

Pediatrics in 21st Century and Beyond

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Abstract Pediatrics is a dynamic discipline and there is awareness and hope for actualizing outstanding achievements in the field of child health in 21st century and beyond. Improved lifestyle and quality of children's health is likely to reduce the burden of adult diseases and enhance longevity because seeds of most adult diseases are sown in childhood. Identification and decoding of human genome is expected to revolutionize the practice of pediatrics. The day is not far off when a patient will walk into doctor's chamber with an electronic or digital health history on a CD or palmtop and a decoded genomic constitution. There will be reduced burden of genetic diseases because of selective abortions of "defective" fetuses and replacement of "bad" genes with "good" ones by genetic engineering. Availability of totipotent stem cells and developments in transplant technology are likely to revolutionize the management of a variety of hematologic cancers and life-threatening genetic disorders. The possibility of producing flawless designer babies by advances in assisted reproductive technologies (ARTs) is likely to be mired by several ethical and legal issues.

The availability of newer vaccines by recombinant technology for emerging infective and for non-infective lifestyle diseases is likely to improve survival and quality of life. There is going to be a greater focus on the "patient" having the disease rather than "disease" per se by practicing holistic pediatrics by effective utilization of alternative or complementary strategies for health care. Due to advances in technology, pediatrics may get further dehumanized. A true healer cannot simply rely on technology; there must be a spiritual bond between the patient

and the physician by exploiting the concept of psycho-neuro-immunology and body-mind interactions. In the years to come, physicians are likely to play "god" but medicine can't achieve immortality because anything born must die in accordance with nature's recycling blueprint. The medical science is likely to improve longevity but our goal should be to improve the quality of life.

Keywords Human genome · Revolution in medical genetics · Stem cell banking · Surgical wonders · Vaccines for non-infective disorders · Holistic pediatrics

Introduction

In order to improve human resource, children deserve high quality of healthcare at all social and ethnic levels without any discrimination [1]. The futuristic model of pediatrics is likely to be greatly modified by technology boom with further erosion of doctor-parent/patient relationship [2]. The day is not far off when a patient walks in the doctor's chamber with an electronic or digital health history on a CD or palmtop. He may be asked to walk through a screening device to decipher his genome and get baseline biochemical parameters. The child is likely to get a computer-based diagnosis with the help of apps-based algorithms and given a print out of the prescription.

Human Genome

Every disease and human behavior is genetically determined by human genome and epigenetics. The life events are predestined on the basis of genome, which is like a sophisticated horoscope or *Janampatri* or "subtle language of God".

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Identification and decoding of human genome is the greatest achievement of 21st century [3, 4]. Human genome project (1984–2003) has identified and sequenced 25,000 genes. Around 3 billion DNA base pairs have been decoded by DNA probes. The scientists have identified 1800 diseases, which are expressed through genes. On the basis of genome, we can plan personalized strategies for prevention, diagnosis and treatment of diseases with patient-specific or tailor-made drugs. Human genome has highlighted one of the mysteries that 90 % of human DNA carries no instructions. Nature can't be wasteful, it is unlikely to be "junk DNA", and it seems to be the storehouse of untapped human mysteries and potential.

Revolution in Medical Genetics

It is possible to diagnose a large number of life-threatening or disabling genetic, chromosomal and developmental diseases in the fetus and offer "selective abortions" to ensure survival of "genetically normal" human beings [5]. It is likely to reduce the burden of disability so that resources are effectively utilized for improving quality of human life. When a genetically abnormal individual is born, it will be possible to replace "bad" genes by "good" genes tagged to carrier viruses by state-of-the-art genetic engineering technology [6]. The technology is already being used for correction of genetic abnormalities in children suffering from severe combined immunodeficiency syndrome (SCID) due to adenosine deaminase deficiency (ADA), Duchenne muscular dystrophy (DMD), cystic fibrosis, hemophilia, familial hypercholesterolemia and some cancers.

Advances in genetic technologies have led to refinements of various assisted reproductive techniques (ARTs) and feasibility to produce "designer babies". It is possible to produce clones of babies with identical genetic makeup by artificial twinning of an embryo or by a more complex technique of somatic cell nuclear transfer (SCNT). The classical example of SCNT is the production of Dolly, the sheep, by Scottish scientists. Dolly was the exact replica of the "mother sheep" whose DNA material of a somatic cell was transferred into the enucleated egg cell of another sheep in-vitro. The embryo was implanted into a surrogate mother and carried to term [7, 8]. However, the newer ARTs have raised several ethical and legal issues.

Stem Cell Banking and Transplantation

Hematopoietic stem cell transplantation (HSCT) by using multipotent hematopoietic stem cells derived from bone marrow, peripheral blood or umbilical cord blood shall be increasingly exploited for treatment of hematologic cancers, non-malignant diseases like thalassemia, aplastic anemia, inborn

errors of metabolism and autoimmune disorders [9, 10]. The source of stem cells may be autologous (stored patient's own blood) or allogeneic, when stem cells are obtained from a compatible donor. In allogeneic stem cell therapy, risk of infection, mismatching, rejection and graft-versus-host disease (GVHD) is much higher. Cord blood is a rich source of stem cells. A number of companies such as Lifecell, Babycell, Cordlife, and Stemade provide services for collection and cryopreservation of cord blood, which can be used for treatment of a number of life-threatening and lifestyle diseases in the donor, siblings and parents in later life. It is possible to repair a defective organ of the body by infusing totipotent natural or cloned stem cells [11].

Diagnostic Marvels

There will be increasing use of technology to assess, monitor and manage patients, with further depersonalization of pediatrics. The communication skills or bedside manners shall be increasingly replaced by technical interventions. The patients are likely to be increasingly fragmented into systems, organs, tissues, cells and DNA. The age old symbol of physicians, the stethoscope, is likely to be replaced by digital stethoscope powered by iPhone or Android smart phone, hand-held ultrasound device, pulse oximeter and apps-based algorithms for making a diagnosis in the ambulatory clinic. DNA and rRNA probes are likely to be increasingly used for diagnosis of infective and genetic disorders [12, 13]. It is envisaged that in due course of time, just a drop of blood will be enough to obtain values of most of the biochemical parameters. Electronic devices in the form of a smart biometric "wrist watch" are in the pipeline to monitor vital signs, some biochemical parameters, hydration status and oxygen concentration. It is based on non-invasive pulse wave data collector using a modified applanation tonometry technique for recording real-time radial artery pulse waves. It can be used as a stand-alone device or paired with your iPhone or Android smart phone [14, 15]. The work is in progress to develop sensors for assessing kidney functions and add-on displays for EKG and EEG. Intelligent scales or cutting-edge wireless smart scales are being developed to monitor body weight, body mass index (BMI), body water, bone mass, and daily caloric intake. Japan is in the forefront to develop smart loos or intelligent toilets to maintain effective bottom hygiene, assess certain body parameters and analyze body wastes.

It is hoped that in the near future "Genometers" will be available to delineate the genomic characteristics of a person to predict personality and vulnerability to various diseases during the life span of a person, akin to an Indian horoscope. Raman spectroscopy is a quick, easy and non-invasive tool that can identify a large number of objects by virtue of their molecular size and DNA characteristics. Almost every

material has its own Raman pattern, based on how strongly its atoms are bonded [16]. Hand-held Raman scanners are available which can be used for identification of drugs of abuse and explosives, diagnosis of cancer, identification of pathogens and allergens and estimation of blood components.

Nutritional Nuances

Three pillars, which are crucial for maintenance of sound health and good quality of life, include sound genetic constitution, safe environment, and intake of wholesome balanced food. Food is indeed the breakthrough drug of the 21st century! Almost 2500 y ago, Hippocrates said, “*Let thy food be thy medicine and thy medicine be thy food*”. There is a popular Indian saying, “When diet is wrong, medicine is of no use. When diet is correct, there is no need for any medicine”. In order to tackle the widespread deficiencies of iodine, iron, zinc and vitamin A, food fortification or use of nutritional sprinklers are likely to become a reality in selected populations. Protein hydro lysates and hypoallergenic foods shall be available for prevention and treatment of food allergies, which are emerging as public health problems in certain populations. The concept of functional foods is being increasingly exploited to prevent illness, promote health and improve quality of life. These foods have potentially positive effects on health beyond nutrition [17]. They promote positive health and reduce the risk of diseases by virtue of phytonutrients, antioxidants, soluble and insoluble fiber, and probiotics [18].

Genetically modified (GM) foods are genetically engineered to produce changes in their DNA for selective and mutation breeding. They are produced for better yield, resistance to pathogens and herbicides and for better nutrient profiles [19]. Most food modifications have primarily focused on cash crops like golden rice, BT cotton, and vegetable oils. But technology is not without travails. The safety of GM foods is controversial because their intake may be associated with greater risk of allergies, immune suppression, elaboration of toxins, emergence of antibiotic resistant super bugs and nutritional problems. The nutritional content of animal foods like milk, eggs, and meat can be improved by feeding the animal a diet rich in omega-3 fatty acids and docosahexaenoic acid (DHA) [20].

Vaccines have accomplished near miracles in the fight against infections with virtual eradication of smallpox and polio from the world. However, the increasing number of vaccine shots is painful and frightening both to the children and their parents. A needleless pen-shaped device has been developed to deliver drugs and vaccines through painless supersonic waves. Oral and mucosal vaccines are being developed against rotavirus, typhoid, flu, cholera, RSV, and measles. Genes from bacteria and viruses are being inserted into the genetic makeup of fruits, vegetables and cereal grains to

produce edible vaccines that are not destroyed by cooking or frying the food [21]. There is hope that in the near future, antigen-primed or transgenic bananas, potatoes, tomatoes, lettuce, rice, wheat, soybeans and corn, shall be available as child-friendly vaccines [22, 23].

Therapeutic Advances

Each human being is unique by virtue of its DNA. But in the modern system of medicine we prescribe the same medicine, in the same dose, through the same route and for the same duration for every patient, which is obviously too simplistic and naïve. X-ray crystallography can identify the atomic and molecular structure of a crystal and is being harnessed to discover and design new tailor-made or personalized drug molecules. Pharmacogenomics is being used to produce specific drugs on the basis of genomic subgroups [24]. It is possible to deliver the drug to the site of disease with the help of liposomes and carrier monoclonal antibodies. It is associated with decreased dosing, better efficacy, and reduced risk of adverse drug reactions. A number of natural biological response modifiers (BRMs) have been identified and are being exploited to control severe infections and certain malignant disorders [25]. They include interferons, interleukins, tumor necrosis factor (TNF), colony stimulating factors (CSF, G-CSF, GM-CSF), cytokines, imiquimod, and monoclonal antibodies.

Milstein and his co-workers have combined two types of immune cells to create hybrid clones of immune cells or hybridoma in order to produce specific antibodies for a wide range of targets [26]. The availability of monoclonal antibodies has ignited the hope for prevention and treatment of life-threatening infections, for transport and delivery of drugs to the site of disease, destruction of cancer cells and identification of metastases with the help of radionuclide antibodies [27].

Efforts are being made to implant memory biochips, arrays of Nano-polymer wires and develop other neurobionic interventions to take over the functions of damaged neurons. It has been shown that electrical stimulation of tongue with the help of a portable neuromodulator stimulator (PoNS) can facilitate the repair of damaged neurons. The Chinese workers have produced progenitor cells from urine waste cells, which are useful for regeneration of neurons. It is feasible to produce cyborgs with superhuman capabilities like an IQ of a genius, eyesight of an eagle and hearing of a bat.

A large number of lasers are available for photodynamic and cosmetic dermatology for treatment of various disorders of pigmentation and birthmarks. They include carbon dioxide laser, Q-switched lasers (Ruby, Nd:YAG, and Alexandrite), Argon laser, pulse-dye and metal vapor lasers [28, 29]. Attempts are being made to produce artificial blood or blood substitute which is either hemoglobin-based or per

fluorocarbon-based oxygen carriers [30]. They are likely to serve the felt need of chronic shortage of blood and eliminate the risk of transmission of blood-borne diseases, immune suppression and other adverse effects of blood transfusion. The research workers at the Massachusetts Institute of Technology (MIT), Cambridge, United States have identified double-stranded RNA activated caspase oligomerisers (DRACO), which are credited with effective antiviral activity [31]. They can serve as broad spectral antiviral agents for a variety of viral illnesses like dengue, flaviviruses, arenaviruses, H1N1 influenza and rhinoviruses.

Surgical Wonders

Imaging-guided interventions and keyhole or minimally invasive surgical procedures with fast recovery and minimal scarring have already become a reality [32]. It is possible to replace each and every defective body organ by biological (human or animals like baboons and pigs) or synthetic spare parts like hearing aids, cochlear transplants, lenses, dentures, pace makers, heart valves, silicon implants, artificial joints and limbs. Computer-aided surgical robots are being increasingly exploited to conduct routine and complex surgical procedures at a local site or a distant location. The robotic surgery is associated with advantages of smaller incision, greater precision, miniaturization, reduced blood loss, less pain and shorter duration of hospital stay. Intelligent surgical knife (iKnife) has been developed for bloodless incision and the vaporized smoke produced while cutting the tissues is analyzed by a mass spectrometer to diagnose malignancy real-time. A large number of electronically guided equipment like lasers, fiber optics, drills and staplers are being used to conduct surgical procedures more effectively and with greater safety. Smart e-pants or electric underpants are available to prevent occurrence of bedsores in chronic and comatose patients.

Tele-Pediatrics

Tele- or distant medicine has become a reality and Canadian workers have made outstanding contributions in this venture [33, 34]. It is possible to transfer the clinical case file through e-mail or clip stored in the cloud. Imaging scans and electromagnetic waves from various body organs can be transmitted through a telephone line or an app. Consultations can be sought globally at the touch of a button. Teleconferences are being increasingly used for distant teaching. It is possible to provide global live coverage of complex surgical procedures through satellite [35].

Future Innovations and Developments

Medicine is dynamic and pediatrics is far more dynamic with a rapid pace of developments to improve survival and quality of life. A large number of innovations have already become a reality or are likely to be introduced in the near future (Table 1).

Emerging Health Catastrophes

Lifestyle diseases and over nutrition among adolescents are emerging as public health problems because of intake of calorie-dense junk food, sedentary lifestyle and indulgence in excessive “screen time”. Obesity is associated with adverse health consequences such as syndrome X, adult-onset diabetes mellitus, hypertension and coronary artery disease. A large number of newer infective disorders like HIV, SARS, bird flu, swine flu, zika, Ebola, and multidrug resistant superbugs are causing serious health issues. Following control of infective diseases by better public health interventions and immunizations, newer non-infective disorders like cancers, allergies, metabolic abnormalities, psychological and stress disorders, degenerative disorders like Alzheimer’s, and diseases due to pollutants, pesticides and toxins are assuming public health proportions. Whenever man tries to improve survival and quality of life, nature tries to seek a balance by unleashing natural disasters. There is an ever-increasing scare of natural

Table 1 List of future innovations and developments

- Better health surveillance by human and microbial genomics with greater emphasis on prevention by genetic counseling, interventions and lifestyle modifications.
- Newer vaccines against HIV, SARS, bird flu, swine flu, malaria, dengue, zika, hepatitis C, CMV, Lyme disease *etc.*
- DNA vaccines for non-infective diseases like obesity, hypertension, type 2 diabetes mellitus, addictions, multiple sclerosis, Alzheimer’s, autoimmune disorders, cancer, contraception *etc.*
- Early diagnosis by bedside antigen-based screening tests and molecular biological techniques like DNA and rRNA probes.
- Robotic and laparoscopic repair and replacement of defective body organs.
- Cryogenics for storage of stem cells and organ banking by cold vitrification.
- Aggressive life saving devices like sophisticated ventilators, heart-lung machine and other organ by-passers.
- Implanting of memory biochips, nano-polymer wires and neurobionic interventions in the brain to take over the functions of damaged neurons.
- Increased chances of survival and enhanced longevity by restoring the length of telomeres and by increasing the concentration of mitochondria, with a greater load of degenerative diseases and health issues pertaining to oldies.

HIV Human immunodeficiency virus; *SARS* Severe acute respiratory syndrome; *CMV* Cytomegalovirus

and man-made disasters like travel accidents, famines, floods, tsunamis, earthquakes, nuclear, chemical and biological wars.

A Step Towards Immortality

Man has always strived to prolong life and cheat death but despite all the technological advances, medicine can never achieve immortality! Nature is a huge recycling plant and birth-life-death-rebirth is in accordance with a pre-ordained celestial principle. Nevertheless, scientists have made attempts to upload human neocortex through cloud with the help of brain-computer interfaces to achieve singularity and digital immortality. It is hoped that by 2050, we will have new breed of computers who will have the ability to feel, perceive, interact and have artificial intelligence with the help of brain-computer interfaces [36].

It sounds fictional but attempts are being made to use cryonics technology to preserve human organs or whole body for future resurrection by using cloning nanotechnology to bring it back to life when a cure is found for the disease that caused the death [37, 38]. It appears man is trying to play god, but these attempts are most likely to prove futile. Instead of prolonging human life, it is more important to improve the vitality of health and quality of life throughout the life span of a person.

Holistic Pediatrics

There is an increasing awareness that technology should not be allowed to further dehumanize medicine. There is a need to provide holistic care by focusing on the “patient” having the disease and not on the “disease” per se. The patients should be viewed in totality, and that too not in isolation but in context with the dynamics of ecology, family, friends, and society. Instead of becoming passive recipients of drugs, patients and their parents, should become active participants in order to augment the process of healing. Effective communication and showing due concern, compassion and empathy can energize the psycho-neuro-immunology axis of the patient. It is desirable that all approaches to healthcare should be exploited to provide healing. The alternative approaches to health care include Ayurveda, Unani, Siddha, Homeopathy (AYUSH), Naturopathy, Acupressure, Acupuncture, Reflexology, Tai-Chi, DiGong, Reiki, Yoga, Meditation, Visualization, Magnetic therapy, Gemology, Aroma therapy, Salt therapy, Prayer and Spiritual healing. In order to improve effective utilization of all complementary therapies, Ministry of Health, Government of India has created a separate wing of Indian System of Medicine and Homeopathy (ISM and H) for effective utilization of herbal medicines and drugless therapies.

Our body is suffused with a cosmic life force energy field consisting of light, heat, sound, electric and magnetic waves emanating from various “chakras”. The bio field, which is called aura, halo or corona, extends beyond the skin and forms a protective sheath. There are seven chakras, which are located along the spine adjacent to various endocrine glands. They are linked with the body Meridians, Nadis, Bhongan, and Duct system. It is believed that life energy or Prana flows into and out of our chakras. Starting from base of the spine to the top of the head, the chakras include Kundalini (coccyx), Hara (sacral), Solar plexus (navel), Heart (midback), Thyroid (base of throat), Brow (third eye), and Crown (sahasrara), which integrates all the chakras and is a source of astral energy (gold sun) or global consciousness or nonbeing. A healthy person, who has physical vitality, mental clarity, emotional, social and spiritual wellbeing, is likely to have bigger and brighter auras [39, 40]. Whenever, there is stress or dysfunction, whether physical, psychological, social or spiritual, the chakra energy field or halo is disturbed. Human chakras can be scanned by various Kirlian equipment like Polycontrast Interference Photography (PIP), Digital Aura Scanning System (DAS), Gas Discharge Visualization (GDV), Medical Thermal Imaging (MTI), Resonant Field Imaging (RFI), and Electro Interstitial Scanning (EIS). When a chakra is found to be diseased or dysfunctional, it can be energized or activated with electric current, magnetic waves, healing touch, Reiki and crystal healing.

The Future Hope

There is tremendous hope and scope for outstanding achievements in the field of medicine in 21st century. There will be a greater focus on public health interventions to improve social, community, and environmental factors to enhance survival and quality of life. Healthy lifestyle and improvements in the health status and quality of life in children is associated with reduced burden of adult diseases because seeds of most adult diseases are sown in childhood. Advances in clinical genetics are likely to revolutionize pediatrics. There will be no issue of survival of the fittest because everyone will survive. Individuals born with defective genes will be managed by insertion of healthy cloned genes by further refinements in genetic engineering technology. Molecular diagnostic tests are likely to be readily available with a possibility of having personalized or tailor-made medicines depending upon the genetic constitution of the patient. A number of newer vaccines for emerging infections are in the pipeline including realization of the revolutionary concept to produce vaccines for a large number of non-infective lifestyle diseases. The scientists are going to play “god” to produce designer babies but it is unlikely to become a reality because of tremendous ethical and legal issues.

Future pediatrics will not merely focus on diseases but will pay attention to children and their parents to energize the psycho-neuro-immunology axis and provide holistic medicine by further refinements and exploitation of a variety of complementary and alternative approaches to promote health. Medicine will become more patient-specific and less disease oriented. We shall be able to prolong life and ensure the quality of life worth living but we should not aim for immortality or resurrection of life. Nature is a huge recycling plant and no body should try to arrest the divine process of birth-life-death-rebirth... However, there is a fond hope that in the next millennium, people are likely to have an IQ of 150 and live to an average age of 120 y—but more importantly they are likely to have a good quality of life worth living.

Compliance with Ethical Standards

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