Considerations in the Purchase of a Nuclear Medicine Computer System

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Selection of a nuclear medicine computer system is a process that should be approached with care and forethought. The general scheme should be to define your needs and constraints, determine what is available, investigate the leading candidates, make a site visit, and, finally, submit an order. Through a series of discussions between members of the Computer Council of the Society of Nuclear Medicine and representatives from the manufacturers of computer systems, a set of important considerations emerged, which are reported in this paper. This paper is not intended to be a step-by-step guideline to the purchase of a computer system. Rather, it is a set of concepts and considerations with which the prospective purchaser should be familiar before undertaking such a purchase.

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The practice of nuclear medicine today requires the use of dedicated nuclear medicine computer systems to acquire, display, and analyze data. Such systems are available from a variety of medical equipment manufacturers. While the various systems have many features in common, they can be quite different in their actual hardware and software implementations. The appropriate choice of a nuclear medicine computer system is thus very important, in that it will determine to a large extent the detailed operation of a nuclear medicine department.

About 2 years ago, the SNM Computer Council organized a series of "round table" discussions between representatives of the academic and clinical nuclear medicine community and industry. This document is an outgrowth of these discussions, and represents an effort to aid the purchaser of a nuclear medicine computer system, by presenting a systematic approach to the considerations involved in the selection of a nuclear medicine computer system. In our approach, the selection process is put in the context of the clinical problems to be addressed by the computer. This emphasizes the performance of the computer system as a whole, rather than its hardware or software per se.

We have divided the selection process into four important steps, whose sequence is the following:

1. Define your needs.
2. Define your constraints.
3. Determine what is available.
4. Investigate the leading candidates.

These steps are likely to be iterative, e.g., after determination of what is available, it may be necessary to redefine your needs.

DEFINE YOUR NEEDS

It is always tempting to select a nuclear medicine computer system based on its hardware or software specifications. Indeed, the nuclear medicine commu-

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nity often seems focussed on the hardware of a system, and industry naturally caters to this focus. It is particularly attractive to emphasize hardware specifications because it artificially simplifies the selection process. Unfortunately, "raw" hardware or software specifications are of limited value in truly finding the best system for you, because "best" is ultimately defined in the context of *what* the system does for you, not *how* it does it. It is, therefore, of utmost importance to first carefully define your needs, so that you can choose a nuclear medicine computer system in that context. It is important to consider the computer both as part of an imaging system (with the camera) and by itself. Because so many of today's cameras are digital, and come with an integrated computer, it is tempting to focus most of your attention on the camera. It is important, though difficult, to initially separate your analysis of the camera and computer.

To begin, you should list the number and types of studies you perform which require a computer. This list should include the various acquisition and processing routines which you would like to have available. You should also consider the need for simultaneous acquisition and processing, hard copy, and mass storage. Do you currently have nuclear medicine computer systems with which any new system must be compatible? Must the new computer be hard-wired to existing computers via a network, or is it sufficient to be able to read floppy disks from other systems? How many cameras will be interfaced to the new computer? Do you need programmability?

Your needs can be separated into generic acquisition, processing, analysis, and data storage needs on the one hand, and nuclear medicine application-specific needs on the other. For example, do you require complete flexibility in the generation of image processing protocols, or just the availability of manufacturer-provided clinical applications protocols? Some examples of needs are:

Gated Blood-Pool Studies

You will certainly want to calculate ejection fractions. However, do you need the additional capabilities of regional ejection fraction, phase analysis, or volume determination? Do you study many patients with atrial fibrillation or frequent PVC's? How does the system handle these patients? How many views do you require? Do you need simultaneous cine display of all views? You might sketch out what you would like the display to look like, including text labeling. Can you modify the display to match your requirements?

First-Pass Cardiac Studies

Do you need to measure cardiac output, left-right shunt fractions, or right ventricle ejection fractions? Do you prefer list mode or frame mode acquisition?

Bone Scans

Do you want to display whole-body images? Do you want to use edge sharpening or resolution recovery filters?

SPECT

You should define which organ systems you want to image (e.g., heart, brain, lumbar spine). Do you want simple, predefined reconstruction, or more sophisticated processing capability? Do you need sinogram display, image reorientation, or filter selection? Do you need 'bullseye display' capability for thallium imaging?

Analysis of Time-Activity Curves

Do you want specific protocols for renograms, gastric emptying studies, CSF, shunt function studies, bolus blood flow studies, and so on? Do you need additional analysis capabilities such as curve fitting, Fourier analysis, or factorial analysis?

Advanced Image Processing

Do you need two-dimensional Fourier filtering, image registration, or other advanced processing features?

Programmability

Do you need (and do you have the capability) to create your own programs? This may be quite important in an academic Nuclear Medicine department. Is protocol generation sufficient for your needs?

Non-Image Processing Capabilities

Do you want to be able to do word processing, database management, or statistics on your system? This is a cost-effective approach in a small department, when the system is not heavily used.

Training and Support

How much training do you and your staff require on the new system? Do you need a toll-free support service from the manufacturer?

Documentation

Is the written documentation adequate for your needs? Do you require onscreen 'help' information?

Service

Do you require very fast turn-around time on service calls? Do you need guaranteed up-time?

DEFINE YOUR CONSTRAINTS

Budget

Your budget should include both the purchase price of the system and the cost of maintenance. There are likely to be unanticipated costs that are not apparent during the initial discussion with the salesman. These include shipping charges and tax, as well as additional software and hardware you assumed were part of the system but were not.

A 1-year service contract is usually included in the purchase price. The term may be reduced if the system is heavily discounted; specifically check the final quotation. Software updates may or may not be included. Make sure the vendor distinguishes between software updates required to maintain the error-free performance of the system, and software options which are usually clinical applications packages available at extra cost. Be aware that some software options require hardware options as well. Facilities renovation should also be considered in the context of the total dollar amount available from the administration. A less expensive system that has greater cooling or electrical requirements may not be a long-term bargain. Consider the possibility of buying options, such as a multi-year service contract, 'up front', and including them in the purchase price. In general, you will get the best overall price on hardware and software options at the time of purchase; plan ahead. Finally, consider whether it makes more sense to lease or buy.

Staff Capabilities

If you have a small clinical department with technologists who work in radiology as well as in nuclear medicine, you want a simple straight-forward system. If you are doing research, and have staff capable of using a more sophisticated system, then you will be able to use the more complex systems effectively. Although the manufacturers are trying to make the newer, more powerful systems easy to use, they may still appear quite complex to the novice. Be aware that what we mean by a complex system includes not only the primary processing system, but also all the peripherals (mag tape, optical disks, printers) and the networking and links that connect it all together. This can result in an extraordinarily complex system, especially if different manufacturers are involved. Be careful that you don't buy an excessively complex system, even if budget is no problem.

Physical Limitations

There are many potential physical limitations that must be considered before purchasing a nuclear medicine computer system. If this is not done beforehand, the installation of the system may be delayed, additional expenses may be encountered because of the need to make changes rapidly, and the installation may be suboptimal.

Space. Where are you going to put the system? Is there a separate room for the noisy, heat-producing equipment? Are the doors wide enough and high enough to get the equipment in? You should sketch how the system fits in the selected room. The computer room should be large enough to be comfortable to work in. Consider installing light dimmers. It is also important to consider how the equipment will get into the computer facility. Are there elevators or ramps that are accessible and big enough? This is very important if the computer will be used with a portable camera. Finally, consider the separation between the computer and cameras interfaced to it, the main computer electronics rack and the operator's console, and multiple computers in a network. What sort of cable length must the electronics be able to drive?

Power requirements. What are the limitations on available electric power (voltage, phase, current)? How stable is the supply? Are there noise spikes and small voltage fluctuations? Is there an uninterruptable power supply?

Cooling and ventilation. Computer equipment often requires air conditioning. You should establish how much heat is generated and if cooling is necessary. What are the limits on heat removal for the available air conditioning? Can additional air conditioning be installed if required?

Fire control. Computers do not work well if they are sprayed with water. Is it feasible to replace the fire sprinklers in the computer room with a more appropriate system such as Halon?

Multiple computers. If you have several computers and several scintillation cameras, you may need cable trays in the ceiling. Are cable trays in place? If not, can they be installed? You may also need to network the computers together.

Portability. Do you need a portable computer to go along with a portable camera? Do you want it built into the camera? This may not be important if it is likely to stay in the intensive care unit.

DETERMINE WHAT IS AVAILABLE

When the prospective buyer begins to consider the purchase of a new nuclear medicine computer system, the first questions and thoughts are likely to involve the details about the hardware. This is quite natural, since the main thing you are apparently buying is the hardware. It is easy to forget that the majority of the cost of the system can be ascribed to software. Frequently the way in which this system is sold is "you buy the hardware and we throw in the software for free". The hardware is important, but a computer without software is worthless. You should emphasize total system performance, rather than hardware, in the comparison of systems. If you do otherwise, you may find yourself frustrated by the limitations of your system.

Hardware

Even though software is more important, you still have to be familiar with the hardware options available. The following is an attempt to list the hardware aspects you should know about in trying to choose a computer system.

Central processing unit (CPU). This generally means the microprocessor that does most of the computation.

Newer systems may have several CPU's operating simultaneously, or a co-processor (see below). The CPU per se does not predict the performance or desirability of the system.

Computational power. This is essentially how fast computations are done. It is dependent on the clock speed, word length, the width of the data busses, the particular CPU involved, the amount of memory, the operating system, additional equipment such as co-processors, pipeline processors, or array processors, and, more than anything else, how it is programmed. Given this complexity, it is clear you cannot compare systems by comparing electronic hardware specifications. You should only assess their performance in the context of your specific problems.

Memory. Memory devices include the high speed integrated circuits in the computer, disk drives, and long term storage devices. The exact amount of high speed memory is not very important since it is now quite inexpensive, and it is unlikely that a modern computer will not have enough memory. Systems often differentiate between CPU memory (also called program memory) and video memory (also called image, display, or refresh memory). You should not be concerned with these distinctions unless they prevent you from doing something.

All modern computers contain Winchester disks. These are high speed, sealed disks that hold all the programs as well as patient data. The advantage of larger disks is that they can store more data, but no matter how big they are, they will eventually fill. You should have some idea of how much data you will want to store, at least temporarily, and then be sure you have a disk capable of storing 1 to 2 wk of data. The Winchester disk is not intended for long term storage, and it is rarely necessary to have more temporary storage space.

If you want to keep data longer, use floppy disks (if you want to keep each patient's data separately), magnetic tape, cassettes, or consider a laser (optical) disk which is capable of storing several months or years worth of data on a single disk. It is helpful to have the vendor state disk memory size in number of images rather than megabytes.

Display. The arrangement of the displays varies between systems. Do you prefer one or more screens? Do you want a high resolution display? The advantages of high resolution are: better pictures and/or more pictures on the screen. The disadvantages are: the display may flicker, it is more expensive, and it may not be compatible with standard monitors and VCR's. Do you want color display? It is pretty, and referring physicians are impressed with it. However, do you really need it? There are a few situations in which color is almost essential (phase analysis, 'bull's-eye' display, and factorial analysis).

Screen pointing devices. These include lightpen, joystick, track ball, and mouse. They all work for generation of irregular areas of interest and for pointing to different parts of the screen. You have to see how you like each one.

Formatter. You will probably want to take transparency images of the video output for archiving patient studies, and to send to referring physicians. The formatters vary considerably in their cost, reliability, quality, and versatility. Don't assume the formatter supplied with the system is the only compatible one. Investigate other possibilities. Can you use the one that was installed with your camera? Do you need non-transparent video hard-copy?

Printers. These are useful for printing time-activity curves, profiles, protocol listings, program listings, and possibly for word processing and database output. Unless you will be doing serious word processing (a relatively unusual use of a nuclear medicine computer system), a dot matrix printer should be sufficient. Do you need a color printer?

Compatibility. Interfacing the computer system to other equipment can be a major source of difficulty. Problems usually arise when devices made by different manufacturers are to be connected. Examples include connection to scintillation cameras, SPECT gantries, networks, other computers, VCR recorders, and formatters. Do not assume you can connect any two devices made by different manufacturers.

Software

While hardware is more tangible, the software of a nuclear medicine computer system is its greatest asset. While every vendor can supply you with a (nearly identical) list of the programs available on his system, the system's performance is critically dependent on the careful integration of hardware, software implementation, and the 'user interface' (how you and the computer interact with each other). You must sit down and try each system; written descriptions are completely inadequate.

There are three important areas to assess in the software: general acquisition and processing capabilities, availability and quality of clinical applications packages, and the user interface.

Acquisition software.

1. What matrix sizes and depths are available? Are these more limited in dynamic studies? Does the matrix size include whole-body capability? Generally 64 × 64 byte mode images are adequate for most dynamic studies, although 128 × 128 images might also be used. Static images are usually acquired as 128 × 128 or 256 × 256 in word mode. Whole body images are usually 256 × 512. The major limitation in most systems is the amount of room on the disk drives and in memory. As memory and disk space is rapidly becoming less expensive, these limitations are likely to disappear.

2. How rapidly can data be acquired? This includes

any limitations in count rate capabilities as well as limitations in frame rate.

3. How are energy windows set up? (This applies to computers integrated into a camera.) Are multi-energy acquisitions possible? This means two or three windows combined to form a single image (such as gallium-67 imaging), or acquiring two images at different energies simultaneously (such as simultaneous acquisition of photopeak data and scatter data during SPECT imaging).

4. Can the system display the image in live time during acquisition? This is particularly important during dynamic or gated acquisitions. What if you are also processing another study? Some systems display as many sequential small images as possible simultaneously, others display single large images. It would be optimum if the user had a number of options on the display of images during acquisition. It would also be optimal if partial processing was feasible on the first several images acquired during a study, while acquisition was still proceeding.

5. What special SPECT capabilities does the system have and do you need? This might include noncircular orbits, 180 degree acquisition, dual headed studies, dual energy studies, or gated studies.

6. What sort of predefined acquisition protocols are available? Can you make your own protocols? Can you modify existing ones? How versatile is the acquisition setup? Can you concatenate studies? Can you easily skip studies that have been set up?

7. What capabilities exist for gated blood pool studies? How many frames are in each study? Is there any choice of frame number, matrix size, or bit depth of the images? Are there heart rate limitations? How is bad beat rejection accomplished? Are the last frames normalized properly if some early beats are encountered?

8. Is there list mode data acquisition capability? If so, will you ever use it? What reformatting software is provided and how fast is reformatting?

Display

The display of images is obviously an essential function of any nuclear medicine computer system.

1. What are the capabilities in terms of the number of images, curves, or cines that can be displayed simultaneously? What are the limitations on matrix size, depth, and the location or size of the image on the screen? Is it possible to magnify an image easily?

2. What capabilities exist for varying grey scale? Window controls should be available. How convenient are they? Are the maximum and minimum values for the window displayed? This is necessary to assure similar displays of images to be compared. Are multiple windows available for different parts of the screen? Are non-linear gray scales (such as logarithmic or exponential) available?

3. If the system has color display, what capabilities exist for choosing different color scales. What sort of color scales are predefined. Can you create your own color scale?

4. What sort of annotation is available? Can you place text anywhere you want easily? Do you have to give coordinates or can you use the screen pointing device. Does the annotation character set include arrows or other special characters? Can you move the annotation around easily?

5. At the time of image photography does the system provide proper gamma correction for your type of film? Are gamma correction tables available for other types of film? At the time of photography is it possible to remove the unnecessary text and characters from the screen while leaving the annotation?

6. What cine capabilities exist? How many cines can be shown simultaneously? What sort of cine speed limitations are there? Can you drop frames easily? What sort of synchronization limitations are there, particularly if two studies with different numbers of frames are being shown? Can you lock the display rate to the acquisition heart rate?

Processing

The data processing capabilities of the software are the most important aspect of a nuclear medicine computer system. These capabilities are also the most variable between systems. Many of the systems allow you to set up processing protocols, and contain prepackaged processing protocols to standardize how data are processed and displayed. This aspect is quite important, especially in smaller clinics or departments.

Region of interest definition. This is an essential capability of all nuclear medicine computer systems. Generally, region of interest (ROI) definition is done with the screen pointing device (light pen, joy stick, track ball) for creation of irregular ROIs or locating rectangular, circular, or elliptical ROIs. Some systems have generalized automatic or semiautomatic techniques for edge detection by edge finding algorithms and thresholding. In addition, there are usually specific ROI generation routines optimized for gated bloodpool studies. You should try these features, paying attention to the convenience and speed of these aspects of the system.

Curve generation and manipulation. Once ROIs have been created, you will generally want to determine the counts in the ROIs in a single image or a sequence of images. This should be easily accomplished immediately after the creation of the ROIs. What is the upper limit on the number of ROIs? Once curves have been generated, they should be displayed easily. The count (vertical) and time (horizontal) axes should be adjustable. Curve processing should include smoothing, log or exponential transformation, curve integration, slope determination, and time of maxima and minima. Finally, the curves should be saved in a format that allows printout and access to the curves through user generated programs.

Profiles. Every system has the capacity to generate horizontal and vertical profiles of counts through an image. Additional features that may not be present in all systems are the capability to create profiles of arbitrary width, generate free-form profiles with the screen pointing device, and save the profiles for later display, printing, and access through user generated programs. The locations of the horizontal and vertical profiles should be rapidly movable with clear display of the width of the profile. The profile should be saved in the same format as a curve, and should be capable of being processed with all the curve processing programs. Are there any matrix limitations on profile generation?

Image filtering. This should include the capability of spatial and temporal smoothing, as well as high pass and low pass filtering. It may also include edge enhancement and resolution recovery filtering. The operator should be able to create his own filters, either in the spatial domain by setting matrix coefficients, or in the frequency domain by defining gain as a function of spatial frequency. The user will need to have a reasonable understanding of the processes of convolution and Fourier analysis and filtering in the frequency domain to fully appreciate and appropriately use these features.

The major limitation of some filtering programs is lack of speed. This is particularly apparent if one is doing a simultaneous temporal and spatial smooth on a sequence of dynamic data, with large matrix size. It is important that an array processor, or other specialized hardware, be used to reduce the processing times. Be sure to determine what limitations on matrix size or image bit depth exist for the filtering programs.

Image arithmetic. This should include the capability of adding, subtracting, multiplying and dividing images. It is also desirable to be able to add, subtract, multiply or divide an image by a constant. It should be possible to compress dynamic images into studies with longer time intervals per frame. During dynamic compression, the possibility of data overflow exists, particularly if the original data were collected in byte mode. It is important to see how this problem is dealt with, and how rapidly data compression is done. Are there any matrix size or image bit depth limitations? With both image filtering and image arithmetic it is important to ensure that the routines used preserve the quantitative nature of the data; not all software does.

Miscellaneous. Can the system perform image rotation, image conversion from one matrix format to another, and uniformity correction? The last feature is particularly important with SPECT images, but may be desirable for planar or dynamic imaging with an older scintillation camera.

Registration. A useful feature that is missing on most systems is the ability to shift images in any arbitrary direction, as well as rotate them through any arbitrary angle. This would make it possible to correct for patient motion in SPECT studies or dynamic studies, and to compare two-isotope studies, such as thallium-pertechnetate parathyroid studies.

Quality control software. Does the system allow the acquisition and processing of quality control procedures to evaluate scintillation camera performance? The programs may include the measurement of flood uniformity (integral and differential), energy uniformity, linearity, and spatial resolution. It is important that all quality control programs produce output that can be photographed or printed for long term documentation.

SPECT processing. The software routines that are associated with SPECT reconstruction should include preprocessing, reconstruction, and post processing programs. Preprocessing options should include: spatial and temporal filtering, sinogram generation, image magnification, and artifact removal.

Reconstruction options should include filter selection, reconstruction method (nearest neighbor or interpolated algorithm with or without iteration), advanced reconstruction techniques, and limitation of the reconstruction volume.

Post-processing options should include volume smoothing, magnification, and oblique reorientation.

It is sometimes necessary to preserve quantitative information in SPECT processing. Can the preprocessing, reconstruction, and post processing of SPECT image be done in such a manner as to preserve quantitative relationships? Can filters, reconstruction, and attenuation correction software preserve word mode images?

Specific applications programs. These usually will include the following. Others may also be available.

1. Gated blood-pool studies. All nuclear medicine computer systems should be capable of acquiring and processing gamma camera data for left ventricular function with gated blood-pool imaging. All systems should be able to analyze the data with manual generation of the ROIs. However, the approach each system uses is somewhat different and you may find one much more convenient than another. Many of the systems have automatic or semi-automatic programs for LVEF calculation. If you choose to use these programs, be sure to validate the technique at least against manually drawn ROIs, and be sure to generate some quality control images of the location of the automatic ROIs, since they can occasionally be misplaced.

Most nuclear medicine computer systems have Fourier analysis capability with display of phase and amplitude images, as well as phase histograms. Some also can generate a cine of the wave of contraction spreading across the ventricles. A variety of other capabilities, such as LV volume determination, exist on some systems. The utility of these added features depends on your individual needs.

2. First-pass cardiac studies. These studies are used for the evaluation and quantitation of left to right shunts, right and left ventricular ejection fractions and cardiac output. The computer must have the appropriate acquisition programs to acquire images rapidly, either in frame mode or via list mode. Reformatting programs are needed in both cases to display compressed data with lower time resolution for ROI placement. Such programs should be fast and convenient. The analysis programs should include gamma variate and exponential curve fitting and subtraction for both L–R shunt and cardiac output determination. Generally, ROI placement is done manually for first pass EF determination, but some systems may use automated or semi-automated techniques. These are important if you do many first-pass studies. However, if you buy a system that does not make it relatively easy to do such studies, then you probably will never do them.

3. Renal analysis. A number of aspects of renal function lend themselves to computer analysis. These include measurements of GFR by the Gates method, ERPF by the Schlegel or Tauxe method, and evaluation of transplant function by the Dubovsky and Tauxe method.

Programming

The three different levels of user programming capability in nuclear medicine computer systems are protocol generation, system specific high level language, and general purpose high level language.

Almost all systems have the capability of protocol generation, often merged into the system-specific high level language capabilities. The protocol generation allows the user to define acquisition or processing sequences to ensure standardization of studies and similarity of output images.

The system-specific high level language adds the capability of predefining image and curve arithmetic and, if appropriately versatile, allows the user to create sophisticated data analysis programs. This system-specific language is sometimes referred to as a command line interpreter.

The necessity for a general purpose programming language such as Pascal, FORTRAN, BASIC, C, or FORTH depends on the existence and capability of the specific high level language. Several systems have these languages as features or options available at extra cost. The user obviously must be capable of programming in these languages to realistically use them. Generally, this will not be necessary in a strictly clinical setting, but is more likely to be necessary in a research setting. Questions to ask regarding programmability are: What sort of editor is available? What library functions are available for input/output image arithmetic, filtering, or curve fitting? These might include image addition, multiplication or division, convolution or frequency domain filtering, and linear, power series or exponential curve fitting. Is there access to the array processor and the FFT (Fast Fourier Transform) algorithm? Can you control color scales, grey scale, the printer, and other hardware?

General Considerations

1. How "friendly" is the system? This is a term that is extremely subjective. A system that is "friendly" for one individual can be quite hostile to another. You have to actually use the system for an hour or so to establish if you are (or can become) comfortable with the overall style of the system.

2. Is simultaneous processing and acquisition possible? This is an important option in a busy department. What additional hardware is required? If it is possible, what limitations exist? For instance, can you process a SPECT study while acquiring another SPECT or gated blood pool study? Be certain you know what is meant by simultaneous processing and acquisition, and whether it is less expensively achieved by time sharing a single CPU in a larger system, or networking two separate smaller computers.

In addition to simultaneous processing and acquisition, can more than one user use the system simultaneously? Some systems have this capability.

3. Is the array processor, as well as other additional hardware, fully utilized by the system? Some systems use the array processor only for SPECT reconstruction, but not for filtering or reorientation. This can make a large difference in the time for completion of certain tasks.

4. Does the system have on-line help files? On-line help can be as extensive as having the entire manual available, or can be non-existent. If on-line help exists, try calling for it at various levels in the system, from the main screen when it is first turned on to when you attempt to analyze data.

5. What sort of software tools are supplied? These are programs other than acquisition or processing, such as programs that allow you to edit studies, delete parts of studies, test for space on the disks and compress the data on a disk. These are important tools that help in the operation of a system, and they vary considerably between different systems.

6. How well does the system recover from software crashes? Unfortunately, almost every large software system has bugs in it. These errors usually are not apparent until the operator does something unforeseen by the programmer. Of course this should not happen very frequently, but when it does happen, do you lose data? How long does it take to get back to where you were? It is probable you will get answers to these questions only from another user.

7. What is the software update policy? How often do

software updates become available? What is the past record? How easy is it to load the update? Do you lose all the patient data when you load an update? How much does the update cost? Is it part of a service maintenance contract? What support will you have if the product is discontinued?

8. Has any of the software been validated with appropriate clinical studies? This applies particularly to thallium and gated blood pool analysis programs, but could also apply to first pass analysis and renal function analysis programs.

INVESTIGATE THE LEADING CANDIDATES

Once you have defined your needs and the capabilities of the prospective systems, you should visit sites using the prospective systems and talk to the users. At the site visit, try to arrange to sit at the terminal and process data typical of your needs. This is likely to be the most important part of the evaluation during the site visit, and it is appropriate to spend a few hours to find out if the system is adequate for your needs. You should also get an appraisal of down-time and hardware and software bugs from other users. The salesman should also make a site visit to your department to establish how his proposed computer system will fit into your space.

Installation of a new system will always be disruptive to the department, and will almost always take somewhat longer than promised. You can get some indication about potential installation problems from other nearby users who have had systems installed recently. Installation (and service) difficulties will vary widely from area to area, and are most dependent on the local service personnel. There may be additional problems when each serviceman blames another vendor's equipment for a system failure.

It is likely that initial, and more advanced training later, will be necessary to fully utilize your new system. Does this cost extra? Was it included in the purchase agreement? You will want a full set of operation manuals. How readable are they?

The most important post-installation support is service and maintenance. This is usually supplied via a service agreement that costs approximately 10% of the purchase price of the system per year. The quality of the service support can vary considerably and is most dependent on the local service personnel. Only by asking current users of the same equipment in your area, can you predict how good or bad service will be. Other areas can be very different. What is the response time you require?

Other support should include software and hardware updates, which frequently must be purchased. These may be part of the purchase agreement or part of the service agreement.

Once you begin to use the system regularly, one of the more important support functions you need is the availability of advice by phone. Inquire about the quality and availability of such advice, from both salesmen and other users.

If you get a nonstandard system made up of components made by several different manufacturers, establish who has the responsibility to support the equipment and get it in writing. Otherwise, there will be considerable confusion and delay when a single component fails.

Finally, once a proposal is made and an order is to be placed, be certain the proposal contains everything you want. Do not assume anything, particularly about extra software features.

SUMMARY

The selection of a nuclear medicine computer system is more difficult than ever before. Complex technology, conflicting claims, uncertainties about manufacturer viability, and the knowledge that you must live with your decision for the next five to eight years can make the experience very unpleasant. You must resist the temptation to base your selection on one or two factors, and instead systematically approach the analysis with the considerations discussed above. If you start by defining your needs and constraints, and then investigate the available systems, site visit the two or three leading choices, spend a few hours using your final choice, and carefully read the purchase agreement, your selection, while not perfect, will indeed be best for you.

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