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Editorial

Precision and Data-driven Anesthesia, Intensive Care Unit, and Pain Management in Resource-limited Settings such as Iran

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Anesthesiology and critical care are experiencing a paradigm shift where technology, epidemiologic needs, and patient expectations are collectively redefining the scope of practice rapidly. For many years, perioperative and critical care management was essentially reliant upon experiential care, protocol-driven management, and post hoc analysis. But with the growing complexity of patients, such as due to an aging population with multimorbidities, increased surgery rates, or increased rates of sepsis, trauma, or non-communicable diseases, there arises an urgent need to pivot towards personalized, data-driven, and predictive management. And such need is not merely a need in developed nations but in resource-limited settings where margins are small but the payoff of optimal management can make or break the future [1].

The trend towards precision medicine has already entered the realm of anesthesiology and critical care. Artificial intelligence in the form of machine learning algorithms has made it possible to predict hemodynamic instability and individualize drug dosages in real time. Closed-loop systems, where computer algorithms titrate the dosages of anesthetic or vasoactive drugs based on constant physiological feedback, are already in the pipeline and showing promising early returns. These computer-assisted care platforms help practitioners predict an impending adverse event based on dynamic changes in vital signs, lab parameters, and waveform analysis, warning them of potential hemodynamic instability in advance of the onset of apparent clinical events [2]. These computer-assisted care technologies aim to support, rather than supplant, the critical care physician or anesthesiologist.

Implications in resource-limited environments are even more far-reaching. Although a lack of equipment and staff in traditional care settings can hinder the execution of traditional care environments, data-driven care can bolster precision as well as optimize the reduction in waste brought about by less optimal care. AI-assisted ultrasound technology can help in regional anesthesia, vascular access, and critical care diagnoses, even in less skilled practitioners. Furthermore, predictive analysis can help in triaging, ventilatory management, and septic care in environments where specialized ICU facilities are absent [3]. Most importantly, it provides the hospital settings an opportunity to gain meaningful insight from internal data analysis, eliminating the need to refer to evidence from developed countries.

Regional Anesthesia illustrates how precision strategies can revolutionize perioperative services in resource-limited settings. Ultrasound-assisted blocks result in less opioid consumption, faster recovery, and simplified postoperative care, all of which contribute significantly in settings where pain management services, intensive care facilities, and rehab facilities are not readily available. New technology involving AI-assisted visualization of the needle, computer-driven identification of ultrasound anatomy, and simulator-based education can help close gaps in expertise and make superior regional anesthesia accessible in all settings. Similarly, recovery programs can dramatically reduce in-hospital stay, especially in our busy government-run facilities.

The use of digital technology in education and simulation offers much promise. Virtual reality, augmented reality, or high-fidelity simulation allows trainees to gain practical experience in dealing with crises, ultrasound procedures, or airway management in a very cost-effective and scalable manner. In environments where there are few trained faculty members and large numbers of trainees per specialist, these technologies can offer sustainable alternatives.

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However, there are challenges in the adoption of precision and data-driven care. These include inadequate information technology support, issues regarding data privacy, lack of integration in the Health Information System, and challenges in changing the long-established medical culture. An algorithm developed in developed nations may not work in the same manner in low- and middle-income countries because of variations in disease epidemiology, availability of resources, and patient population characteristics [4].

It is important to build data registries in the region and support medical research so that developments can lead to actual improvements in patient care. Going forward, the future of anesthesia and critical care in resource-scarce environments will depend largely on the extent to which they can harness precision technologies. Ideally, the long-term goal in these settings is not to re-create the model of care in developed nations; rather, it is to innovate in such a manner as to make the most of what they have. At the current point in the development of data-driven methods, there is certainly potential in these technologies to reduce risk in surgery, optimize care in the ICU, and produce postoperative benefits.

In these times of accelerated and global transformation, anesthesiologists and critical care experts practicing in resource-constrained environments offer an unusual perspective. By capitalizing on the precision medicine paradigm, harnessing low-cost digital innovations, and developing relevant evidence in these environments, these medical experts can dramatically change the manner in which care can be delivered. The future will not merely be shaped by technology but rather by the intelligent use of such technology—turning challenges into innovation catalysts in bringing about a new dawn in the perioperative and critical care era of precision.

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