Acta clin Croat 2002; 41 (Suppl): 5-7 Review

RADIOLOGY IN 2002 AND BEYOND

Hedvig Hricak

Department of Radiology, Carroll and Milton Petrie Chair
Memorial Sloan-Kettering Cancer Center, New York, NY, USA

Introduction

Ever since Roentgen's discovery of x-rays, more than 100 years ago, medical imaging has undergone, and continues to undergo, dramatic advances. It has become one of the important mainstays of modern medicine, indispensable for diagnosis, treatment planning and follow-up. Progress in medical imaging has been driven by the continuing increases in computer power, advances in microinstrumentation, communication technology and, lately, by the impact of molecular biology. The increase in computer power has been most impressive, even exceeding Moore's law of doubling the number of transactions *per* chip every 18 months. The fact that the price for constant computer power has decreased by the logarithmic scale has been responsible for the relative affordability of the advances in computer technology. These advances have made much of cross-sectional imaging as well as PACS and teleradiology possible. PACS has empowered many leading medical centers in the United States, Western Europe and Japan to become "film-less". Many other countries are in transition. Teleradiology promises access to sophisticated subspecialty imaging interpretation worldwide and may help in overcoming the anticipated shortage of radiologists in the industrialized world. The general forward direction of medical imaging aims toward increasing sensitivity and specificity, while decreasing invasiveness and minimizing cost.

Correspondence to: *Hedvig Hricak,* Chairman, Department of Radiology, Memorial Sloan-Kettering Cancer Center Professor of Radiology, Cornell University 1275 York Avenue, C278 New York, New York 10021
Telephone: (212) 639-7284
Facsimile: (212) 794-4010

Advances in Cross-Sectional Imaging

The increasing computer power in cross-sectional imaging has facilitated the acquisition of 3 dimensional data, permitting high-resolution volumetric acquisition of images, thus facilitating diagnosis. Multi-row detector CT and 3D MR have also made virtual endoscopy an increasingly accepted clinical imaging technique. This technique is presently being applied to practically every anatomic channel: colon, esophagus, stomach, small bowel, bronchial tree, blood vessels, urinary tract (including the bladder), etc. Virtual endoscopy promises to reduce the number of invasive procedures and limit conventional, invasive endoscopic procedures to targeted biopsy if the virtual studies disclose abnormalities. Fusion of images generated from different imaging modalities, such as MR, CT and PET, is showing that the advantages of two techniques can be maximized. Several large equipment manufacturers are already marketing PET-CT scanners for clinical use. The advantages of PET's ability to detect malignant nodes are thus combined with the superior spatial resolution of CT. Several companies are presently designing combined MR-PET instruments, which will have important applications particularly in the brain. Fusion of MR and CT is currently used in radiation therapy planning. Proton spectroscopic MR imaging has presently become clinical in the study of brain tumors and prostate carcinoma. A grid is superimposed on the MR image and the voxels can display in color the increased presence of choline and NAA for the study of brain tumors. This is particularly valuable in the differentiation of tumor recurrence from necrosis following radiation therapy. For prostate cancer, the use of different three-dimensional spectroscopic imaging data has resulted in improved detection, diagnosis of extracapsular spread, assessment of tumor aggressiveness, and evaluation of treatment. In the future, as MRSI expands its role, other MR spectroscopic markers for cancer, even more specific than increased choline levels, will undoubtedly be discovered. Extension of these successful MR spectroscopic techniques to breast cancer and brain, as well as development and identification of metabolic processes affected by birth injury in neonates, are underway in multiple centers. Mapping of foci of specific brain activity with functional MRI by displaying images of metabolic activity data, as for instance for heat/pain sensation, motor, memory centers, etc., is becoming the basis of functionally based medicine and will have an important future role in the study of mental diseases. The development of new imaging modalities like optical coherence tomography, adds new dimensions to medical imaging. It is expected that it will be possible in the future to identify early dysplastic, precancerous changes in many organs. An example are changes in Barrett's esophagus as well as in the bronchial mucosa of heavy smokers.

Genomics, Molecular and Medical Imaging

Future advances in medicine are going to be closely linked to genomics. The identification of the genome will result in a better understanding of disease, more rational treatment, and will expand the role of medical imaging. Genetic imaging is assuming increased importance. To be able to participate in genetic medicine imaging, the information must be imaged at the molecular level. The directions of genetic imaging are:

A. Gene expression using intracellular or extracellular reporter genes. An accepted technique in animal genetic imaging employs reporter genes such as luciferase (the firefly gene). The techniques presently used in molecular imaging are: PET, optical imaging and MR.

B. Screening of populations at known risk (either specific gene identification or family disease history) in order to discover the earliest phase of disease

C. Providing guidance for and follow-up of gene therapy. Image-guided gene therapy, whether introducing good genes carried by adeno or retroviruses, or with stem cells carrying the good gene, is making slow advances. All present imaging techniques will be used to guide the micro-catheters or needles to the desired target. While progress is painfully slow there have been successes.

Computer-Aided Diagnosis

This approach will, in the future, be an essential component of any imaging screening of genetically susceptible individuals. The reduction and eventually the elimination of perception errors can be achieved by using neural-network computers taught what is normal and all of its variations. The computer should eventually be able to identify normal appearing structures making the reading by the radiologist unnecessary for a large proportion of screened images. This may provide screening at an affordable price. Computer-aided diagnosis will be particularly important in the screening of identifiable populations at risk, for instance, of heavy smokers after a given period of "pack-years". High-resolution CT computer-aided screening in such populations may improve the odds of survival. Computer-aided diagnosis will be used in reading images obtained with most techniques, such as virtual CT colonoscopy and lung CT as it is now employed in mammography.

References

1. FEIG SA, YAFEE MJ. Digital mammography, computer-aided diagnosis and tele-mammography. Radiol Clin North Am 1995; 3:1205-30.
2. MOSHAGE WE, ACHENBACH S, SEESE B, BACHMANN K, KIRCHGEORG M. Coronary arterystenoses: three-dimensional imaging with electrocardiographically triggered, contrast agent-enhanced, electron-beam CT. Radiology 1995, 196:707-14.
3. COLLINS FS, PATRINOS A, JORDAN E, *et al.* New goals for the U.S. human genome project: 1998-2003. Science 1998; 282:682-9.
4. JOHNSON CD, DACHMAN AH. CT colonography: the next colon screening examination? Radiology 2000;216:331-41.
5. DACHMAN AH, KUNIYOSHI JK, BOYLE CM, SAMARA Y, HOFFMANN KR, RUBIN DT, HANAN I. CT colonography with three-dimensional problem solving for detection of colonic polyps. AJR Am J Roentgenol 1998;171:989-95.
6. LUBOLDT W, BAUERFEIND P, WILDERMUTH S, MARINCEK B, FRIED M, DEBATIN JF. Colonic masses, detection with MR colonography. Radiology 2000;216:383-8.
7. TANG Y, YAMASHITA Y, ARAKAWA A, NAMIMOTO T, MITSUZAKI K, ABE Y, KATAHIRA K, TAKAHASHI M. Pancreaticobiliary ductal system: value of half-Fourier rapid acquisition with relaxation enhancement MR cholangiopancreatography for postoperative evaluation. Radiology 2000;215:81-8.
8. LEE CC, JACK CR Jr, RIEDERER SJ. Use of functional magnetic resonance imaging. Neurosurg Clin North Am 1996;7:665-83.
9. KURHANEWICZ J, VIGNERON DB, HRICAK H, NARAYAN P, CARROLL P, NELSON SJ. Three-dimensional H-1 MR spectroscopic imaging of the *in situ* human prostate with high (0.24-0.7-cm^3) spatial resolution. Radiology, 1996;198:795-805.

10. NELSON SJ, HUHN S, VIGNERON DB, *et al.* Volume MRI and MRSI techniques for the quantitation of treatment response in brain tumors: presentation of a detailed case study. J Magn Reson Imaging 1997;7:1146-52.
11. TEARNEY GJ, BREZINSKI ME, SOUTHERN JF, BOUMA BE, BOPPART SA, FUJIMOTO JG. Optimal biopsy in human gastrointestinal tissue using optical coherence tomography. Am J Gastroenterol 1997;92:1800-4.
12. VARMUS H, WEINBERG RA. Genes and the biology of cancer. New York: Scientific American Library, 1993.
13. WEISSLEDER R, MAHMOOD U. Molecular imaging, Radiology 2001;219:316-33.
14. LANDER ES, *et al.* Initial sequencing and analysis of the human genome. Nature 2001;409:814-23.
15. VENTER JC, *et al.* The sequence of the human genome, Science 2001;291:1304-51.

Sažetak

RADIOLOGIJA U 2OO2. I POSLIJE

H. Hricak

Od Roentgenova otkrića x-zraka prije više od 100 godina, medicinsko oslikavanje doživjelo je golem napredak koji se nastavlja. Slikovni prikaz postao je jedno od važnih uporišta suvremene medicine, prijeko potreban pri dijagnozi, planiranju liječenja i praćenju bolesnika. Napredak u medicinskom oslikavanju potaknut je sve većom snagom računala, napretkom u mikromanipulaciji, komunikacijskoj tehnologiji i, u najnovije vrijeme, utjecajem molekularne biologije. Najviše zadivljuje povećanje snage računala, koje čak prelazi Mooreov zakon prema kojemu se broj transakcija po čipu udvostručuje svakih 18 mjeseci. Činjenici da se cijena konstantne snage računala smanjuje logaritmički možemo zahvaliti za relativnu dostupnost najnovije računalne tehnologije. Napredak u ovom području omogućio je različite slikovne prikaze poprečnih presjeka, PACS i teleradiologiju. PACS je omogućio mnogim vodećim medicinskim centrima u Sjedinjenim Američkim Državama, zapadnoj Europi i Japanu radiološke pretrage bez uporabe filmova. Mnoge druge zemlje su u prijelaznom razdoblju. Teleradiologija nudi mogućnost interpretiranja sofisticiranih supspecijalističkih slikovnih prikaza po cijelome svijetu, a može pomoći i u rješavanju predviđenog manjka radiologa u industrijaliziranim zemljama. Općenito, medicinsko oslikavanje teži sve većoj osjetljivosti i specifičnosti, a sve manjoj invazivnosti i cijeni.