RECENT ADVANCES IN PHYSIOLOGY

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A Collection of Scientific essays written by the students of 1st Year MBBS Batch 2022 of AIIMS Guwahati

Foreword

I am happy to put forward this effort by the first year MBBS students of batch 2022 of AIIMS Guwahati to compile a collection of articles on recent advances in Physiology.

Physiology aims to understand the mechanisms of living organisms, from the cellular level to the integration of the various systems leading to the smooth functioning of the organism as a whole. Research in the field of Physiology helps us to understand how our body functions in health and how it responds and adapts to the challenges of day-to-day life. It facilitates our understanding of new treatments and guidelines to maintain health and provides important insight into the complex nature of the human body, increasing our understanding of the various systems and processes that occur to keep us alive. Developments in this field provide the basis for the development of novel treatments and therapies that are crucial for the advancement of medicine and improving the health and well-being of people around the world.

The field of education is witnessing rapid changes as we move from the conventional didactic classroom teaching to more interactive and self-directed learning. Effective teaching is the art of creating autonomous, independent and self-directed learners. It is indeed heartening to note that the First year MBBS students of batch 2022-23 of AIIMS Guwahati have taken the first steps towards self-learning by exploring the world of knowledge beyond routine academics.

I wish this endeavour all success and hope that this trend of joyful learning continues.

Prof. Ashok Puranik
Executive Director
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PREFACE

It is matter of great pride and joy to pen down a few lines as preface to this unique effort by the students of AIIMS Guwahati. It is said that assessment drives learning and majority of academic pursuits during student life are exam oriented. However, this booklet is a deviation from this stereotype. Therefore, it is heartening to see the first year MBBS students delve into the latest advances in Physiology out of sheer interest and curiosity. The compilation of their efforts into this booklet is an expression of our appreciation for them. I hope this gesture will be a motivation for upcoming batches.

Physiology, the science of life is a speciality that is woven into the MBBS curriculum in its entirety. The understanding of all disease processes is incomplete without the knowledge of Physiology. Moreover, the roots of all the recent advances in contemporary times can be traced back to this discipline. The student's effort in understanding and decoding this is truly commendable. I will fail in my responsibilities if I do not mention the silent guidance and perseverance of the all the faculty members of the department of Physiology. My sincere gratitude for each one of them.

I wish luck to the entire department and wish the very best to my beloved students.

Dr. Manasi Bhattacharjee

Professor and Head

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Tissue Engineering

Mon Bahadur Limbu

Tissue engineering is a multidisciplinary field that combines principles of engineering, biology, and materials science to create functional biological tissues. Researchers aim to develop artificial organs or repair damaged tissues by cultivating cells on scaffolds, fostering natural regeneration. The triad of tissue engineering involves biomaterials, cells and signaling molecules.

BIOMATERIALS are biological or synthetic substances which can be introduced into body tissue as part of an implanted medical device or used to replace an organ, bodily function. They may be metals, ceramics, carbons or polymers. The cells used may be differentiated cells of the particular tissue or stem cells (embryonic, fetal or adult). Further, they may be autologous, allogenic or xenogeneic. The signaling molecules, which may be mitogens, growth factors or morphogens, are usually delivered using a biomaterial as the carrier. An additional requirement in tissue engineering is a scaffold, an artificial structure capable of supporting three-dimensional tissue formation, into which the cells are implanted or seeded. Scaffolds allow cell attachment and migration, deliver and retain cells and biochemical factors, enable diffusion of vital cell nutrients expressed products and exert certain mechanical and biochemical influences to modify the behavior of the cell phase. The steps in tissue engineering are:

1. Appropriate cell source must be identified, isolated and produced in sufficient numbers
2. Appropriate biocompatible material that can be used as a cell substrate or 4 cell encapsulation material isolated or synthesized, manufactured into desired shape and dimensions
3. Cells seeded onto or into material, maintaining function, morphology
4. Engineered structure placed into appropriate in vivo site

Using well-designed scaffolds and optimized cell growth, various tissues such as skin, bone, cartilage and intestine have been successfully engineered to some extent. More complex organs such as lung, liver, heart and kidney, requiring multiple types of cells and intricate scaffolds, are also not far behind in development.

This innovative approach holds promise for treating various medical conditions, offering potential solutions for organ transplants, wound healing, and personalized medicine. The importance of tissue engineering lies in its potential to revolutionize healthcare by providing alternatives to traditional treatments, addressing organ shortages, and enhancing the body's ability to regenerate tissues. The future of tissue engineering appears poised to unlock unprecedented medical possibilities, propelling us into an era where regenerating damaged organs becomes a routine therapeutic option. Advanced biomaterials, gene editing technologies, and 3D bio-printing are converging to create intricately designed tissues that mimic natural structures. Imagine a world where personalized organs can be engineered, tailored to individual patients, minimizing rejection risks. As our understanding of cell behavior deepens, and the synergy between biology and technology evolves, the future of tissue engineering holds the potential to reshape the landscape of medicine, offering transformative solutions to previously insurmountable health challenges.

Neuromodulation

Bitopan Kalita

Neuromodulation is a therapeutic approach that involves the targeted alteration of nerve activity through various interventions. This field has gained prominence for its potential in treating a wide range of neurological and psychiatric disorders. The fundamental principle is to modulate neural activity, either enhancing or inhibiting it, to restore normal functioning or alleviate symptoms.

One prevalent form of neuromodulation is electrical stimulation. Techniques like deep brain stimulation (DBS) involve surgically implanting electrodes into specific brain regions. These electrodes emit controlled electrical impulses, influencing neuronal activity. DBS has shown success in managing conditions like Parkinson's disease, essential tremor, and obsessive-compulsive disorder by disrupting abnormal neural signalling.

Another method is transcranial magnetic stimulation (TMS), a non-invasive technique that applies magnetic fields to induce electrical currents in specific brain areas. TMS is used in treating depression, and research is ongoing for its potential in conditions such as chronic pain and schizophrenia.

Neuromodulation extends beyond the brain to peripheral nerves. Peripheral nerve stimulation (PNS) involves placing electrodes near nerves outside the central nervous system. This approach is employed for chronic pain management, targeting specific nerves to interrupt pain signals.

The field also includes chemical neuromodulation. Pharmacological agents, like medications or neurochemical substances, can be used to modify neural activity. For example, medications targeting neurotransmitter systems can alleviate symptoms of mood disorders or psychosis.

Neuromodulation's impact is not limited to traditional medical applications; it plays a role in emerging areas like brain-computer interfaces (BCIs). BCIs aim to establish direct communication between the brain and external devices, enabling paralyzed individuals to control prosthetics or even interact with computers using their thoughts.

Ethical considerations accompany the progress in neuromodulation. As the technology advances, questions about privacy, consent, and the potential for misuse arise. Additionally, the long-term effects and safety of some neuromodulation techniques require thorough investigation.

In conclusion, neuromodulation represents a diverse and evolving field with profound implications for healthcare. Its ability to intervene in neural circuits holds promise for addressing a myriad of neurological and psychiatric disorders. However, ongoing research is crucial to unlock its full potential while addressing ethical concerns associated with manipulating the intricate workings of the human nervous system.

Exploring the brain-computer interface

Rishav

A brain-computer interface (BCI), also known as a brain-machine interface (BMI), is a system that enables direct communication between the brain and an external device, such as a computer or prosthetic limb, without the need for muscular activity. In essence, it allows individuals to control devices or applications using only their thoughts. Here's how a typical BCI works:

1. Brain signal acquisition: BCIs capture signals produced by the brain
2. Signal processing: The raw brain signals are processed to extract meaningful information. This involves filtering out noise, amplifying the relevant signals and identifying patterns.
3. Feature extraction: Once the signals are processed, features relevant to the task at hand are extracted.
4. Classification or decoding: Machine learning algorithms or pattern recognition techniques are applied to classify the extracted features into specific mental states or commands.
5. Device control: The decoded commands are used to control external devices or applications.

Types of BCIs

1. Invasive BCIs involve implanting electrodes into the brain tissue.
2. Non-invasive BCIs capture brain signals from the surface of the body.
3. Hybrid BCIs use a combination of invasive and non-invasive techniques.

Application of BCIs in the field of Medicine:

1. Assistive technology: BCIs can empower individuals with disabilities to control assistive devices like prosthetic limbs, wheelchairs, or communication aids using their thoughts.
2. Neurorehabilitation: BCIs are used in rehabilitation settings to aid in motor recovery for individuals with stroke or spinal cord injury.
3. Communication: BCIs enable individuals with severe motor impairments to communicate by translating their brain activity into text or speech output.
4. Research: BCIs are useful tools for studying the brain's functioning, understanding neural mechanisms and advancing our knowledge of brain-computer interaction.

Despite its promising potential, BCI faces challenges such as signal variability and reliability. Advances in signal processing and machine learning are being employed to address these issues. Additionally, ethical considerations about maintaining data privacy and data security must be navigated to ensure responsible and secure BCI systems.

Recent years have witnessed remarkable BCI applications. It has enabled paralysed individuals to control robotic limbs, restoring a sense of independence. Cognitive applications include neurofeedback for improving focus and memory. The gaming industry has embraced BCIs, creating immersive experiences controlled by neural signals. Currently, research in the field of BCI is focussed on increasing the biocompatibility of implants and enhancing signal quality and resolution.

Responsive Neurostimulation

Chaki Gitanjali Bulton

Seizures are temporary disruptions of brain function resulting from abnormal, excessive neuronal discharges; epilepsy is a chronic condition of repeated seizures. The cellular counterpart of an epileptic spike seen in an EEG is Paroxysmal Depolarisation Shift (PDS). There are 2 things that are extremely essential to see an epileptic spike – hyperexcitability which manifests in the form of a PDS , and hypersynchronous discharge, meaning thousands of these PDS have to occur at the same time to be able to produce the epileptic spike. Conventional methods of treatment include medication (anti epileptic drugs) and surgical excision of the focus. This was followed by Brain pacemakers- deep brain stimulation or Vagus nerve stimulation. Responsive Neurostimulation is the latest method of controlling seizures.

How does a Responsive Neurostimulator work?

- Changes or modulates brain activity to prevent or stop spreading of scissors. It's short term effects may be due to its effect on inhibitory neurotransmitters.
- Consist of an implanted stimulator connected to one or 2 subdural strips or depth leads, each containing 4 electrodes.
- This leads are placed at seizure foci and deliver a stimulation in response to detected electrocorticography (ECoG) patterns. The pattern recognition is programmed by the physician and is tailored to the patients's ictal ECoG Patterns.

3 major functions of a responsive neurostimulator-

- Monitor brain waves
- Detect unusual activity
- Respond by sending stimulations within milliseconds

Advantages over other forms of treatment-

- In 1/3 of epilepsy patients, medications do not work.
- In patients where the focus is in a necessary area of the brain, surgery is not an option.
- It does not send continuous signals like a brain pacemaker and is much smaller in size.
- The RNS system also includes a magnet that instructs the Neurostimulator to record brain activity when it is swiped over the implant site. At first, the Neurostimulator is programmed to only record brain activity, during later visits, it is programmed to deliver responsive stimulation.
- People can't feel the stimulation, it doesn't cause pain or any unusual feelings, it is not permanent and can be removed as desired.
- The neurostimulator's battery generally last for about 2 and a half to 4 years. You can get it replaced and unless the leads need to be replaced, the neurostimulator will be connected to the same leads.

But, after the device is implanted, you must avoid certain medical treatments such as MRI, transcranial magnetic stimulation.Thus, responsive neurostimulation provides an option of treatment to patients whose seizures cannot be controlled by other medical treatments.

Recent Advances in Understanding Neuroplasticity: Implications for Brain Function & Disorders

Sumedha Jha

Neuroplasticity, the brain's remarkable ability to reorganize and adapt in response to experiences, has been a focus of extensive research in recent years. This abstract provides a concise overview of recent advancements in elucidating the physiological mechanisms underlying neuroplasticity and their implications for brain function and disorders.

Recent studies have revealed the dynamic nature of synaptic plasticity, the fundamental mechanism underlying learning and memory processes. Molecular pathways involved in synaptic plasticity, such as the roles of neurotrophic factors, neurotransmitters and intracellular signalling cascades have been elucidated, offering insights into the cellular mechanisms underlying neuronal adaptation.

Advancements in neuroimaging techniques, including functional magnetic resonance imaging (fMRI) and diffusion tensor imaging (DTI), have provided unprecedented insights into structural and functional changes associated with neuroplasticity. These include alterations in gray matter volume, white matter connectivity, and cortical reorganization following learning, rehabilitation, or environmental enrichment.

Furthermore, research has highlighted the role of experience-dependent plasticity in shaping brain development and function across the lifespan. From critical periods in early development to ongoing plasticity in adulthood, environmental stimuli, behavioural experiences and therapeutic interventions can modulate neural circuits, influencing cognitive functions, sensory processing, and motor skills.

Understanding the mechanisms of neuroplasticity has profound implications for neurological and psychiatric disorders. Harnessing the brain's plasticity holds promise for developing novel interventions for neurorehabilitation following stroke, traumatic brain injury, or neurodegenerative diseases. Additionally, targeting maladaptive plasticity may offer new avenues for treating psychiatric conditions such as addiction, anxiety disorders and depression.

In conclusion, recent advances in the physiology of neuroplasticity have deepened our understanding of the brain's remarkable capacity for adaptation and rewiring. These insights not only shed light on the mechanisms underlying brain function but also offer exciting prospects for developing innovative approaches to promote recovery and resilience in the face of neurological and psychiatric challenges.

Recent Advances in Understanding the Physiology of Major Depressive Disorder

Priyansh S Mishra

Major Depressive Disorder (MDD) is a complex psychiatric condition with multifactorial etiology, involving various genetic and neurobiological factors. It is a state of low mood and aversion to activity, along with a variety of cognitive and vegetative disturbances. It is usually associated with severe and persistent symptoms leading to important social role impairment and increased mortality.

In Major Depressive Disorder, neurotransmitters are believed to play a significant role in the development and manifestation of depressive symptoms. Much evidence has accumulated suggesting that depression might be caused by the diminished formation in the brain of *norepinephrine, serotonin, dopamine* or all in conjunction. Moderate number of ***norepinephrine-secreting neurons*** are located in the brainstem, especially in the *locus ceruleus*. These neurons send fibers upward to most parts of the brain limbic system and cerebral cortex. Many ***serotonin-producing neurons*** are located in the *midline raphe nuclei* of the lower pons and medulla, sending signals yet again to the limbic system

A principal reason for believing that MDD might be caused by diminished activity of *norepinephrine- and serotonin-secreting neurons* is that drugs that block their secretion such as **reserpine**, frequently cause depression. Conversely, about 70% of depressive patients can be treated effectively with drugs that increase the excitatory effects of these NTs. The ***neurotransmitter hypothesis of depression*** suggests that imbalances or deficiencies in these neurotransmitters, particularly serotonin, play a role in the development of depressive symptoms.

Research on the pathophysiology of depression has made significant advances in recent years, providing valuable insights into the underlying mechanisms of the disorder. A few of them are as follows:

i. ***Neuroplasticity:***

   Refers to the brain's ability to change and reorganize itself in response to experiences and environmental stimuli. Recent research has focused on cellular mechanisms involved in neuroplasticity and their role in depression.

ii. ***Inflammatory Processes:***

   There is growing evidence suggesting a link between inflammation and depression. Studies have found increased levels of inflammatory markers in individuals with depression.

iii. ***Epigenetics:***

This refers to changes in gene expression that do not involve alterations in the underlying DNA sequence, research has shown that epigenetic modifications play a crucial role in the development of depression, influenced by traumatic life events.

iv. ***Gut Microbiota Theory:***

Recent studies have highlighted the bidirectional communication between the gut microbiota and the brain, known as the gut-brain axis and its influence in mood and behavior. Imbalances in the gut microbiota, known as ***dysbiosis***, have been associated with depressive symptoms.

v. ***Brain Imaging Techniques:***

Advances in neuroimaging techniques, such as ***functional magnetic resonance imaging*** (fMRI) and ***positron emission tomography*** (PET), have allowed researchers to examine the brain's structure and activity in individuals with depression. These techniques have provided insights into the neural circuitry involved in depression, identifying abnormalities in regions such as the prefrontal cortex, amygdala, and hippocampus.

Advances in precision medicine have facilitated the identification of biomarkers that may aid in early diagnosis, prognostication and personalized treatment strategies for MDD. Integrating multidimensional data from genomics, neuroimaging, and clinical assessments holds promise for the development of targeted interventions tailored to individual patients.

In conclusion, recent advances in the physiology of MDD have expanded our understanding of the intricate mechanisms underlying this debilitating disorder. These insights not only enhance our conceptualization of MDD but also pave the way for the development of novel therapeutic approaches aimed at improving outcomes for individuals living with depression.

It has also opened up new dimensions of treatment and has increased awareness amongst the patients as well as society in general that there needs to be a strong and cumulative response to this menace.

Drug Delivery Through Blood Brain Barrier by Using Hydrogels

Neha Poonia

Blood Brain Barrier is specialized barrier separating blood stream from brain tissue allowing entry of limited substances and that too in limited quantities. This, by nature, is one of the most effective protective methods present in our body. However, this hinders treatment process related to brain tissues when we need to treat a brain related disorder by restricting the availability of drug at specific brain tissue sites.

Conventional methods of drug administration, whether oral or intravenous, have several limitations like:

- Restrictive entry of drugs through BBB.
- Drug will travel all through the body before reaching the target tissue in brain and will, in one way or the other, cause damage to non-target tissue.
- Drugs needed to be administered in high doses in order to ensure their availability at target site in required amount.
- Less efficiency and efficacy of drugs administered.

In order to overcome all these challenges, scientists are exploring various strategies like nanotechnology, carrier systems, targeted approach and innovative formulations like hydrogels. Out of these numerous advances, I would like to focus mainly on hydrogels.

What are hydrogels?

- In simple terms, hydrogels are three dimensional cross-linked networks of hydrophilic polymer chains that can absorb and retain a significant amount of water or biological fluids while maintaining their structural integrity. They are typically composed of biodegradable and biocompatible polymers. Hydrogels can be designed with various polymers, which can be natural (gelatin, Alginate, hyaluronic acid) or synthetic (polyethylene glycol, polyvinyl alcohol). The choice of polymers influences the mechanical properties, swelling behaviour, biodegradability and biocompatibility of the hydrogel.

Hydrogels offer several advantages for drug delivery through BBB, such as:

- Controlled drug release
- Protection and stability
- Increased drug delivery
- Targeted drug delivery
- Biocompatibility

Use of hydrogels increases the target specific drug delivery with limited amount of drug with less frequent administration. Hydrogel systems offer the possibility of delivering multiple drugs or therapeutic agents simultaneously by incorporating different drugs within the

hydrogel matrix or designing multi-layered hydrogel structures. By this method, synergistic effects can be achieved enabling combination therapy for improved therapeutic outcomes.

The process of drug delivery using hydrogels consists of:

1. Incorporating the drug molecules in to the hydrogel matrix, known as Loading.
2. Surface modification of hydrogels to enhance their uptake and interaction with cells or tissues.
3. Administration of the hydrogel as intranasal spray, intracerebroventricular injection or as implants.
4. Penetration of the blood brain barrier by hydrogels using carrier-mediated transport, receptor-mediated transcytosis, adsorptive transcytosis or BBB disruption.
5. Release of drug by hydrogels by various techniques like diffusion control release, swelling control release, degradation control release, stimuli responsive release.

This method can be used in treatment of many clinical conditions like:

- Alzheimer's disease
- Spinal cord injury
- Parkinson's disease
- Traumatic brain injury

Use of this method still has its own potential hazards like it may cause inflammatory response as it is still a foreign material for body even after so many alterations and surface modifications done in order to make it resemble natural body tissue. It has another issue of leakage or bursting.

These problems need to be further addressed properly and modified for its safe, better and increased usage in treating various brain related clinical conditions.

Gustatory Transduction and Recent Advancements in Physiology of Taste

Ansh Jain

Taste is a chemosensitive sense which helps us identify and distinguish between different food items consumed by a person, Taste is perceived by the tongue using different taste receptors present on different papillae present on the dorsal surface of tongue.

There are 3 Types of taste receptors which are present

Those are

- Type 1
- Type 2
- Type 3

All the different tastes are perceived by activation of one or more of these receptors. The taste perceived are distributed among the receptors through different channels present on them as follows

Fig 1 : Different Taste and their properties.

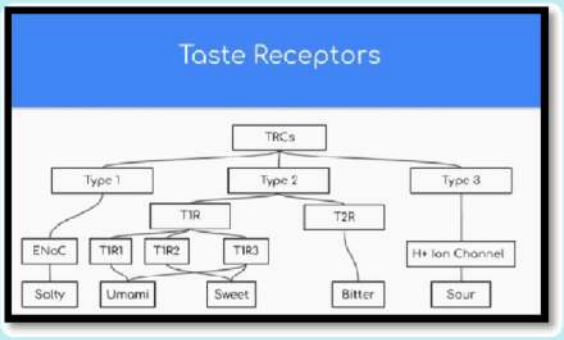

Fig 2: Distribution of tastes among the receptors.

Recent Advancements

There are 2 different Advancements in taste has been made in the recent time i.e

1. OTOP 1 H+ Channels
2. Channel Synapses

OTOP 1 H+ Channels

The Type 3 Receptor are basically H+ Channels, many different cation channels were proposed, but one which was confirmed is the OTOP 1 channel which is also found in brain,

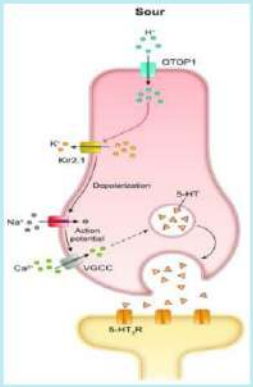

Fig 3: OTOP 1 H+ Channel

Channel Synapses

In type 2 Taste receptors there was no sign of exocytosis, so after extensive research by patch clamp method and also through careful calculation of capacitance were done and it was finally revealed that the way that the neurotransmitter release is through a ATP channel found in the pre synaptic membrane.

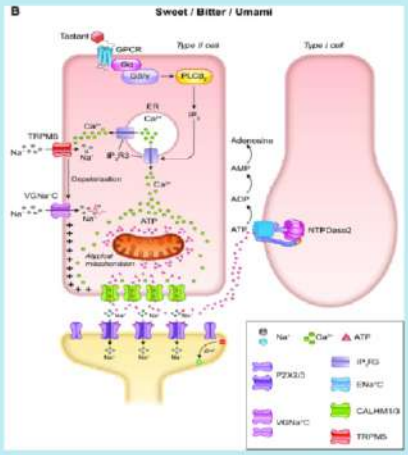

Fig 4: Channel Synapse

Uses

- To understand oral drug Delivery
- Increase compliance of patients by altering taste of drugs
- To understand and better enhance knowledge of taste

Cardiac output monitoring: Conventional to newer methods

Aakarsh Upadhyay

Measurement of the cardiac output is one way to monitor the functioning of the heart. Keeping this in mind, Adolf Eugen Fick put forward the Fick's principle which states "*the total uptake of (or release of) a substance by the peripheral tissues is equal to the product of the blood flow to the peripheral tissues and the arterial-venous concentration difference (gradient) of the substance.*" This is the basic principle on which the measurement of cardiac output depends.

Measuring cardiac output is broadly divided into two categories i.e invasive and non-invasive. There are no significant recent advancement in Invasive methods, although the accuracy of indicator dilution and thermodilution method is more, the former is based on assessment of concentrations of dye injected into large systemic vein as they passes and later one is based on temperature measurement in the pulmonary artery after injecting cold 5% normal saline in right atrium.

The non invasive methods have evolved significantly as Endotracheal Cardiac Output Monitor (ECOM) in which current is passed from electrode on the shaft of endotracheal tube and change in impedance secondary to aortic blood flow is detected by electrode on the cuff.

The other method is Trans Oesophageal Echocardiography(TEE) , it can quantify Cardiac Output more precisely by measuring both the velocity and the cross-sectional area of blood flow at appropriate locations in the heart or great vessels i.e.
Flow = Cross sectional area X Velocity
SV= Flow X ET (Systolic Ejection time)
CO=SV X HR

One of the safest and most widely used cardiac monitoring in critically ill patients is by Trans Thoracic Echocardiography (TEE) in which device targets the pulmonary and aortic valves, accessed via the parasternal and suprasternal windows in order to assess cardiac output completely non invasively.

Cardiac Radionuclide Imaging

Ashutosh Chakraborty

Cardiovascular disease is a major cause of morbidity and mortality worldwide. Cardiac radionuclide imaging plays an important role in evaluating patients of heart failure and cardiomyopathy with much potential for increased utility.

Radio nuclear imaging of the heart uses a special detector i.e. the gamma camera to create an image following injection of a radioactive material. It detects emissions of photon or positron from radioactive material taken up by the tissue and captured by a gamma camera, exactly like a PET-CT. It includes Single Photon Emission Computed Tomography (SPECT), myocardial perfusion imaging, infarct avid imaging and radionuclide ventriculography. Radionuclide imaging of the heart is useful in the evaluation of valvular disorders, cardiomyopathy, congenital cyanotic heart diseases, coronary artery diseases.

SPECT, which uses a rotating camera system and tomographic reconstruction to produce a 3-dimensional image, helps in the identification of inferior and posterior abnormalities, small areas of infarction and the vessels responsible for the infarction. With multi-head SPECT systems, imaging can often be completed in ≤ 10 minutes.

In myocardial perfusion imaging, IV radionuclides are taken up by the tissues of the heart roughly in proportion to their perfusion. This helps to identify areas of decreased uptake, which may be due to relative or absolute ischemia.

Infarct avid imaging uses radiolabelled markers that accumulate in areas of damaged myocardium. However, with the availability of less expensive and equally reliable tests, such as cardiac biomarkers, this technique is rarely used now-a-days.

Radionuclide ventriculography helps in the assessment of ventricular function. It involves the intravenous injection of Technitium-99m-labelled red blood cells followed by evaluation of right and left ventricular function. This can be a beat-to-beat evaluation or a ECG-synchronised blood pool imaging done over several minutes. Coupled with an ECG, it gives a "gated" or phase wise imaging of heart, known as multiple-gated acquisition or MUGA.

With newer advances in the coming years, the contribution of cardiac radionuclide imaging improving patient care and management looks promising.

"The Mechanical Heart"

Suman Saha

The escalating prevalence of Cardiovascular diseases (CVDS) poses a significant global health challenge. These conditions affecting the heart and blood vessels include coronary artery disease, heart failure and stroke. Factors contributing to these includes: Sedentary lifestyle, unhealthy dietary habits, stress and mental health and various lifestyle choices.

CVD has become the leading cause of mortality in India. The estimated CVD death rate of 272 per 100000 population in India is higher than the global average of 235 per 100000 population. Premature mortality in India has increased by 59% from 23.2 million (1990) to 37 million (2010).

An estimated 17.9 million people died from CVDs in 2016.

Treatment options available includes lifestyle modifications, medications and surgical intervention.

One of the advanced surgical intervention is Mechanical Circulatory Support.

Mechanical Circulatory Support or Artificial Heart is a device that replaces the abnormal heart and is used to bridge the time to heart transplant or to permanently replace the heart where transplantation is impossible. The 1st artificial heart was made by Soviet Scientist Vladimir Demikhov. Other pioneers in this field includes Forest Dewey Dodrill, Domingo Liotta, Willem Johan Kolff.

Types of Mechanical Circulatory Devices (based on two principles)-

i) Pulsatile Pump used in Left Ventricular Assist Devices.

It mimics the natural rhythmic action of the heart. It helps the lower left chamber of the heart to pump blood out of the ventricles to the aorta and rest of the body.

ii) Continous-flow Pump used in Total Artificial heart or Biventricular Assist Devices

It replaces both the left and the right ventricles.

Both these devices consist of Pump, Drivelines which is connected outside the body with the controller and the power supply.

Challenges and complications:

Now the question arises which one to choose Pulsatile pump or the Continuous flow pump.

Pulsatile pump has shown to have greater impact on regulation than continuous flow pump but creates shear forces on the Blood vessels and are prone to thrombosis.

Continuous flow pump on the other hand is smaller in size reducing surgical trauma, better energy efficiency and reduced thrombogenicity.

Risk factors involved are:

i) Blood clots

ii) Haemolysis

iii) Infections

iv) Stroke

v) Gastro-intestinal bleeding

Future directions & Possibilities:

i) Focus has been given on developing devices which have cons of both the continuous and pulsatile flow.

ii) Further development is done in reducing the size of the devices and rechargeable prosthetics. like Impella, Carmat, Abiocor.

In Conclusion, as the incidence and prevalence of cardiovascular diseases continues to rise, a comprehensive and multi-disciplinary approach to prevention, diagnosis, and treatment is essential. As it is said prevention is better lifestyle modifications is the safest option. Combining medical intervention with ongoing research into advanced therapies can help mitigate the impact of cardiovascular diseases on individuals and communities.

Extra Corporeal Membrane Oxygenation

Pratyay Talukdar

ECMO stands for extracorporeal membrane oxygenation. The ECMO machine is similar to the heart-lung by-pass machine used in open-heart surgery. It pumps and oxygenates a patient's blood outside the body, allowing the heart and lungs to rest. When you are connected to an ECMO, blood flows through tubing to an artificial lung in the machine that adds oxygen and takes out carbon dioxide, then the blood is warmed to body temperature and pumped back into your body.

There are two types of ECMO. The VA ECMO is connected to both a vein and an artery and is used when there are problems with both the heart and lungs. The VV ECMO is connected to one or more veins, usually near the heart, and is used when the problem is only in the lungs.

Indication of ECMO use:

- For patients recovering from heart failure, or lung failure or heart surgery.
- As a bridge option to further treatment, when doctors want to assess the state of other organs such as the kidneys or brain before performing heart or lung surgery.
- For support during high-risk procedures in the cardiac catheterization lab.
- As a bridge to a heart assist device, such as left ventricular assist device (LVAD).
- As a bridge for patients awaiting lung transplant. The ECMO helps keep tissues well oxygenated, which makes the patient a better candidate for transplant.
- It was even used in critically ill patients during COVID 19 pandemic.

In patients of SARS-CoV-2, data were collected from 40 patients between 22 and 64 years of age who required ECMO support in severe respiratory failure. A single-access, dual-stage right atrium to pulmonary artery cannula was used. Primary outcome survival following safe discontinuation of ventilatory and ECMO support was hypothesized. All patients were successfully discontinued from ECMO support in the mean of 2.6 days from ECMO initiation. Thus, single-access, dual-stage cannula offered better direct pulmonary artery flow, improved oxygenation and ventilation, and early mobility. To prevent thrombosis, all patients received systemic anticoagulation as patients with COVID-19 are prone to develop severe thrombosis.

Overall, this study showed promising outcomes with most patients being alive and discharged home without any oxygen support, complications were minimal, no ischemic stroke, ionotropic support and tracheostomy were required. But this study was limited to 40 subjects, single access, dual-stage venovenous ECMO with early extubation. Ongoing studies are necessary to define the further long-term outcomes of this approach.

Risks of ECMO:

- Bleeding, due to the medication that's given to prevent blood from clotting in the tubing.
- Infection at the sites where the tubes enter the body.
- Transfusion problems, since a person on ECMO is given blood products.
- Small clots or air bubbles forming in the tubing.
- Increased chance of stroke.

The use of ECMO is likely to continue to expand, owing to advances in technology, increased experience in a variety of new patient populations, and success of ECMO support in patient populations historically avoided, such as trauma, cardiac arrest, bridge to transplant, and even intracranial hemorrhage. Bleeding and thrombosis remain the most common complications associated with increased morbidity and mortality. The lack of a standardized, scientifically refined algorithm for anticoagulation monitoring and lack of any testing regimen that is associated with improved outcome, despite many years of experience and research, remains a conundrum and frustration for ECMO providers.

Use of blood components, previously driven by historical recommendations rather than scientific rationale, may continue to decrease as our knowledge base expands. RCTs of more conservative red blood cell transfusion thresholds have been proposed, though none have been funded or completed. Similar research is required for other products, such as platelets, plasma, and AT concentrate, to guide appropriate use of these products. Reduced phlebotomy from unnecessary laboratory tests also represents an opportunity for reducing the need for transfusion. Assessing cost savings is also, important. Incorporating hematology experts in multidisciplinary teams caring for ECMO patients can improve understanding and care for these complex patients.

Artificial Kidney

Sohum Sahoo

As end-stage renal disease deaths are rising across the globe, dialysis, also known as artificial kidney, is playing a major role in decreasing mortality and morbidity associated with this condition. Chronic kidney disease can be seen as a complication of various non-communicable diseases such as diabetes, hypertension etc. conventional methods of dialysis have undergone various changes in recent times, increasing its outreach manifold.

Dialysis works on the principle of osmosis. There are mainly two methods of dialysis, haemodialysis and peritoneal dialysis. An important development is the field of dialysis is the development of the home haemodialysis system. This benefits patients, especially elderly patients, who may otherwise need repeated hospital visits. There are various types of the home haemodialysis system: conventional type, short daily type or night type.

New dialysate delivery system like Central Concentrate delivery system and central dialysate delivery system help deliver dialysate fluid to a large number of people at the same time. Newer mechanical and safety monitors help check the pressure to allow proper diffusion and maintain composition and temperature, thus helping to prevent hypotensive shock.

Newer bicarbonate delivery system and water quality maintenance systems help in checking the aluminium levels (implicated in anaemia, dementia and osteomalacia). Newer synthetic membranes like polyacrylonitrate membranes help remove substances like beta-2 microglobulin, which cannot be removed by cellulose membrane. Much progress has been done to bring down the cost of dialysis and make it accessible to all.

Beyond the surface: The magic of Endoscopic exploration

Priyo Pratim Phukan

Endoscopy is a minimally invasive medical procedure that employs a flexible, lighted tube equipped with a camera, enabling visualization and examination of internal organs and structures. This advanced diagnostic technique plays a pivotal role in identifying and treating various medical conditions, offering a comprehensive view of the gastrointestinal tract, respiratory system, and other body cavities.

Pill endoscopy, a revolutionary development in endoscopic technology, involves a small, swallowable capsule containing a miniature camera. As it traverses the digestive system, it captures high-resolution images, providing valuable insights into the condition of the gastrointestinal lining. This non-invasive approach offers a patient-friendly alternative to traditional endoscopy, particularly for small intestine examination.

The uses of endoscopy are extensive, ranging from the detection and diagnosis of gastrointestinal disorders such as ulcers, polyps, and cancers to therapeutic interventions like removing foreign bodies or collecting tissue samples for biopsy. Its precision and versatility make it an indispensable tool for healthcare professionals seeking accurate assessments and targeted treatments.

Looking toward the future, endoscopy continues to evolve with emerging technologies and innovations. Potential applications include enhanced imaging capabilities for early disease detection, integration with artificial intelligence for real-time diagnostic assistance, and the development of more compact, efficient devices. These advancements aim to further streamline procedures, improve diagnostic accuracy, and enhance the overall patient experience in the realm of endoscopic medicine.

Respiratory & Cardiovascular Changes in Covid-19 Patients.

Akimul Rahman

The cardiovascular complication and respiratory complications are well described but post covid cardiovascular and respiratory manifestations have not yet been comprehensively characterized. Many individuals recovering from acute SARS-CoV-2 infection suffer prolonged respiratory dysfunction for months to years after viral clearance.

Post Covid-19 airways show immune and proteomic changes that not reflected in blood. An activated immune system after covid increase BAL cytotoxic T cells are linked to epithelial damage and airway disease. (BAL- Broncho Alveolar Lavage). Morbidity from a range of persistent symptoms, including breathlessness, fatigue and memory impairment, has been noted in patients recovering after acute illness and described under the umbrella term of "Long Covid".

From Research of Immunologist Bavithra Vijay Kumar (Imperial college London, UK) and his team that complex respiratory complications have been found in up to 18.4% of in patients and persistent breathlessness, fatigue and memory impairment has been noted in patients recovering after acute illness in more than 50% of patient.

SARS-CoV-2 infection results in formation of long lasting systemic immunological memory with virus- specific antibody &T cell responses still detectable in majority of infected at least 8 months post infection. Comparing cellular composition of BAL fluid in post-cavid-19 patients with healthy control by flow cytometry- Post-covid-19 patients had significantly higher number of cells in their airways it was due to elevation of airway macrophages, T cells, B cells.

One year after moderate Covid, the incidence rate of impaired DLCO & persistent lung damage exceeds 30%.

Covid 19 can damage heart by myocarditis or lack of oxygen due to lung pathology, cytokine storm.

The incidence of Covid induced pulmonary fibrosis caused by Covid can be estimated based on a 15-year observational study of lung pathology after SARS. In 20%, of SARS cases significant lung fibrosis occurs in 5-10 years. There are reasons to believe fibrosis may become one of the major long term complications of COVID. Risk & burden of cardiovascular disease in survivors of acute covid-19 are substantial. So, the post-covid recovered patients should be treated with care not like normal people but by keeping an eye on these complications.

Recent advances in treatment of Hepatitis

Prabal Das

Viral hepatitis is a global health concern. According to the WHO, 350 million people are suffering from viral hepatitis worldwide. Recent times have seen significant advances in the treatment of this condition, in form of introduction of newer anti-viral medications, newer treatment guidelines and development of effective vaccines.

One significant development is the introduction of Direct Acting Anti-viral (DAA) medications. These drugs target specific steps in the viral replication process, effectively inhibiting the growth and spread of the virus. They have revolutionized the treatment of hepatitis C, offering shorter treatment duration, fewer side effects and higher cure rates.

The development of effective vaccines has been instrumental in the prevention and control of viral hepatitis. Vaccines against hepatitis A and B have been available for several decades. More recently, vaccine against hepatitis E virus has been developed. Also, various vaccines against hepatitis C and D virus are in various phases of clinical trials and may be available in the commercial market in the near future.

Future breakthroughs in the treatment of viral hepatitis are likely to involve development of more targeted anti-viral therapies, introduction of personalized medicine and exploration of innovative treatment modalities such as gene therapy. Additionally, ongoing research may uncover newer strategies to increase the efficacy and tolerability of existing treatments.

The various advances in the management of viral hepatitis have significantly improved patient outcomes and contributed to the global efforts to eliminate viral hepatitis.

REFERENCES:

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