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The Use of Positron Emission Topography

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THE USE OF POSITRON EMISSION TOMOGRAPHY

by:
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The American society has watched technology develop and soar to
great heights during the last century, particularly in the last few decades.
The American people, and all humans in highly developed countries, have
not only put their faith in the scientists of the world to continue this growth of
technology at its present rate, but they have also begun to expect scientists to
provide the technology needed to solve any problem. The more that is
provided, the more the public wants. This problem is very obvious in the field
of medicine.

From the field of medical research, many great lifesaving procedures
and techniques have been developed; however, with each new discovery that
is made, the public's expectations rise higher and higher. For this reason
researchers and physicians are usually expected to be able to accomplish
anything. Luckily, our society is growing closer and closer to that ability. As
we develop more advanced research and testing techniques and learn more
about such diseases such as cancer and heart disease, the pieces of the
mysteries are falling together. With the technology we have available today,
we are getting closer to a possible breakthrough; however, most of these
technologies have a few drawbacks, the main one being affordability and as a
consequence of that is the lack of availability to the general public. The
specialty of radiology has been plagued by this problem for quite awhile.

The field of diagnostic radiology was changed quite dramatically
during the 1970s when the computerized axial tomographic scanner (CT)
was introduced to the clinical setting at a price close to $1 million dollars.
Many hospitals rushed to obtain one only to be hurt soon afterwards when
the quality increased and the price decreased as was shown by Lewis (1, p.
20). It was also demonstrated that in the mid 1980s the CT scanner was
again improved by the introduction of "a fast cine CT scanner, a $1.5 million
system that is so advanced it can produce stop-action pictures of the beating heart (1, p. 20)." The CT scanner is but one example of the technological dilemma that hospitals and radiologists have faced in the past few decades. The most recent piece of equipment and technology that has put radiologists in a similar dilemma is positron emission tomography, more commonly known as PET scanning.

PET is a diagnostic radiological imaging technique which can be used to study the living human body in vivo. The procedure involves the injection of a radioactivity labeled isotope followed by the detection of its decay. Because PET utilized compounds which are either present in the body or are used as fuel by the body, it is a very natural and fairly harmless method of study. The isotopes are prepared by the bombardment of certain elements with particles. The three elements most often used are oxygen, nitrogen, and carbon since these are so commonly found in the human body. Another element commonly used is fluorine since it can be utilized by the body. These radioactive isotopes are produced in a cyclotron, an accelerator that propels particles, namely protons and deuterons, into a magnetic field using an alternating electric field as described by Siemens (2, p. 8). Once these isotopes are formed they must be chemically inserted into organic compounds. Many different compounds are produced and can be used; the form utilized depends on the type of PET study that the physician desires to perform. According to Dr. Gary Smith the most common compounds used are water, glucose, and ammonia (3). After the production of an appropriate compound is completed, the injection of it is made into the patient. This entire procedure must be done quite quickly since the isotopes have very short half-lifes, ranging from 2 minutes to a little less than 2 hours as was reported by Ter-Pogossian et al. (4, p. 181) After the injection the scanner
immediately takes over and begins to make its recordings.

When the compound reaches the point of decay, the radioactive element which was incorporated into the studied compound will emit a positron, a positive electron, as reported by Phelps et al. (5, p. 238). Once this positron has been emitted the compound in which it was once incorporated will break-up into stable elements, and the positron will soon collide with an electron and undergo annihilation as shown by Ter-Pogossian et al. (4, p. 174). This distinguished group also reported that upon annihilation two gamma-rays are emitted 180 degrees from one another, each with 511 KeV (4, p. 174). It is these gamma-rays that are recorded by PET's ring of detectors which surrounds the patient. Each gamma-ray hits a detector at approximately the same time. This simultaneous detection is required in order for the computer to record a true annihilation. Once all of the annihilations have been recorded, the computer can integrate them into an image of the area being scanned, whether it be the brain or part of the torso. As Dr. Gary Smith stated, the PET scanner records the radioactive activity in multiple slices through-out the patient; these scans can be viewed both individually or together in an integrated three dimensional image on the computer screen (3). This 3-D image capability makes PET unique. PET thus gives the medical field new ways to study and observe the human body.

The technology of PET has been used to research many aspects of the metabolism of the human body. According to Dr. Gary Smith the three main areas in which this research has been conducted are oncology, neurology, and cardiology (3). These are areas that have in the past been hard to study directly because of the fact that they involve several very sensitive parts of the body; however, since PET is a non-invasive procedure the doors have been opened to study the brain and heart in more detail. PET
is designed to reveal function of the body, not simply form, which is what is revealed with other forms of radiology such as CTs and MRIs. As a consequence physicians can now determine how an organ is performing instead of simply how the organ appears. With the use of PET, many theories about the body have been confirmed and the opportunity to discover the elusive causes of many diseases now exists.

ONCOLOGY

Cancer is a very serious disease that has recently developed and is one of biggest killer in this country. Research has been conducted in this area for many years, and even though many ideas have been found, no true cure has been found. In the recent years more emphasis has been put on the development of treatment for all of the different types of cancer that are so life-threatening. PET is one of the developments that has aided in the treatment of certain aspects of oncology. Two areas of oncology that can benefit from PET are breast cancer and neurological tumors.

Breast cancer is a very serious form of the disease which affects 139,816 women every year and kills 40,534 women each year in the United States alone, and in recent years this disease has begun to kill men also (6, p. 565). Weiss states that breast tumors are separated into two major groups, tumors that contain estrogen receptors in them and ones that do not contain any such receptors (7, p.276). Because those that possess estrogen receptors are treatable by an innocuous drug, it could be determined before surgery if a tumor was receptive to estrogen. Then the woman affected could often be treated without even having to go through any type of surgery at all. Until PET was developed physicians were unable to distinguish between the two
types without doing a biopsy. Once the difference was determined, however, it was of no benefit to the patient, even if she were to later develop another tumor; the occurrence of one type of tumor does not necessarily predict what type the next one might be. However, as Weiss also demonstrated, with the innovation of PET, this problem is solved (7, p. 276). Women who have been diagnosed with a tumor can be injected with an analogue of estrogen which is labeled with a radioactive fluorine-18 isotope. Once the study has been run the tumor can be classified. If the tumor takes up the estrogen the patient is able to be treated with a drug that can block the receptors so that the tumor is no longer enhanced by estrogen. If the scan is negative, then the physician will know not to waste any precious time treating that patient with anti-estrogen therapy, as shown by Weiss (7, p. 276). This is only one example of how PET can be used in oncology. The other major oncological area that is affected by PET is one that carries over into the neurological aspect of medicine, the area of neurological tumors.

NEUROLOGY

Neurology is the scientific study of the brain. In previous studies many different neurological abnormalities have been discovered, ranging from epilepsy and psychiatric disorders up to tumors. One of the most disturbing forms of oncology are those affecting the neurological system. PET is quickly becoming one of the major diagnostic tools for neurological tumors. Oncological masses are not simply masses of tissue different from the cells of a normal human body, they also have a metabolic rate which is radically altered from that of the normal cells. Since this difference is the case PET is an excellent tool for diagnosing and classifying tumors. Although tumors of
the brain can be detected in other ways, such as CT and MRI, no other way is capable of showing the rate of metabolism; this rate of metabolism can be used to diagnose the level of malignancy. A major problem which has recently arisen is the fact that once a tumor has been removed from the brain, scar tissue is left behind. Neurological tests and scans which simply show form and structure, such as CT scans, will always show an abnormal spot in the brain at the area of the scar tissue. Often a patient who has had a tumor previously will develop different neurological problems later, after the tumor has been removed. It was not until the PET scanner was put into use in such cases that the physicians could tell if the problems were arising from the loss of the brain tissue or from recurrent tumor growth. With PET it is very easy to tell if the area is growing again or if it is simply necrotic tissue. From this information the decision can be made as to what type of treatment is necessary.

Another neurological disease that physicians have had some degree of difficulty treating is epilepsy. Epilepsy is a disease which involved attacks of seizures that can often be very violent. These seizures are comparable to an intense electrical storm, except that it is occurring inside of a person's brain and affects his entire body. Many children are plagued by this disturbing disease, and their lives are often threatened by the severe seizures. PET has been credited with saving the lives of many such troubled children. By measuring either the brain metabolism or the cerebral blood flow, it can be determined where the focal point of the epileptic seizures is located. During the seizures the focus has both increased metabolism and blood flow, while they are both decreased between seizures as was shown by Jacobson (8, p. 2705). By performing the PET scan it can often be determined whether it is feasible to surgically remove the affected area. In the most
severe case one hemisphere is removed entirely; however, this type of drastic operation can only be performed on very young children. Since the developing brain of a young child is so plastic due to the large numbers of neurons and synapses present, large portions of the brain may be removed with little or no effect on the child later in life which was shown by Bowers (9, p. 281). The child must learn to speak, walk, and do other basic functions after the operation is completed however; it has been compared to being reborn. Not only is this procedure important because it pinpoints the focus of the seizure, but also because without it one could not even tell the general location of disturbance in the patient's brain. Although CT and MRI are very accurate in pinpointing physical abnormalities such as tumors, both procedures show the epileptic brain as being perfectly normal which was also demonstrated by Bowers (9, p. 280). Now that PET is becoming more available to clinical use, perhaps more epileptic children can be cured and saved a lot of pain and hardship. PET also opens up the doors to researchers to study epilepsy more effectively, and hopefully we will obtain a better understanding of the debilitating disease.

Other neurological diseases which have been difficult to treat and understand are degenerative diseases such as Alzheimer's disease and Huntington's chorea. As Bootzin and Acocella state, "degenerative diseases are those organic brain syndromes characterized by a general deterioration of intellectual, emotional, and motor functioning as a result of progressive pathological change in the brain" (10, p. 408). Both Alzheimer's disease and Huntington's chorea are diseases which can have their onset as early as the age of forty; however, the prevalence rises with age. Both of them have also been diagnosed with the use of PET.

Alzheimer's disease is characterized by the loss of memory and
concentration which leads to the inability to perform complex tasks, such as playing bridge as Bootzin and Acocella have shown (10, p. 408-409). Even though many elderly people are often diagnosed with this affliction, the diagnosis cannot be confirmed until an autopsy has been performed. In order to confirm Alzheimer's disease the autopsy must reveal senile plaques and neurofibrillary tangles. Although physicians can now identify Alzheimer's disease as a cause of death through autopsy, they have never been able to find any visible physical signs of the disease while the patient is still alive. With PET scanning the brain metabolism can be revealed. Because of the degeneration that takes place in the tissue of the brain, the PET scan reveals great degrees of hypometabolism. Since the cause of Alzheimer's disease is not known, it is very likely that PET will become a diagnostic tool which is used often with suspected cases of the diseases in hopes of uncovering the cause or a lead to that cause. Bootzin and Acocella stated that of the different theories that exist of the cause, the biochemical belief is based on the fact that acetylcholine levels are below normal for suspected victims (10, p. 409). In order to test this hypothesis, a PET scan could be performed using an acetylcholine analogue which has been radioactively labeled. Using this process could help to research the possibility of acetylcholine deficits as a possible cause, or it could be determined that it is simply an effect of disease itself. Not only does PET provide a possible method of making a definite diagnosis, but it also provides a pathway to a possible cure for Alzheimer's disease.

Another degenerative disease which can be studied with the technology of PET is Huntington's chorea. "Huntington's chorea is one of the very few neurological disorders definitely known to be transmitted genetically" as stated by Bootzin and Acocella (10, P. 412). The disease is
initially characterized by changes in behavior and emotions, such as developing a slovenly appearance and inconsistent or unpredictable mood swings, and is later characterized by uncontrolable spasms of the limbs as was demonstrated by Bootzin and Acocella (10, p. 412). The area of the brain which is affected by this disease in the basal ganglia, which is composed of the caudate nucleus, putamen, and globus pallidus; this center is responsible for motor systems and posture, accounting for the inability to control voluntary muscles which develops as the disease progresses as was shown by Holman (11, p. 7). PET studies which have been performed on subjects at risk for Huntington's chorea have proved that changes in metabolism often occur before there is any change in cell structure. In one comparison study done by Dr. David Kuhl, who pioneered PET, hypometabolism of the putamen and caudate were noticeable on the PET scans well before any structural changes appeared on the CT scans (12, p. 14).

The comparison study of Huntington's chorea by Dr. David Kuhl demonstrates how PET can reveal metabolic damage (function) before CT will reveal structural damage. The first comparison shows no change in either; however, the PET scans show an abnormality in the second scan while the CT did not (12, p. 14).
As a result of this ability to determine early metabolic abnormalities, physicians and scientists hope to be able to pinpoint the sites which are first involved, and in turn find a way to treat the disease before too much damage is caused. As Bootzin and Acocella state, at this point in time victims of Huntington's chorea will inevitably die (10, p. 412). However, it is hoped that with the use of PET a cure can be found and death will no longer be inevitable.

Not only can PET be used to study neurological problems which develop into a physical abnormality, but also to study behavioral problems, those previously studied and treated by trained psychiatric professionals only. The theory on psychological disorders has always been that they are emotional, or thought oriented, and not physical in any manner. However, in the past decade during PET research some doubt has arisen due to the evidence that PET has shown that certain psychological disorders show a dramatic change in brain metabolism. Two disorders which have shown obvious metabolic trends are schizophrenia and depression.

Schizophrenia affects approximately 1 to 2 percent of the entire population of the United States, and close to fifty percent of all beds in psychiatric hospitals are occupied by schizophrenic patients and shown by Bootzin and Acocella (10, p. 348). "Schizophrenia is the label given to a group of psychoses in which deterioration of functioning is marked by severe distortion of thought, perception and mood, by bizarre behavior and by social withdrawal," and the disorder often includes hallucinations and delusions as was stated by Bootzin and Acocella (10, p. 348). Many psychologists consider schizophrenia as an escape mechanism for people who come to a point where they can no longer cope in their world. It is not
known whether there is a physical problem which causes certain people to simply break under pressure or whether these people are simply weak emotionally. Some studies have shown during autopsies that schizophrenic patients have a higher number of D2 receptors for dopamine than normal humans possess. However, since schizophrenic patients are often given drugs that block dopamine receptors, it is not known if the increase is due to the disease itself or to the receptor blocking drugs. There have been conflicting reports from PET studies as to which cause the increase is attributed. In one study schizophrenics who had been treated with receptor blocking drugs and those who had never been treated with any such drugs both had close to three times as many D2 receptors as normal. In another study which used a slightly different radioligand did not find any increase in those receptors in schizophrenics as reported by Jacobson (8, p. 2708). More studies need to be performed, paying close attention to the statistical and analytical approaches that are used. PET appears to be an excellent tool to use in establishing whether the increase in D2 dopamine receptors occurs before or after the onset of schizophrenia. In studies of metabolic rates in patients who had recently been diagnosed as schizophrenic showed hypometabolism in the frontal cortex, the area in which the D2 receptors are located (12, p. 14). This is a very good indication that there is some abnormality in the normal receptors. In severe cases of schizophrenia, a majority of the brain shows hypometabolism, which leads one to believe that there is some sort of cumulative damage occurring neurologically. If a neurological treatment could be found through the use of PET, then a lot of damage could be prevented. Thus, we would not be faced with the problem of large numbers of incurable schizophrenics being hidden away in a hospital somewhere.
Another psychological disorder which has demonstrated that it involves metabolic rate changes through PET studies is that of depression. Bootzin and Acocella show that depression is a psychological state which is characterized by very intense sadness that usually overcomes its victim gradually over weeks or months; however, certain traumatic episodes can cause one to become depressed overnight. The cycle ends much the same way as it began, gradually. Depression has several characteristic features presented by Bootzin and Acocella: "depressed mood..., loss of pleasure or interest in usual activities..., disturbance of appetite..., sleep disturbance..., psychomotor retardation or agitation..., loss of energy..., feelings of worthlessness and guilt..., difficulties in thinking..., recurrent thoughts of death or suicide" (10, p. 229-231). Most victims of depression do not simply have one occurrence of depression, instead they run in cycles of depression and normal feelings, and at times in cycles of depression and mania, or extreme euphoria. This pattern is very obvious when looking at neurological metabolism. During periods of depression the rates are very low, whereas during times of normal function the rates are comparable to rates of healthy patients. These PET studies seem to point toward biochemistry for control of the disorder. If the depressive patient could be treated in such a way as to keep his neurological metabolism steady then he may not suffer from bouts of depression. This treatment could be monitored and developed through PET research.

PET has certainly found a great use in neurology both in research and clinical settings, and it is my opinion that its uses will continue to grow, especially in the clinical setting. PET is a very useful tool in clinical oncology, which overlaps somewhat with neurology. A third major medically oriented category which has benefited from this technology is
CARDIOLOGY

Cardiology is simply the scientific and medical study of the heart, its processes, and its diseases. This study is one of utmost importance to the citizens of the United States because heart disease is one of the biggest killers of Americans. Since PET can show both cardiovascular blood flow and metabolism it is very useful to cardiologists in diagnosing the type of cardiac problem present in their patients, in determining the degree of damage if any, and in deciding on the most beneficial form of treatment for individual cases. Many people suffer from heart disease, however, each case is different. The main aspect of cardiology in which PET is useful is the diagnosis of blocked coronary arteries.

A heart attack takes place when the blood supply is either reduced or completely cutoff to part of the cardiac muscle. This restriction can occur in several manners. A heart attack can occur when a clot forms in the coronary vessel, thrombus, or even when the clot forms in another region of the body and flows to the coronary artery where it becomes lodged, embolus. It can also occur when the artery becomes clogged by artherosclerosis, the simple clogging of arteries by deposits, as Worth has shown (13, p. 716). Even though these clots and deposits can occur in any of the coronary arteries, the majority of people who suffer a heart attack are affected in the descending left coronary artery. This artery leads to the left ventricle of the heart, the hardest working chamber. Since the left ventricle must pump blood to the extremities of the body, the muscles surrounding it must be quite strong and healthy in order for the body to get the oxygen amounts
that are required. When the blood to this area is restricted in any way, the blood flow is affected. If the problem is not detected the muscle will begin to die, and a heart attack will occur. However, if the blockage is detected before much damage is done the problem can be corrected by one of several methods, and the risk of death is greatly reduced. A few methods of treatment are angioplasty, bypass surgery, thrombolytic therapy, and in some cases, simply a change in diet. Some of these treatments are much more dangerous and difficult than others, and it is not always quite clear which treatments would be beneficial for each patient and which ones would only cause them more harm. PET had become quite useful in making such distinctions.

Since PET is able to detect both metabolism and cardiovascular blood flow it is a very good method to determine whether certain methods of treatment are safe and practical for each individual cardiac patient, or if they would simply do them more harm. In many cases of blocked arteries, the physician cannot tell how much tissue is being damaged or how extensive the damage is, in other words whether or not the tissue is still viable. If the damage is too extensive, then most treatments are not worth performing. Using N-13 labeled ammonia PET can determine how much tissue is actually being affected. Then by following up with a metabolic study, perhaps using F-18 deoxyglucose, the physician can determine whether any of the tissue is still viable or not.
This study presented by Schelbert utilized N-13 ammonia to measure the flow of blood through the heart of a cardiac patient at three levels. Each three studies were paired with a metabolic study using F-18 deoxyglucose. The dots in the ammonia study show the location of the myocardium. Although the blood flow is low, the muscle is still viable (14, p. 126).

This information is very helpful in determining whether such dangerous procedures as bypass surgery would be more beneficial than it would be harmful. If the extent of the damage is great, these expensive and unnecessary procedures can often be avoided, possibly saving the patient's life and certainly saving him or her much money and pain. It is these serious cases that the patient could be monitored through his diet and exercise. Although these methods may seem mild and unhelpful, it is much better than losing the patient altogether.
SOCIETAL ISSUES

Even though the technology of PET has many great uses, there is some controversy over the practicality and true usefulness of PET in a clinical setting. At this point in time, the main problem with PET as a clinical diagnostic tool is the fact that the cost of the system is quite expensive. This high expense also inevitably affects the availability of the technology to all people. The scanners themselves cost between $1.2 and $2.4 million; however, even though that cost is not much more than other radiological devices, it is only less than half of the total expense of setting up a PET system according to Wagner (15, p. 56). As previously stated in order to perform the studies, radioactive isotopes must be available to be injected into the patient. In order to provide these isotopes, the hospital must have access to a cyclotron. These cyclotrons range in costs from $1.4 million up to $2.2 million, and because of the enormous size and weight of the cyclotron most hospitals must do major renovations to their existing facilities, thus increasing the cost of installation by another $1 million as was also reported by Wagner (15, p. 56). Once all the costs are totaled the entire figure is between $4 and $5 million, an amount that most hospitals cannot afford.

When a hospital is considering the installation of such a system they must explore several areas in order to determine if the cost can be justified: demographics, operating costs, competitive costs, and reimbursement. If the area that is served by the hospital has many people who could both benefit from the technology and provide some way of paying for the procedure, then that number could possibly outweigh the cost of operations. It may then be feasible for that hospital to consider installing a system.
However, those conditions are not so easy to meet, and they must also consider possible competition. One of the main problems is the reimbursement aspect of PET. As Wagner states approximately only six states have reported any reimbursement of PET studies by insurers, and Medicare does not cover the procedure in any way (15, p. 56). Because of this lack of money being provided for PET studies, only a few studies are being done for those people who can afford the cost. However the majority of studies being performed are being written off as research.

Not only is society concerned with the expense of PET scanning, but also with the benefits and side effects of the procedure compared to those techniques already available. One of the main benefits of PET is its lack of side effects. PET does use trace amounts of radioactive materials in its process, however, the levels are so low that they are comparable to a normal dose of radiation that humans are exposed to every day. They are also considerably lower than those levels of radiation that a patient is exposed to when a CT scan is performed. In comparing PET with MRI, the main advantage that is noticed is the difference in the length of the study. PET scans average around twenty to twenty-five minutes whereas MRI studies take well over an hour on average. Another major benefit it is PET's non-invasive characteristics. These studies can be performed in vivo without any damage or potential for damage as many other diagnostic method tend to do. The lack of side effect is very important because of the fact that even though it is desirable to find any abnormalities, it is undesirable to risk causing other problems in the process. However, PET is by no means threatening to replace either CT or MRI, in fact it is quite the opposite. PET is meant to enhance those methods already in use. By using PET to determine the function and some other method to determine the structure,
the two can be compared to one another to have a more accurate diagnosis. PET has opened up new territory in radiological diagnosis.

**FUTURE OUTLOOK**

PET has been a slow growing technology since its development in the 1970's, however, in the next few years it is believed that it will grow quite quickly. The United States Department of Energy reported that the number of PET centers in the U.S. in 1976 totaled only 4, however that number had increased to 37 in 1989, and they have estimated that in the next 5 years than number will more than double (16, p. 15). The reason for such high projections is the amount of time and research being spent to develop good quality equipment at a lower cost to the hospitals. Some of the projections for the future made by the Department of Energy are newer and easier ways to produce radioisotopes, smaller and simpler accelerators, generators to provide radioisotopes, and distribution centers to provide several hospitals with isotopes (16, p. 15). CTI, a Knoxville, TN based company which is a division of Siemens, is one of the main companies which provide the PET equipment, including both the scanners and the cyclotrons. According to Leslie Randolph, a CTI spokeswoman, not only has CTI been working on plans to develop several distribution centers to replace the need for individual hospitals to purchase cyclotrons, but they have also been working to develop a new scanner that would cost approximately one-half of what the scanners presently cost (17). CTI was also the first company to develop a cheaper, smaller cyclotron. This cyclotron is self-shielding and can be installed in a normally structured room, 20 by 25 feet. Before the invention of this cyclotron, the instrument had to be provided with special
supports to withstand the enormous weight, an extremely large room to accommodate its size, and thick radiation shielding walls to prevent escape of radioactivity. Thus not only does the new cyclotron save money in its purchase, it also saves money on installation. As this company and others competing with it work to cut the costs, the presence of PET in more hospitals will come about. As more hospitals acquire the use and access to PET, more research will be made, and hopefully more answers will be found.

CONCLUSION

Positron Emission Tomography was pioneered in the early seventies by a handful of prominent physicians. Dr. David Kuhl was one of these great people. Through his hard work much progress has been made, and today it is a rapidly growing diagnostic tool. However, there are still many people, physicians included, who are skeptical of its usefulness and practicality. Dr. Lewis Thomas stated that "health care workers are hamstrung by 'halfway technology' (such as devices and machines) when what is needed is 'fully developed technology' (vaccines and effective drugs)" (1, p. 17). There are many people in the medical field who agree with Thomas' point of view; however, it is not that simple. At this point in our life, we have no quick cure, no "fully developed technology", for such devastating diseases as heart disease, cancer, dementias, and many others. There is a growing belief that no cure exists for such diseases, only preventions and possible treatment through early detection. Radiological tools are excellent methods for the detection and diagnosis of such diseases, and PET is simply adding a new angle to the capabilities of these tools.
PET provides physicians with an in vivo look at the actual function of the human body. As has been shown PET is remarkable in revealing the biochemical reactions which occur in the body in respect to the fields of cardiology, neurology, and oncology. Great steps have already been made, and many more seem to be coming. As PET research continues, many more uses for the technology are discovered. Hopefully, in the future the use of PET scanning will expand to study the entire body instead of concentrating on the brain and the heart. At this point the main drawbacks to PET are the expense and availability.

Even though PET is extremely expensive, and thus not available to many hospitals, it is my belief that in the next few years these costs will begin to diminish due to the fact that all developers of the technology are doing vast amounts of research in creating the equipment at a lower cost. These lower costs would give more people access to PET and would thus increase their sales and profits. However, at this point there is no feasible way to provide this technology to all people and all hospitals; only those hospitals with university and research ties can really afford to take such an expensive step. Even though the advances of PET are great and many, at this point they are not very useful simply because PET cannot be provided for the majority of people who can benefit from it. Hopefully the researchers will be able to develop a method of lowering costs so that this technology can be beneficial to all, for in my opinion, due to the type of information that position emission tomography provides and to the lack of side effects caused, it would be a disgrace to allow this technology to go to waste.
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