Editorial

Technology, engineering and innovations- Power buffers in the COVID driveline.....

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THE GREAT COVID DISASTER

The coronavirus disease (COVID)-19 through its first, and second brutal wave, has produced what has been labelled as an 'unprecedented human crisis' that satisfies every criterion of the definition of 'a mass disaster'.[1] It has resulted in great harm, damage, death and has challenged the global health infrastructure. Death, chaos and melancholy have not just only invaded our lives but seem to test our very psyche and attitude towards humanitarian crisis. We anaesthesiologists and intensivists have been a helpless testimony to the faces of dying COVID patients and have witnessed the helplessness of their family and friends. The memories of young COVID patients sinking into the folds of death due to hypoxia will haunt us in the years to come. These memories advocate that COVID-19 is one of the worst global disasters humankind could ever witness.

At present, clinically managing the COVID patients and academics at the same time seems like two ends of the real world rather than two sides of a coin. As we write this editorial, we are overpowered by our emotions and have become numb with our bitter clinical experiences. Death and a sense of hopelessness prevail all around us, and yet, we have to write this editorial. The manuscript submissions and resubmissions to our journal, the Indian Journal of Anaesthesia (IJA), continue even in this catastrophic situation. We are proud to say that the present editorial team, reviewers and authors of IJA continue to work with undeterred enthusiasm and vigour even during these troubled times. In spite of the technical challenges and snags of the new website and submission system as well as the COVID barriers, IJA is being regularly published, maintaining the academic vitality among its readers.

SETBACK TO THE DISASTER MANAGEMENT SYSTEMS BY THE CHALLENGES OF THE COVID PANDEMIC

COVID-19 became a serious pandemic mainly because of a global lack of common awareness, insufficient infrastructure and lack of proper management strategies.[2] Preparedness for disaster management, disaster response and post-disaster measures are important areas of disaster management. Unfortunately, the COVID-19 pandemic clearly exhibited lacunae in all these areas with a clear collapse of our fragile health care system. As a country, we were not well prepared to deal with the pandemic, especially the second surge.Our response to the pandemic was impotent and our post-first COVID surge measures and plans were half-hearted and weak.

The Disaster Management Ministry and the Union Health Ministry laid down guidelines and ramped up activities for the detection and treatment of COVID victims. State Governments, district administrations and local non-government organisations are working actively day and night to help in the crisis; yet, the 'game of deaths' continues. The desperate scramble of our citizens to get dyspnoeic patients admitted to hospitals;the inability to do so because of lack of oxygen beds; hospitals sending SOS messages for oxygen; weak and breathless patients dying on the stretcher/in auto-rickshaws in front of casualty departments even before being attended to; patients both in corporate hospitals and government-run hospitals dying suddenly because of oxygen shortage;and the mad race for oxygen cylinders speak volumes about our lukewarm preparedness to manage the second COVID wave and our management strategies. We clearly exhibited ourselves as a nation crippled by the agonies of oxygen shortage, vaccine shortage, lack of hospital beds and lack of COVID-essential drugs. Humanity has gone to shameless levels as the hoarding and black marketing of the drugs and life-saving equipment is going unabated.

THE SPECIALITY AND 'ENGINEERING AND TECHNOLOGY'—A STRONG CONTINUUM OF PARTNERSHIP

Technology has helped anaesthesiologists in preventing perioperative disasters and helped improve perioperative care. Technological advances have occurred over the last few years focusing on automation, monitoring and decision support systems. Currently, automated anaesthetic systems incorporating independent closed loops including a combination of two independent closed-loop systems for titration of intravenous anaesthetics, analgesia and fluid management, especially goal-directed fluid therapy, are undergoing feasibility studies.[3]

Innovations that have led to a reduction in the invasiveness of monitoring and helped in the collection of non-invasive data include cardiac output monitoring via pulse-wave contour analysis of arterial line, cerebral pulse oximetry to assess brain auto-regulation, the analgesia nociception index (ANI), surgical pleth index and nociception level (NOL) index.[4,5] Use of novel non-invasive methods of cardiac output measurement in critically ill patients,e.g.,using a mobile phone application, Capstesia™, have been reported.[6] Randomised controlled trials on the use of NOL index-guided opioid dosing during general anaesthesia for reduction in postoperative pain have been conducted and some more studies on this topic are currently underway.[7] Although research work on target controlled infusion (TCI) including work on the pharmacokinetic and pharmacodynamic fronts of TCI, intraoperative ANI, non-invasive cardiac output measurement and NOL index, has been done, more research work in these areas by Indian researchers is the need of the hour.[8-10]

The successful use of telemedicine in pre-anaesthetic assessment, remote intensive care unit (ICU) management and pain clinic, especially in COVID times, and the perioperative surgical home has been made possible only because of the high-resolution cameras, microphones and broadband data connections which are a product of modern computer technology. The electronic medical records and anaesthesia information management system (AIMS), and artificial intelligence help in documentation, and have made possible the upcoming of the clinical decision support system (CDS).[11,12]

Technology has, thus, undoubtedly made anaesthesia practice safe, smooth, refined, efficient and pleasant. Improvements in perioperative technology include continuous real-time monitoring of haemodynamics, oxygenation, ventilation, neurological status, urine output, core temperature and the degree of neuromuscular blockade. Video laryngoscopes, advanced supraglottic airway devices, extubation catheters, fibreoptic bronchoscopes, transnasal humidified rapid-insufflation ventilatory exchange (THRIVE) and virtual endoscopy for preoperative airway assessment have made amazing contributions in improving airway management. Lung protective ventilation strategies are now routinely practised and are a topic of interest for several researchers. Extracorporeal carbon dioxide removal has now been shown to be a promising adjunctive therapeutic strategy for the establishment of protective or ultraprotective ventilation in patients with acute respiratory distress syndrome (ARDS) and acute respiratory failure.[13] Bedside ultrasound in the ICU and in the operation theatre (OT) is now routinely practised and the ultrasound machine is the anaesthesiologist's most trusted companion today. Gastric ultrasound for preoperative assessment of gastric volume, ultrasound of the spine for spinal and epidural blocks, inferior vena cava ultrasound for intravascular volume assessment and lung ultrasound for those on mechanical ventilation are now a hot topic of researchers and are being increasingly implemented in the clinical practice.[14-17] This issue of the IJA with four original articles on studies wherein ultrasound has been used to guide the anaesthesiologist, supports this statement emphatically. In one of these articles, real-time ultrasound-guided spinal anaesthesia has been compared with preprocedural ultrasound-guided spinal anaesthesia in obese patients. The authors found that the time taken for the identification of the space, the number of attempts, the number of passes, and the time taken for successful lumbar puncture was more in the preprocedural ultrasound group as compared to the real-time ultrasound group, thus showing that real-time ultrasound facilitates the performance of spinal anaesthesia.[18] Ultrasound machines for applications like echocardiography, regional anaesthesia or central line placement can now be connected to a smartphone or e-tablet thus making them hand-held ultrasound machines.[19]

In another study published in this issue, the researchers have worked on a novel idea and tried to probe into the link between the gut microbes and the brain; the gut flora was altered with probiotics and the effects on sleep and anxiety were preoperatively assessed by assaying the stress biomarker salivary alpha-amylase with a kinetic reaction assay kit made especially for research purposes. Nevertheless, if an easier, faster and cheaper method of assaying salivary stress markers is available (like blood sugar estimation by glucose oxidase strip method), we can probably use this non-invasive objective method routinely in the estimation of salivary stress and anxiety biomarkers in every patient perioperatively so that our anaesthetic drugs and doses can be tailored accordingly[20]; Nonetheless, biotechnology and biomarker science are fast progressing and this may become a reality in the days to come.

ENGINEERING AND TECHNOLOGY COMING TO THE RESCUE IN COVID DISASTER MANAGEMENT

Biomedical engineers are undoubtedly the unsung heroes of the current pandemic. They are wanted in almost every corner of the COVID ICU and wards and are rendering yeoman service. They are the ones who have helped design personal protective equipment (PPE), build and maintain the functioning of ventilators, oxygenation and ventilation accessories. 'Ventilators', PPE', 'saturation' and 'oxygen' have now become household words. Pulse oximetry is practised by the layperson. The biomedical engineers are using reverse engineering techniques to deconstruct items and then recreate them in order to hasten the production and testing process of ventilators and PPE while maintaining high health and safety standards.[21] 3D printing to fabricate items including face shields and face masks has been now consolidated by manufacturers to combat shortages in PPE. A study showed that face shields were approximately twice as fast to 3D print compared to face masks and used approximately half as much filament.[22]

The biotechnology industry suddenly found itself very busy trying to develop vaccines and targeted drug therapies and diagnostic kits for the virus. The genetic structure of the severe acute respiratory syndrome coronavirus (SARS-CoV-2) was sequenced within weeks of its discovery by both scientists and engineers. Optical, electrical, mechanical, computer and chemical engineers were involved in the process.

The process of cell culture helps in understanding the basic molecular and physiological process that allows cells and tissues to function and respond to drugs. There are different methods of 3D cell culture, including 3D hydrogels, spheroids, organoids, 3D bioprinted tissues, organ-on-a-chip and rotating wall vessel bioreactors. 3D *in vitro* human-engineered lung tissue models including airway organoids created with bronchiolar epithelial cells, lung microvascular endothelial cells and lung fibroblasts have now been engineered.[23] These organoids offer a new tool for the study of lung-based diseases and cell-based therapy.

Multiple methods and a wide and diverse number of technological platforms have been tried for the development of the coronavirus vaccine by several institutions and manufacturing companies. The repeated mutations, genomic changes and drifts in the SARS-CoV-2 have posed several obstacles in the development of the vaccine. Nucleic acid (RNA/DNA) and recombinant viral vectors vaccines are innovative technological approaches that have been used to expedite the COVID-19 vaccine development process.[24]

Simulation tools and engineered models for intervention measures, random testing, contact tracing and assistance in the understanding of transmission dynamics of COVID-19-type infections have also been developed.[25]

A never-seen-before situation of acute oxygen shortage was exhibited and it continues unabated. Chemical engineers utilised all their knowledge and skills in the rapid production of medical oxygen, rapid development of oxygen bottling units, development of 'oxygen enrichment technology' and oxygen concentrators. The 'Oxygen Express' operated by the Indian Railways to transport liquid medical oxygen is an excellent example of an amazing amalgam of the applications of mechanical and chemical engineering. Each tanker of the Oxygen Express carried around 16 tonnes of medical oxygen to different parts of an oxygen-lorn country. The flying into the country of oxygen-generation plants, ventilators and essential drugs was possible only because of the advances in modern engineering and technology. The COVID data hubs, desktop and mobile apps meant to provide helpful resources;platforms like Zoom, GoToMeeting for administrative staff meetings and academic discussions are very useful in troubled COVID times. Nevertheless, simulation-based teaching and online training for sensitisation on airway and ventilation management have been effectively utilised to teach non-anaesthesiologist doctors in COVID times.[26,27] Robots have helped in disinfection, automated testing, transport of essential drugs and diagnostic kits and promote public safety during lockdowns. Drones have delivered PPE kits, coronavirus test kits and drugs to people in remote areas in several countries.

Furthermore, the contribution of civil engineers in building new make-shift COVID hospitals, designing new ICUs and refashioning old wards and operation theatres to make them COVID compatible can also not be forgotten.

ENGINEERING SKILLS OF ANAESTHESIOLOGISTS

Anaesthesiologists as the 'small engineers' in the OT have also contributed their share of technological innovations in the war against COVID-19. The aerosol box and its many modifications for intubation, the customised face mask as a solution to facial nerve blocks, a do-it-yourself videolaryngoscope for intubation in COVID patient, aerosol containment devices, the COVID aerosol protection Dome, and anti-fogging techniques as part of PPE are various innovations published in the previous issues of the IJA.[28-34] Technological modifications in COVID operation theatres were advised soon after the onset of the pandemic in the guidelines published by the ISA National.[35]

The technological innovations in the first surge served as food for research so that studies including randomised controlled trials (RCTs) were published on them.[36,37] The innovations ofthe first surge included the detection kits, face shield, aerosol box, PPE and oxygen delivery devices, whereas those of the second surge included devices focused on conservation of oxygen and on mechanical ventilation especially non-invasive. This technological ebb and fall will continue in the years to come, but let us hope that the COVID surge will fall, never to rise again. Till then, we have to whisper and pray to the Almighty, 'Please bring back the old times'.

As an old quote says 'Life starts all over again when it gets crisp in the fall'…the frightful and long COVID fall!

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