Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Editorial

On strife, natural selection and success in airway management during the COVID-19 pandemic: Shifting from *best guess* to *best practice*

For more than 18 months, nations across the planet have been engaged in a new global conflict. As for the preceding world wars, it began as a regional fracas, but has spread until no country is truly immune – even those who have fortified their borders and strived assiduously to remain isolated and unaffected have experienced hardship and fear. Unlike armed conflicts, however, this battle has been waged against a common and unifying enemy, in the form of an invisible pathogen which relies on the essentially interconnected and sociable nature of our species for its own survival, propagation and mutation.

While times of peace may bring prosperity, it is a common theme that one wage of war is rapid innovation and advancement of science. As per the principle attributed to the great Chinese military strategist and philosopher Sun Tzu, "*In the midst of chaos, there is also opportunity.*" [1] Certainly, the COVID-19 pandemic has shown what an opportunity for unified focus on science can achieve: the speed at which multiple vaccines have been created, investigated, produced and put into practice is an excellent example. Similarly, a virus resulting in profound isolation, paradoxically succeeded in joining people from all parts of the world together under the umbrella of research, clinical practice and scientific divulgation through webinars, online events and inventive teaching methods [2–4]. In anaesthesia and critical care, we have looked to the development of knowledge, strategies, and equipment which will allow us to improve the outcomes of severely ill COVID-19 patients and those presenting for surgery, while striving to protect staff from infection. For every new challenge that emerges, however, new strategies must evolve from "*best guess*" based on prior knowledge to "*best practice*" based on robust evidence [5]. It is inevitable and a core tenet of the scientific process that repeatedly testing new ideas will be met with frequent failure, but in the words of another wartime leader, Winston Churchill, "*… no one can guarantee success in war, but only deserve it.*" [6].

An area of nearly unbridled innovation and enthusiasm in the field of protection against SARS-CoV-2 infection during airway management has been the development of barrier devices for use during intubation. Some expert opinion and an early review of the topic queried the use of these devices, and strongly called for further research [7]. Referring to such Perspex boxes and plastic drapes as APE ("Ancillary Protective Equipment") Jain et al. [8] from Chandigarh, India, report in the August issue of TACC volume 39 (www.sciencedirect.com/journal/trends-in-anaesthesia-and-critical-care) on a study pursuing this avenue, adding to the rapidly growing evidence base on the subject. [9, 10]

Recognizing that barriers may complement but cannot replace personal protective equipment (PPE), the Chandigarh investigators compared standard intubation in COVID PPE with PPE plus either a Perspex box or plastic drapes. To further enrich the comparisons, each scenario was repeated using both direct and video laryngoscopy. As other studies have found [9], [-13] they observed longer intubation times and increased difficulty with APE, as well as an instance of breech in PPE.

Do we now know enough about the use of ancillary protective equipment (APE)? Robust data are still to emerge on whether APE may interfere with use of airway adjuncts such as tracheal introducers [14], despite their recognized efficacy in combination with videolaryngoscopes [15,16], or with routine diagnostic ICU procedures such as bronchoscopy, specimen collection, tube exchange or extubation [17], or – a debate within the debate – if emergency front of neck access may be affected or made impossible by concomitant use of APE [18,19]. Should we then conclude that APE use is advantageous, or conversely, that we should quit monkeying about with further APE species? Expert opinion and increasing evidence leans strongly towards the latter: the increased difficulty, time taken for intubation, ongoing theme of breeches in PPE, and most significantly the lack of evidence for effectiveness in preventing transmission of infection suggest that barrier devices were an inventive concept which have proven inadequate in practice [11–13].

Jain et al. conclude their paper with a strong statement on the need for "*..aggressive simulation based training … before using … in clinical practice, and … further testing in the real world scenario.*" [6] It is interesting to consider a second study in this edition in the light of this statement. Continuing with the theme of protection during intubation, Schumacher and colleagues in London, United Kingdom, examined intubation times using a control group and three different forms of PPE: the common standard approach of a disposable FFP3 mask with visor, a full-face air-purifying respirator, and a powered air-purifying respirator (PAPR) with hood [20]. Again, different airway devices were assessed, including direct, optical, video and flexible intubation. In contrast to earlier work which has suggested or demonstrated degradation in performance with advanced forms of PPE [21], Schumacher et al. used members of their specially trained COVID intubation team, consisting solely of anaesthesiologists with specific simulation and practical experience. Indeed, using the kind of training alluded to by Jain et al., they found that intubation times across all devices were half those of a pre-COVID study which used a less challenging model. It is thus noteworthy that this study demonstrates that advanced levels of respiratory PPE did not degrade performance when used by a suitably trained and experienced team. As an association has been shown between higher levels of PPE and decreased healthcare-worker transmission of SARS-CoV-2 [22], this work will allow a reframing of the risk-benefit debate around best practice and PPE

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use for airway management in patients with respiratory pathogens. At same time, the research by Schumacher and colleagues highlights what is possibly the most powerful weapon we have in the war against COVID-19: the human factors, in terms of cooperation, collaboration, communication, organization [23,24], and the absolutely human capability of rapidly adapting to changes, making us the most evolved species on the planet. As wrote one observer on the works of naturalist Charles Darwin, *"It is not the strongest that survives, but the species that survives is the one that which is able to best adapt and adjust to the changing environment."* [25]

In the realm of adaptation and evolution in the management of COVID-19, only development of vaccines and well-timed use of steroids have superseded the adoption of high-flow oxygen and non-invasive ventilatory strategies. The adoption of high-flow nasal cannula oxygen (HFNC/HFNO) as a bridging or maximal therapy and integration into hospital-wide responses has undoubtedly reduced requirement for mechanical ventilation, decreased morbidity, and saved lives [26–29]. Faced with the "… *crisis of space, equipment, and [hu]manpower* …" so familiar to clinicians in the COVID pandemic around the world, Betancur and colleagues in Madrid, Spain, turned to the inventive use of a nasal CPAP device to support patients when all other options had been depleted [30]. They describe the compassionate experimental use of the SuperNO_2VA device in a series of 14 patients, despite the acknowledgment that the technology was neither developed nor has been tested for acute respiratory failure. This is an excellent example of how a mechanistic understanding of the problem and pathology can suggest a potential solution; reporting the findings guides further refinement. In this instance, the majority of patients successfully sidestepped intubation and ventilation. Recognizing the heterogeneous group and retrospective nature of the work, this is nonetheless useful for hypothesis generation. Until robust data can be provided to support such innovation, care and critical thinking must be adopted when interpreting and applying results. A remarkable explosion of scientific productivity has occurred during the pandemic in attempts to evolve and use the opportunity created by the chaos. Emergency situations may call for emergency solutions, but conduct of strong research has to be encouraged to maintain perspective and avoid the so-called MacGyver effect [31].

Three studies elucidate three evolving phases of innovation, once again illuminating how the 'isolating' SARS-CoV-2 pandemic in some ways has united the world. In Madrid, Spain an idea shows promise and invites investigation. In Chandigarh, India structured evaluation guides us towards a conclusion that good ideas often have unintended consequences. In London, UK we learn how to leverage an idea to inform best practice. As a medical and scientific community, we must embrace the fact that continuing to evolve and innovate in fighting this war against the pandemic may and must involve research that ends in futility, and maybe in frustration. Here, Mr Churchill would undoubtably agree: "*Victory is traditionally elusive. Accidents happen. Mistakes are made. Sometimes right things turn out wrong, and quite often wrong things turn out right.*" [32]

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