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Digital Angiography

The Physician's Love Affair with the Computer

The dawn of the computer age of electronic information is clearly upon us. Even fearless physicians find themselves increasingly entangled in data bases and electronic worksheets or hounded by pixelization, deconvolution algorithms, and gigabytes. To better understand this process, let us review one particular phase of the application of computers in medicine, *ie*, digital cardiac angiography.

An x-ray picture of the heart can be converted into a computer format that consists of a large series of numbers in the same way that satellite pictures of Saturn are formatted before transmission. The reason for changing photographic images into a computer format is that images, when reduced to a matrix of numbers, can be manipulated for specific advantages. During the experimental development phase of radiologic imaging computers, intense effort was made to make the computers fast, reliable, and capable of providing image quality that was comparable to film-based images. These basic requirements have now been met by the imaging computer industry working in conjunction with academic medical laboratories.

Initial clinical studies with digital imaging explored the possibility that angiograms could be obtained less invasively. These studies demonstrated that computers can enhance iodine contrast about fourfold to permit visualization of aortic, carotid, renal or femoral arteries following intravenous administration of contrast media. For cardiac imaging, digital acquisition can be used to obtain first-pass right and left ventriculograms following intravenous injections. Analysis of these images is relatively easy because the images are already in a computerized format and are readily available for quantitative analysis without the laborious techniques that are required for analyzing film-based images.

Subsequent studies have indicated that a more attractive application of digital angiography is to use the computer-processed images as an adjunct to standard intra-arterial catheterization, thereby allowing images to be obtained with less contrast media. The paper by Mancini et al in this issue of *Chest* (see page 598) corroborates work by other investigators and demonstrates the ease with which complicated quantitative analysis of left ventricular function can be performed from low dose ventriculograms through the use of imaging computers. Such low dose left ventriculograms are clinically important because they make it possible to obtain multiple images of the heart without using an excessive contrast media load. Thus, it becomes feasible at the time of routine cardiac catheterization to perform interventional studies such as atrial pacing in order to assess the functional significance of specific coronary stenoses.

Computerized images also can be manipulated with simple (for a computer) mathematical processes such as mask mode subtraction, edge enhancement, and picture magnification in order to improve coronary artery visualization. For example, there are a variety of analyses that can be used to quantitate the severity of coronary stenoses such as operator or automatic edge detection, and videodensitometry. The latter process assesses the relative volume of contrast media in the narrowed and nonnarrowed coronary segments and has the advantage of being relatively independent of any irregular geometry of the stenosis. Other researchers are attempting to use digital coronary angiograms to assess myocardial perfusion by measuring the density of contrast media throughout the capillary system. An alternate approach uses the computer to look at the relative time of arrival of a contrast bolus in order to determine the functional significance of coronary stenoses.

Another direct application of digital angiography is the ability to obtain aortic root angiograms with relatively low amounts of contrast media. These images are immediately available within the catheterization laboratory (since there is no film to develop) and can be reviewed for the presence of atherosclerotic stenoses of the left main and proximal coronary arteries. Such information may allow coronary angiography to be performed more safely because the greatest risk from this procedure occurs when one cannulates the coronary arteries for selective injection in patients who have disease of the left main coronary artery.

One of the more exciting applications of digital

imaging has been the development of "digital roadmapping" for coronary angioplasty. In this process, the computer's ability to store and recall images is used to superimpose a previously obtained image of the contrast-filled coronary arteries onto the live fluoroscopic image which shows the position of the guidewire and the dilatation catheter. The digital roadmap thus provides a reference to the angiographer which facilitates manipulation of the guidewire into the proper arterial branch and the accurate placement of the dilatation balloon relative to the coronary stenosis.

In response to these experiences with digital cardiac angiography, several cardiac catheterization laboratories are starting to be converted, either partly or completely, to a format where routine clinical studies are acquired digitally. The computer age of radiographic imaging is upon us in 1985. At the present rate of advances in computer technology, there are likely to be clinical applications available within the next decade that are all but inconceivable today.

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Oral Diltiazem and Supraventricular Tachyarrhythmias

The slow inward current, carried predominantly by calcium, is considered responsible for propagation of impulses within the sinus and atrioventricular nodes.[1] Intravenous administration of slow inward current inhibitors such as verapamil or diltiazem are quite efficacious in terminating reentrant tachycardias by suppressing action potentials in the sinoatrial and atrioventricular node or in accessory pathways.[2,3] However, few data are available which determine the pharmacokinetics and electrophysiologic mechanism of action of oral calcium blocker drugs in preventing paroxysmal supraventricular tachyarrhythmias. In this issue (see page 639) Yeh and colleagues describe an interesting model which sheds some light on this problem. Their report contains 16 patients with reentrant supraventricular tachycardias who underwent serial electrophysiologic testing (EPS) at baseline and every hour for eight hours after a third dose of oral diltiazem, 90 mg q8h. At baseline, sustained tachycardia could be induced in each patient. Following therapy with diltiazem, sustained tachycardia could no longer be induced in seven patients, nonsustained tachycardia could be induced in three patients, and no significant change in the tachyarrhythmia was noted in six patients. Diltiazem was found to slow the sinus rate, antegrade AV nodal conduction, and retrograde conduction through accessory pathways for up to eight hours. The retrograde ventriculoatrial conduction effective refractory period was also prolonged, whereas the ventricular effective refractory period was unaltered. In patients in whom the EPS showed a beneficial drug effect, the action was maintained during chronic oral therapy.

The data extend previous observations from the same group which determined that oral diltiazem (90 mg q8h) was effective in preventing reentrant supraventricular tachycardias in 28 of 36 patients.[4] In the earlier series, 13 patients in whom sustained supraventricular tachycardia could not be induced two hours following administration of diltiazem were discharged on drug; none had a recurrence after an average follow-up of five months.

The results from Taipei and other reports using intravenous and oral diltiazem for the treatment of paroxysmal supraventricular tachycardia are encouraging and should stimulate its use in the treatment of reentrant narrow QRS complex tachycardia.[5,6] However, the drug should not be employed routinely in patients with ventricular preexcitation who have suspect or proven paroxysmal atrial fibrillation and in whom an accelerated ventricular response may occur. At the present time, the intravenous form of diltiazem is not commercially available in North America. Oral diltiazem is an effective antianginal drug which is usually well tolerated without significant adverse effects on left ventricular function.[7,8]

The concept of hourly serial EPS studies for eight hours after oral dosing to drug equilibration is intriguing and may lead to a better understanding of the temporal relationship of certain tachyarrhythmias to drug pharmacokinetics. However, empiric drug therapy is often effective for many patients with supraventricular tachyarrhythmias. Additional research is necessary in a larger patient series to document the safety of multiple repeat EPS testing and the necessity of performing hourly measurements to obtain this type of antiarrhythmic drug information.

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