M.D., Associate Professor of Radiology and Medicine; Head of Nuclear Medicine, University of California, San Francisco, California

ERNEST J. RING, M.D., Associate Professor of Radiology; Chief of Vascular Radiology, University of Pennsylvania, Philadelphia, Pennsylvania

NELSON B. SCHILLER, M.D., Assistant Professor of Medicine and Radiology; Co-Director, Adult Non-Invasive Laboratory, University of California, San Francisco, California

HOWARD A. SHAPIRO, M.D., Clinical Professor of Medicine; Director, G.I. Diagnostic Center, University of California, San Francisco, California

DOUGLAS J. SHEFT, M.D., Associate Clinical Professor of Radiology, University of California, San Francisco, California

ROBERT C. STADALNIK, M.D., Associate Professor of Radiology (Nuclear Medicine), University of California School of Medicine, Davis, California

ROBERT J. STANLEY, M.D., Professor of Radiology; Chief, Abdominal Section; Co-Director of Computed Tomography, Mallinckrodt Institute of Radiology, Washington University School of Medicine, St. Louis, Missouri

KENNETH J. W. TAYLOR, M.D., Ph.D., Professor of Diagnostic Radiology; Head, Section of Diagnostic Ultrasound, Yale University School of Medicine, Yale New Haven Hospital, New Haven, Connecticut

W. RICHARD WEBB, M.D., Assistant Professor of Radiology, University of California, San Francisco, California

Contents

General Considerations

THE ROLE OF CT IN MEDICINE AND SOCIETY: PRESENT AND FUTURE

Alexander R. Margulis, M.D.

Computed tomography (CT) has acquired visibility well beyond its role in medicine or even in radiology. No one can deny that non-invasive diagnostic approaches are an extremely important development. However, the proliferation of committees, laws and regulations that have been spawned by CT do not justify the fraction spent on CT from the $189 billion that this nation expends on medical care every year. Computed tomography can be credited with the creation of certificate of need laws at the state and federal levels, with creation of committees to review medical technology and its use, and with a rash of other agencies at municipal, county, state, and federal levels. The concentration of attention and the focusing of hostility to medical advances through CT in many ways are due to its initial, tremendous success in diagnosing abnormalities of the head and brain, the outstanding contribution that it makes in the diagnosis of diseases of the abdomen, and the publicity that it has created.

The enthusiasm of physicians and surgeons for CT has been infectious. This trend has made hospital boards insist on acquiring computed tomography equipment for their hospitals. They also have been spending inordinate amounts of funds on litigations to reverse unfavorable decisions regarding certification of need made by controlling agencies. Yet the costs of many other medical equipment systems have increased over the years at an astounding rate. Many basic radiologic installations over the years have exceeded computed tomographic units in price, without attracting attention to the question of duplication of services in a community and long term periods of inactivity of expensive equipment.

The cost of all medical equipment has soared due to the combination of inflation and increased sophistication resulting from advances in engineering. CT units for the head have increased in price from $300,000 (when they came on the market approximately six years ago) to close to $800,000 for large aperture scanners required for sophisticated neuroradiological studies. The cost of installation for these machines has also shown similar increases. As the value and diagnostic advantages of CT become more obvious and more widely recognized, hospitals which have difficulty increasing their bed occupancy are vying for acquisition of CT units. Physicians and surgeons will not bring patients to hospitals that do not have this latest of diagnostic modalities. They will even refuse staff appointments at these hospitals. It becomes, therefore, a losing battle for regulating agencies to prevent determined hospitals, the medical profession and, ultimately, patients from acquiring machines. Politicians and even courts of law, who are acutely aware of this situation, often hamper controlling agencies. The proliferation of computed tomography, therefore, has become symbolic to those who wish to reduce national health expenditures which are inching towards the $200 billion per year mark. Computed tomography is considered to be the symbol of waste, unchecked expense and medical/industrial conspiracy. In relationship to inflation, and in spite of the greater cost of the machines, the rise in prices for CT procedures has been moderate. This is due to faster patient throughput: the more procedures, the lower the cost.

The popularity of computed tomography continues to increase also because there have been many impressive technical advances and many more are expected. These improvements are and will continue to occur in the area of *improved spatial resolution*. There is also continued improvement of accuracy of *density determinations* which will lead to the widespread use of CT for many quantitative applications. CT densitometry is already being applied to problems ranging from bone mineral quantitation in osteoporosis and prolonged bed rest to diffuse liver diseases with fat infiltration, iron deposition, et cetera. Dynamic densitometry with CT is being applied to blood flow measurements using the indicator-dilution principle. Quantitative CT methods are also used in sizing regions of interest and in determining linear dimensions, as well as areas and volumes. This is of particular importance in following tumor shrinkage during radiotherapy and in reducing the size of the field of irradiation.

Advances in *image manipulation* and display techniques are being used and will be used increasingly to exploit the three dimensional capability of CT. Many CT machines are already capable of sagittal, coronal and oblique section reconstruction. Even more advanced techniques are being investigated by institutions and the industry. Digitized radiography will provide convenient means for enhancement of information. It will probably lead to replacement of selective catheterization for arteriography by intravenous angiography.

Speed of CT scanning will increase with the resulting improvement in image resolution as well as in widening the scope of its application. In the foreseeable future scans in milliseconds will be achieved.

Specific contrast media for use in CT scanning are being slowly developed for the study of the liver, improved visualization of the gastrointestinal tube and vascular network.

All of these technical advances promise even further applications for CT, particularly in the replacement of invasive studies. The prospect of CT replacing myelography, arthrography, coronary and most other angiography will further enhance the demand for CT units. Diagnostic laparotomies and operations for obtaining tissue samples for histologic studies are already disappearing with present capabilities of CT.

Yet, no society can afford to expend more than it is able or willing to spend, even on desirable goals. Therefore, computed tomography and all similar procedures must fit into a new diagnostic approach. New procedures cannot be additive. Rather, they must substitute for other investigations that will be eliminated. There is a need for the development of algorithmic approaches for various clinical presentations of symptoms and signs. These approaches have to be worked out by teams of physicians, surgeons and radiologists. They must be flexible and must change as new techniques appear and as the value of newer methods is established to be superior over the older ones. In order not to threaten the physicians and to enhance acceptance of these algorithims, our colleagues must participate in their development. As more non-invasive procedures replace those invasive ones, the majority of diagnostic procedures will be performed on outpatients. This will significantly reduce the cost of the procedure. Examples of reduction of cost for the diagnosis of several sets of clinical presentations of disease are given in Tables I to III. The figures are based on U.C.S.F. prices effective in 1975 when computed tomography and ultrasonography were not available, and costs in 1980 when these new approaches are used and replace older approaches. The cost savings attendant to the use of the new modalities are also accompanied by a reduction in the amount of radiation dosage and the fact that new technologies reduce radiation dosage should be emphasized (Tables IV to VI).

Eventually, with the reduction of invasiveness, reduction in time of hospitalization and reduction of cost, another problem will surface. Newer technology and its proper use will further reduce the need for the present number of hospitals and hospital beds. This will produce a threat to employment of many individuals, i.e., orderlies, technicians, physicians and administrators, et cetera.

However, the additions of new diagnostic procedures undoubtedly will result in better treatment and advances in therapeutic technology, as more precise diagnosis eventually leads to more precise modes of therapy. This, in turn will result in increased costs. Ultimately, society will have to come to grips with how much it wants to expend on treatment of incurable diseases. It will have to be decided whether society wishes to expend huge amounts of funds to prolong life without improving its quality.

TABLE I

Radiologic Diagnostic Workup of Jaundice

1975	*Examination*	*# of Hospital Days and Cost*	*Cost of Rad. Exam*
	Plain Film	}	$ 46.25
	Intravenous Cholangiogram	} 1	152.00
	Angiogram	}	677.75
	UGI & Small Bowel	1	145.50
	Barium Enema	2	110.00
	Hypotonic Duodenogram	1	121.75
	Nuclear Scan		215.00
	Percutaneous Transhepatic Cholangiogram	1	215.75
	(ECRP - Optional)		(161.50)
		6	$1684.00
		6 days × $217/day =	1302.00
	Cost Based on 1980 Prices ECRP Excluded	Total	$2986.00
	if ECRP Performed, Add 1 Day at $217 + 161.50 =		$378.50
1980			
	CT		$335.00
	Percutaneous Transhepatic Cholangiogram	1	215.75
			$550.75
		1 day × $217/day =	217.00
		Total	$767.75

TABLE II

Radiologic Diagnostic Workup of Liver Mass

1975	*Examination*	*# of Hospital Days and Cost*	*Cost of Rad. Exam*
	Plain Film	1	$ 46.25
	Intravenous Cholangiogram		152.00
	IV Pyelogram	1	114.25
	Celiac Angiogram		677.75
	UGI & Small Bowel	1	145.50
	Barium Enema	2	110.00
	ERCP	1	161.50
	Nuclear Liver Scan		215.00
		6	$1622.25
		6 days × $217/day =	*1302.00
		Total	$3085.75

*Cost Figures 1980 Prices

TABLE III

Radiologic Diagnostic Workup of Liver Mass

1980	*Examination*	*# of Hospital Days and Costs*	*Cost of Rad. Exam*
	CT & Ultrasound		$335.00
			70.25
	Biopsy	1	104.50
			$509.75
		1 day × $217/day =	217.00
		Total	$726.75

TABLE IV

Radiation Skin Dose for Radiologic Diagnostic Workup of Jaundice

1975	*Examination*	*Skin Dose*
	Plain Film	0.5 r
	Intravenous Cholangiogram	2.0 r
	(ERCP - Optional)	(5.0) r
	UGI & Small Bowel	8.5 r
	Barium Enema	8.0 r
	Percutaneous Transhepatic Cholangiogram	16.0 r
	Total*	35.0 r
*Without ERCP		
1979		
	Plain Film	0.5 r
	Percutaneous Transhepatic Cholangiogram	16.0 r
	CT	2.0 r
		18.5 r

TABLE V

Radiation Skin Dose for Radiologic Workup of Liver Mass

1975	*Examination*	*Skin Dose*
	Plain Film	0.5 r
	Intravenous Cholangiogram	2.0 r
	IV Pyelogram	2.5 r
	Angiogram	20.0 r
	UGI & Small Bowel	8.5 r
	Barium Enema	8.0 r
	ERCP	5.0 r
		46.5 r
1979		
	Plain Film	1.0 r
	CT (Liver)	2.0 r
	Ultrasound	
		3.0 r