Emerging Role of High-Tech Medicine

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INTRODUCTION

In recent years, medical sciences have evolved a great deal, especially in the field of investigative procedures and high-technology diagnostic modalities. More stress these days is on the selection of the correct modality of investigation, rather than on cumbersome clinical tests. This, however, does not belittle the importance of subtle clinical signs. In other words, modern diagnostic procedures and clinical tests go hand in hand; however, high-tech investigations have taken an upper hand in the final appraisal of the patients.

In recent years, modern diagnostic tests have touched new heights. Advanced diagnostic tools provide information on patient’s vital signs as well viz. digital stethoscope, noninvasive blood pressure monitors, electrocardiogram (ECG), etc. This provides higher degree of convenience to the health care providers as well as help in enhancing the health-seeking behavior amongst the communities.

Today, the most advanced medical technology operates on the level of cells and molecules, thus opening unprecedented prospects not only for curing and preventing illness but also for shaping life itself. Thus, high-tech medicine seems to offer more efficient means to remove the restrictions of physical abilities and to improve and “repair” vital processes. It promises to enhance life.

Historically, the early advances in modern medicine like the microscope, the X-rays, applications of bacteriology and improved surgical techniques were applied to fight death and morbid diseases—tuberculosis, smallpox and cancer, for example. The practical mission of medicine was to expel lethal and severely impairing diseases and to build a wall of medical knowledge and care to protect the vital processes of individuals, populations and society. Modern medicine was epitomized by the late 19th and the early 20th century measures to root out contagious diseases, (tuberculosis in particular) for mass screenings, vaccination programs, campaigns for improvement of general hygiene and sanatoria. Public health was the focus of such medicine, and bacteriology was its scientific spearhead, in which the breakthrough of pharmacology was also embedded. By the bedside, the progress was most notable in surgery and cancer treatment.

The above rationale characterizes well even today’s medicine. However, a new aspect of medical knowledge and care has emerged, and it is prominent especially in the areas that are in the cornerstone of medical research and the development of diagnostic and treatment techniques. Today, the focus of advancing medical technology is on the protection of vital processes than on life enhancement.

Today, high-tech medicine is a global industry. The rise of molecular medicine has given an upswing for the commercial side of medicine, especially by intermingling medical science and business more deeply than ever before.

LIMITATIONS OF CLINICAL MEDICINE

Although there is no substitute to a good clinical history and a thorough clinical examination, the same are often inconclusive, and at times may be far from the actual diagnosis as well. These are the situations where investigations play a pivotal role.

The arrival of high-tech medicine, in medical practice however distorts the professional approach to a clinical problem. This leads to irrational and unnecessary high-tech investigation of the patient. For example, the CT scan heralded as the greatest discovery after X-ray by Roentgen in 1895 and it is the only way to look at the brain substance. It helps in the diagnosis of infarctions, tumors and other masses in the brain and abdomen. However, many a time the CT/MRI scans are used inappropriately, i.e. ordering CT scan in all cases of dementia, headache and metabolic encephalopathies. The inappropriate investigations ordered, may be due to practice of defensive medicine, patients’ demand, specialists’ ego and sometimes due to lack of knowledge.

However, in this era of consumerism, where every patient is a consumer and every doctor is looked upon as a mere health care provider, the cautious use of newer modalities can impart both good health care and satisfy the patient as well.

In a study recently published by Juan Sanchis et al. it has been shown that the role of clinical history in patients with acute chest pain, electrocardiogram, (which is nondiagnostic) and with normal troponin has widespread limitations.

Same is the case in evaluation of patients with severe anemia, where the role of laboratory investigations is so promising, that the course of treatment cannot be decided based on clinical examination and history alone.

We mention here, one of our own cases that presented to us with history of dyspnea on exertion and palpitations. Transthoracic echocardiography was suggestive of a congenital pulmonary stenosis. Patient was advised surgery which the patient deferred. The transesophageal echocardiography (TEE) was not done due to financial constraints. A few weeks later, the patient presented with ischemic stroke, with infarction in the right basal ganglia. This could not be explained by his earlier echo report showing a pure left-sided lesion. A transesophageal echocardiography was then conducted which revealed a small atrial septal defect. This explained the occurrence of embolic stroke in this patient and could have been prevented if TEE was done earlier.

HIGH-TECH PROCEDURES

Positron Emission Tomography

Positron emission tomography (PET) is a nuclear medicine imaging technique that produces a three-dimensional image or picture of...
functional processes in the body (Figures 1A to C). The system detects pairs of gamma rays emitted indirectly by a positron-emitting radionuclide (tracer), which is introduced into the body on a biologically active molecule. Three-dimensional images of tracer concentration within the body are then constructed by computer analysis. In modern scanners, three-dimensional imaging is often accomplished with the aid of a CT X-ray scan performed on the patient during the same session, in the same machine.

The PET/CT scanner, attributed to Dr David Townsend and Dr Nutt, was named by TIME Magazine as the medical invention of the year in 2000.

Positron emission tomography is both a medical and research tool. It is used heavily in clinical oncology (medical imaging of tumors and the search for metastases), and for clinical diagnosis of certain diffuse brain diseases such as those causing various types of dementias. PET is also an important research tool to map normal human brain and heart function.

**Single-photon Emission Computed Tomography**

Single-photon emission computed tomography (SPECT), or less commonly, SPET is a nuclear medicine tomographic imaging technique using gamma rays. It is very similar to conventional nuclear medicine planar imaging using a gamma camera. However, it is able to provide true 3D information. This information is typically presented as cross-sectional slices through the patient, but can be freely reformatted or manipulated as required.

Because SPECT permits accurate localization in 3D space, it can be used to provide information about localized function in internal organs, such as functional cardiac or brain imaging (Myocardial perfusion imaging, functional brain imaging, etc.).

**Infrared Thermography**

Infrared thermography (IRT), thermal imaging and thermal video are examples of infrared imaging science. Thermal imaging cameras detect radiation in the infrared range of the electromagnetic spectrum (roughly 9,000–14,000 nanometers or 9–14 µm) and produce images of that radiation, called thermograms. Since infrared radiation is emitted by all objects above absolute zero according to the black body radiation law, thermography makes it possible to see one’s environment with or without visible illumination. The amount of radiation emitted by an object increases with temperature; therefore, thermography allows one to see variations in temperature. When viewed through a thermal imaging camera, warm objects stand out well against cooler backgrounds; humans and other warm-blooded animals become easily visible against the environment, day or night (Figures 2A and B).

**Magnetoencephalography**

Magnetoencephalography (MEG) is a technique for mapping brain activity by recording magnetic fields produced by electrical currents occurring naturally in the brain, using very sensitive magnetometers (Figure 3). Arrays of superconducting quantum interference devices (SQUIDs) are currently the most common magnetometer, and spin-exchange relaxation free (SERF) being investigated for future machines. Applications of MEG include basic research into perceptual and cognitive brain processes, localizing regions affected by pathology before surgical removal, determining the function of various parts of the brain and neurofeedback.

Recent studies have reported successful classification of patients with multiple sclerosis, Alzheimer’s disease, schizophrenia, Sjögren’s syndrome, chronic alcoholism and facial pain. MEG can be used to distinguish these patients from healthy control subjects, suggesting a future role of MEG in diagnostics.
Nuclear Medicine

Nuclear medicine is a medical specialty involving the application of radioactive substances in the diagnosis and treatment of disease. In nuclear medicine procedures, radionuclides are combined with other elements to form chemical compounds, or else combined with existing pharmaceutical compounds, to form radiopharmaceuticals. These radiopharmaceuticals, once administered to the patient, can localize to specific organs or cellular receptors. In some diseases, nuclear medicine studies can identify medical problems at an earlier stage than other diagnostic tests. Therefore, a disease can be detected well before the advent of clinical symptoms or even before it is picked up by other conventional diagnostic modalities.1

In the future, nuclear medicine may provide added impetus to the field known as molecular medicine. This will improve the understanding of biological processes in the cells of living organisms. Specific probes can be developed to allow visualization, characterization, and quantification of biologic processes at the cellular and subcellular levels.1,4

Genetic Medicine

Advances in genetics, genomics and proteomics are leading to progress in identifying and treating disease, developing treatment and improving health. Use of genetic testing and molecular diagnostics is rapidly expanding in clinical practice, creating a new, personalized approach to medicine.

Genetic testing analyses an individual’s or an organism’s genetic material, including around 23,000 protein-coding genes and biomarkers. It often uses molecular diagnostic techniques and is available for an estimated 2,500 conditions, both rare and common. Recent estimates suggest that there are 1,000–1,300 genetic tests available. New tests are regularly emerging. Increasingly, information from genetic and molecular screening and testing is helping patients and their doctors to:

- Identify a person with a predisposition for a particular disease
- Detect whether a person has a disease, often at earlier stages of the illness
- Identify the effectiveness of a particular drug therapy for an individual.

The CARTO System

CARTO is a brand-name for the medical system produced by Biosense-Webster, a subsidiary of Johnson and Johnson.

The CARTO XP EP navigation system is designed to visualize the real-time calculated position and orientation of a specialized RF ablation catheter within the patient’s heart. The goal of this technology is to minimize radiation exposure during fluoroscopy, increase the accuracy of targeted RF ablation and reacquisition of pacing sites for reablation.

The CARTO navigation system calculates the position and orientation of the catheter tip, using three-known magnetic sources as references.5

Transcatheter Aortic-Valve Replacement

For decades, inoperable critical aortic stenosis has been considered untreatable. A randomized, controlled trial, conducted by the partner investigators (Placement of Aortic Transcatheter Valves) has generated excitement. In this trial, transcatheter aortic-valve implantation has been compared with medical therapy.

In percutaneous aortic valve replacement or transcatheter aortic valve implantation (TAVI), a replacement valve is delivered via a catheter using one of the several access methods: transfemoral (in the upper leg), transapical (through the wall of the heart), subclavian...
(beneath the collar bone) and direct aortic (through a minimally invasive surgical incision into the aorta).

In high-risk patients with severe aortic stenosis, transcatheter and surgical procedures for aortic-valve replacement had similar rates of survival at 1 year, although there were important differences in risks associated with the procedure.6-8

**Monoclonal Antibodies**

Monoclonal antibodies (mAb or moAb) are monospecific antibodies are produced by identical immune cells that are all clones of a unique parent cell, in contrast to polyclonal antibodies which are made from several different immune cells.

Production of monoclonal antibodies involving human-mouse hybrid cells was described by Jerrold Schwaber in 197310,11 and remains widely cited among those using human-derived hybridomas.

The key idea was to use a line of myeloma cells that had lost their ability to secrete antibodies, come up with a technique to fuse these cells with healthy antibody-producing B-cells, and be able to select from the successfully fused cells.

**Applications**

**Diagnostic tests:** The western-blot test and immunodot blot tests detect the protein on a membrane. They are also very useful in immunohistochemistry, which detects antigen in fixed tissue sections and in immunofluorescence tests, which detect the substance in a frozen tissue section or in live cells.

**Cancer treatment:** One possible treatment for cancer involves administering monoclonal antibodies that bind only to cancer cell-specific antigens and induce an immunological response against the target cancer cell. Such mAb could also be modified for delivery of toxin, radioisotope, cytokine or other active conjugate. MAb approved by the food and drug administration (FDA) include the following:12

- Bevacizumab
- Cetuximab
- Panitumumab
- Trastuzumab.

**Autoimmune diseases:** Monoclonal antibodies used for autoimmune diseases include infliximab and adalimumab, which are effective in rheumatoid arthritis, Crohn’s disease and ulcerative colitis by their abilities to bind to and inhibit tumor necrosis factor. Basiliximab and daclizumab inhibit IL-2 on activated T cells and thereby help to prevent acute rejection of kidney transplants. Omalizumab inhibits human immunoglobulin E (IgE) and is useful in moderate-to-severe allergic asthma.

**Role of Stem Cells in Modern Medicine**

Stem cell treatment is a type of intervention strategy that introduces new adult stem cells into damaged tissue in order to treat disease or injury. Many medical researchers believe that stem cell treatment has the potential to change the face of human disease and alleviate suffering.13 The ability of stem cells to self-renew and give rise to subsequent generations with variable degrees of differentiation capacities,14 offers significant potential for generation of tissues that can potentially replace diseased and damaged areas in the body, with minimal risk of rejection and side effects.

Medical researchers anticipate that adult and embryonic stem cells will soon be able to treat cancer, Type 1 diabetes mellitus, Parkinson’s disease, Huntington’s disease, Celiac Disease, cardiac failure, muscle damage, neurological disorders and many others.15,16

During chemotherapy, most growing cells are killed by the cytotoxic agents. These agents, however, cannot discriminate between the leukemia or neoplastic cells, and the hematopoietic stem cells within the bone marrow. It is this side effect of conventional chemotherapy strategies that the stem cell transplant attempts to reverse; a donor’s healthy bone marrow reintroduces functional stem cells to replace the cells lost in the host’s body during treatment.

**Super Accelerated Neuron Regulation Technique**

The most recent and hi-tech technique is called super accelerated neuron regulation (SANR) technique. All opiate addicts can be treated with this technique. In this technique, dead addiction/detoxification is done in just 4–5 hours and it is absolutely painless. In this technique, the brain cells are washed and normalized with special medicines so that within 4–5 hours complete neuroregulation takes place and the drug present in the body is completely washed out. SANR technique requires admission for 1 day. Fasting for 24 hours is required. Patient can take soft drinks and water during this fasting period. Detailed medical investigations are carried out and medical fitness is given by one/two physicians. Once the patient is medically fit, SANR process starts next morning and is complete within 4–5 hours. The patient is kept in the hospital overnight and the next morning he is discharged in fit state and can resume his routine activities. No treatment is given after this, except for one tablet of naltrexone a day so that there are absolutely no chances of relapse. Hypnotics can be prescribed for a few days.

**Reproductive Medicine**

Reproductive medicine is a branch of medicine that deals with prevention, diagnosis and management of reproductive problems; goals include improving or maintaining reproductive health and allowing people to have children at a time of their choice. It is founded on the knowledge of reproductive anatomy, physiology, and endocrinology, and incorporates relevant aspects of molecular biology, biochemistry and pathology.

The field cooperates with and overlaps mainly with reproductive endocrinology and infertility, sexual medicine and andrology, but to some degree with gynecology, obstetrics, urology, genitourinary medicine, medical endocrinology, pediatric endocrinology, genetics, and psychiatry.

In the assessment of patients with imaging techniques, laboratory methods and reproductive surgery may be needed. Treatment methods include counseling, pharmacology (e.g. fertility regulation), surgery and other methods.

In vitro fertilization has evolved as a major treatment modality that has enabled the study of the embryo prior to implantation.

Surrogacy, cloning and recent advances in techniques of fertilization have brought new hope in the lives of infertile couples.

**CONCLUSION**

Thus we see that a variety of newer investigations have come up and a lot more are being developed. Many of these are still in the experimental stage and yet not easily available to the patients. They also require high skills for operating them and expertise in deciphering them. Nevertheless, the importance of clinical methods cannot be overlooked. The high-tech medical investigations need to be used judiciously and as adjuncts, not substitutes to clinical methods. But in the modern era, clinical medicine appears handicapped without the use of these high-tech procedures.

Science has been progressing every second. What was disbelieved yesterday, is a reality today. Various, earlier modalities, considered rather essential at that time, are now obsolete, having been replaced by newer procedures. Many new techniques have been accepted and others are in the queue of acceptance. But, we do not have to be biased and judgmental. All modalities have to be used judiciously and in concert with clinical judgment. This will be better both for our patients as well as in strengthening our own clinical acumen.
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