The Role of Nuclear Medicine in Organ Transplantation

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The Seminar will be organized around Nuclear Medicine's role in organ transplantation. The experience of the speakers has been gleaned principally from the transplantation program of the University of Pittsburgh and will naturally cover the experience associated with the organs that are commonly transplanted there: heart, heart-lung bloc, lung, liver, kidney, and marrow. The pancreas and small bowel have been transplanted less frequently in the past, but we currently do not follow these patients with Nuclear Medicine techniques.

In all these operations, Nuclear Medicine plays an important role in assessing directly the function of the organ(s) transplanted. It may play a role in the diagnosis of the basic disease process. In the case of transplantation from a living related donor, the donor may himself be evaluated before and after the surgery.

In almost all transplant situations, the kidney becomes the target organ, involved in part because of "alliances" with other organ syndromes, such as cardio-renal syndromes or hepatorenal syndromes in which renal function may be altered as part of the basic pathologic process necessitating the transplant in the first place, but it is nearly always involved by the anti-rejection regimens.

At the University of Pittsburgh, most of the cadaveric donors die outside its hospital system. Some, however, may die "in-house" and Nuclear Medicine may be called upon to verify brain death.

In assessing Nuclear Medicine's role in the various procedures, one must consider; A. What can go wrong with the various transplanted organs? B. What procedures can Nuclear Medicine employ to elucidate the various problems? C. How can the data gleaned from Nuclear Medicine testing be interpreted? D. How do Nuclear Medicine data correlate with those of other studies? These questions will be discussed at the seminar. Abstracts of the discussions of the individual organs follow.

**BRAIN DEATH ASSESSMENT**

It is generally crucial to obtain fresh tissue for organ transplantation, therefore, the definition of death must be cessation of cerebral function rather than cardiac function. In 1988, the American Bar Association, the American Medical Association, the National Conference of Uniform State Laws, and the President's Commission for the study of ethical problems in medical, bio-medical and behavioral research proposed the following moral statute entitled "The Uniform Determination of Death Act".

1. Irreversible cessation of circulatory and respiratory functions or;

2. Irreversible cessation of all functions of the entire brain, including the brain stem.

This statute was subsequently endorsed by the American Academy of Neurology and the American Electroencephalographic Society.

Since this is only a model statute and not a law, most clinicians insist on confirmatory tests, particularly radionuclide angiography, or four vessel contrast angiography, digital subtraction angiography and contrast enhanced computer tomography. A discussion of our techniques and experience will be presented.

**HEART TRANSPLANTATION**

The transplanted heart is usually studied by Nuclear Medicine techniques on a routine protocol basis—usually on a weekly schedule for a month then on a monthly basis for two months, then on an annual basis.

Two general types of studies are generally carried out—one set of procedures on the heart...
Single lung transplantation has of course many advantages over heart lung transplantations. The operative procedure is less extensive and can often be performed without cardiac bypass. The availability of organs increases: two donor lungs may be used in two different recipients and the heart may be used in a third. Complications from rejection of the heart are also avoided. Although function of the one lung is sufficient for maintaining a good quality of life, completely normal lung function is never achieved. The remaining native lung may serve as an extra reserve, however, should rejection occur in the implanted lung, the possibility of transplanting on the other side can be carried out later. The indication for single lung transplantation, selection of recipients for lung transplantation, selection of donor, choice of which side should be transplanted, etc. will be discussed.

Nuclear Medicine plays a major role in the pretransplant work-up in that it is useful in determining the individual lung flow ratios when the disease is generalized. After transplantation, serial examination of the VQ scan in the diagnosis of rejection has proved to be very important. Usually this is a routine VQ study, but quantitation in the form of right to left ratios of both ventilation and perfusion elements is essential. The Nuclear Medicine procedure will be compared with the plain radiograph and right and left cardiac catheterization data as well as MUGA heart scans.

HEART-LUNG BLOC TRANSPLANTATION

The transplantation of both lungs and the heart is indicated when both systems have failed. Usually this is the result of congenital heart valvular disease. Tetralogy of Fallot, Eisenmenger’s complex for example.

Both cardiac and pulmonary function may be studied by the Nuclear Medicine techniques as described above, but ciliary function in both major bronchi and trachea need also to be studied, since airway disease is a major cause of transplant failure.

We have carried out in all heart-lung bloc transplants a procedure involving the inhalation of aerololized 99mTc-labeled colloid particles, followed by continuous cinematographic imaging over the transplanted structures. As in other Nuclear Medicine studies involving transplantation, the computer plays a major role in the processing of the resultant data. These factors will be illustrated and discussed.

LIVER TRANSPLANTATION

Liver transplantation is now an established form of therapy for irreversible end stage liver disease. In most settings, the Orthotopic liver transplantation technique is used in which the diseased liver is replaced by a new graft. While a variety of radio-nuclides is proving useful, the bone scan before liver transplantation and hepatobiliary imaging in the post operative period are most useful. After transplantation, problems with vascular and biliary anastomoses, rejection and bile leak all produce
characteristic patterns in hepatobiliary images. Often labeled erythrocyte images are needed to detect intra-abdominal hemorrhage. The role of the hepatic perfusion index for rejection will be also discussed. Nuclear Medicine results will be compared with those of CT scan and Ultrasound.

**KIDNEY TRANSPLANTATION**

In the case of transplantation from a living related kidney donor, we routinely employ a combined *in vitro in vivo* study before and after surgery to evaluate the suitability for donation, to decide which kidney to donate and to evaluate the success of surgery. This test complex involves the determination of differential ERPF, an index of radio-pharmaceutical transit time along with quantitative scintigraphic analysis.

After donation in the kidney recipient we employ routinely on protocol an assessment of perfusion of the kidney by use of $^{99m}$Tc-DTPA starting on the first post-operative day, twice weekly for the first week, then weekly for a month. If any difficulties are detected, a program similar to that used for donor evaluation is used.

Since the kidney is the target organ for most organ transplantation problems, e.g., cardio-renal and hepatorenal syndromes, anti-rejection regimens, such as cyclosporine or FK506, we have found the determination of the glomerular filtration fraction to be most helpful. This consists of the quotient of the values of GFR and ERPF obtained from the use of $^{123}$I-iothalamate and $^{131}$I-orthoiodohippurate.

Techniques and interpretations of test results will be explained.

**BONE MARROW TRANSPLANTATION**

Transplantation of the marrow is the most recent procedure to utilize Nuclear Medicine techniques. These are currently being analyzed and evaluated.

Transplantation is generally indicated for replacement of marrow cells after they have been eliminated by chemotherapy irradiation in the treatment of leukemias and lymphomas.

We have found that staging of the disease prior to any therapeutic or destructive measures is of great interest. This may be done after injection of bone scanning agents or radiogallium. In certain diseases radioactive particles are of value, e.g., microaggregated albumin or mini microalbumin.

After transplantation, the patient may be followed by use of gallium, particles, or diphosphonate. It is usually important to assess the reticuloendothelial system by use of particles, or the possibility of recurrence of disease by gallium.

We are in the preliminary stages of assessment of erythropoiesis by use of cyclotron produced $^{55}$Fe and PET imaging.

When cyclosporine is used, it is wise to assess renal function by the glomerular filtration fraction mentioned above. Techniques will be presented with illustrative examples and explanation of results.

腎移植における核医学の臨床的意義

藤野 淡人（北里大学医学部泌尿器科）

本邦で慢性腎不全に対して腎移植が行われるようになったのは 1964 年からであるが、その実施数は年々着実に増加している。約 30 年の歴史を顧みると腎移植の成績は生存率、graft 生存率ともに年を追って向上している。その要因を担うものとして、HLA-DR typing をはじめとする組織適合性検査の進歩、各種免疫抑制剤、特にシクロスポリンの登場があげられる。しかし、腎移植はあくまでも外科的治療であり、急性尿細管障害や拒絶反応以外に様々な術後合併症が生じうる。例えば、無尿期には、その原因検査の手段として、血液化学や尿化学検査成績などは指標となりえず、