Pulse Oximeter: Disruptive Technology or Standard of Care?

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Disruptive technology: what images does this term conjure? Driverless cars? Drones delivering packages? Elon Musk's Space X company sponsorship of the Hyperloop Pod Competition, which would develop technology to move pods of people up to 750 mph?[a]

What is disruptive technology? Harvard Business School professor Clayton M. Christensen coined the term "disruptive technology". In his 1997 best-selling book, *The Innovator's Dilemma, Christensen* separates new technology into 2 categories: sustaining and disruptive.[1] A disruptive technology is one that displaces an established technology and shakes up the industry or a groundbreaking product that creates a completely new industry. Examples include: personal computers, cell phones, e-mail, laptop computer, cloud computing, and social networking.[b]

There are approximately 86 million Americans aged 55 years and older who have seen these transformative technologies in their lifetime.[c] This generation has seen the development of not only personal computers and cell phones, but also moon landings and space shuttles, hybrid cars, and many other things that are now commonplace. These things are so indispensible to our daily lives that we can't imagine living without them.

Many of us are now looking at the things that the under 25-year-old crowd is embracing. We don't understand many of them, but some will be like the transforming technology of the cell phone. You can bet that surgery and anesthesia will certainly see their share of changes, improvements, and disruptive technologies.

The study and practice of medicine is constantly changing. Hospitals and specialty societies develop protocols and standards of care based on what is thought to be the best evidence and science at the time. Over the years, these things change or even go in cycles: leaches for bloodletting, tourniquets for limb salvage at the scene of trauma, and crystalloid versus colloid for resuscitation. Standards for patient monitoring during anesthesia at Harvard Medical School were published in 1986.[2] These standards were used during formulation of the American Society of Anesthesiologists Standards for Basic Intra-Operative Monitoring adopted on October 21, 1986.[3] An editorial in *Anesthesiology* in 1988 stated: "We believe that pulse oximetry should become part of the routine monitoring of all patients undergoing general anesthesia."[4]

The most recent version of the American Society of Anesthesiologists Standards for Basic Anesthesia Monitoring was last affirmed on October 28, 2015.[d] No surprise to anesthesia providers in high-income countries, these standards include use of pulse oximetry and end-tidal CO_2 monitoring.

> Standard 2.2.2 Blood oxygenation: During all anesthetics, a quantitative method of assessing oxygenation such as pulse oximetry shall be employed.
>
> Standard 3.2.2 When an endotracheal tube or laryngeal mask is inserted, its correct positioning must be verified by clinical assessment and by identification of carbon dioxide in the expired gas.[d]

Although some practicing anesthesia providers in Western countries remember administering anesthesia without these monitors, no one would accept that as appropriate in 2016. Although we might forgo continuous temperature monitoring or make clinical decisions about frequency of blood pressure determination or use of invasive monitors, none of us would perform an anesthetic without a pulse oximeter or end-tidal CO_2 monitor, and if we had equipment failure during an anesthetic, we would insist on a replacement monitor immediately.

Enright et al.,[5] in this issue of *A&A Case Reports*, describe the amazing work of the Lifebox project. What started as a discussion about mortality rates from anesthesia in low- and middle-income countries has grown into the Lifebox Foundation (founded in 2011), an organization that has seized a responsibility to be an advocate for the provision of safe anesthesia and surgery for all patients. This impressive work has now led to a worldwide initiative to ensure that a reliably functioning pulse oximeter is available in every operating room and recovery room worldwide and that the clinicians using this device have been educated in its effective application to the anesthetized patient. Their goal is that every anesthetic is monitored with a pulse oximeter. Their results are impressive. Ninety countries reached, >11,000 oximeters delivered to hospitals in low- and middle-income countries and 10 million more anesthetics every year are now being monitored with a pulse oximeter than before the Lifebox initiative began.

As anesthesiologists we pride ourselves on being vigilant. We pride ourselves on our safety record and our appropriate use of technology to improve patient care and safety. We advocate for improvements in safety, in proven clinical

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[a]Available at: http://www.spacex.com/hyperloop. Accessed February 18, 2016.

[b]Available at: http://whatis.techtarget.com/definition/disruptive-technology. Accessed February 18, 2016.

[c]Available at: https://www.cia.gov/library/publications/the-world-factbook/geos/us.html. Accessed February 19, 2016.

[d]American Society of Anesthesiologists: Standards for Basic Anesthetic Monitoring. October 2015. Available at: http://www.asahq.org/~/media/Sites/ASAHQ/Files/Public/Resources/standards-guidelines/standards-for-basic-anesthetic-monitoring.pdf. Accessed on February 19, 2016.

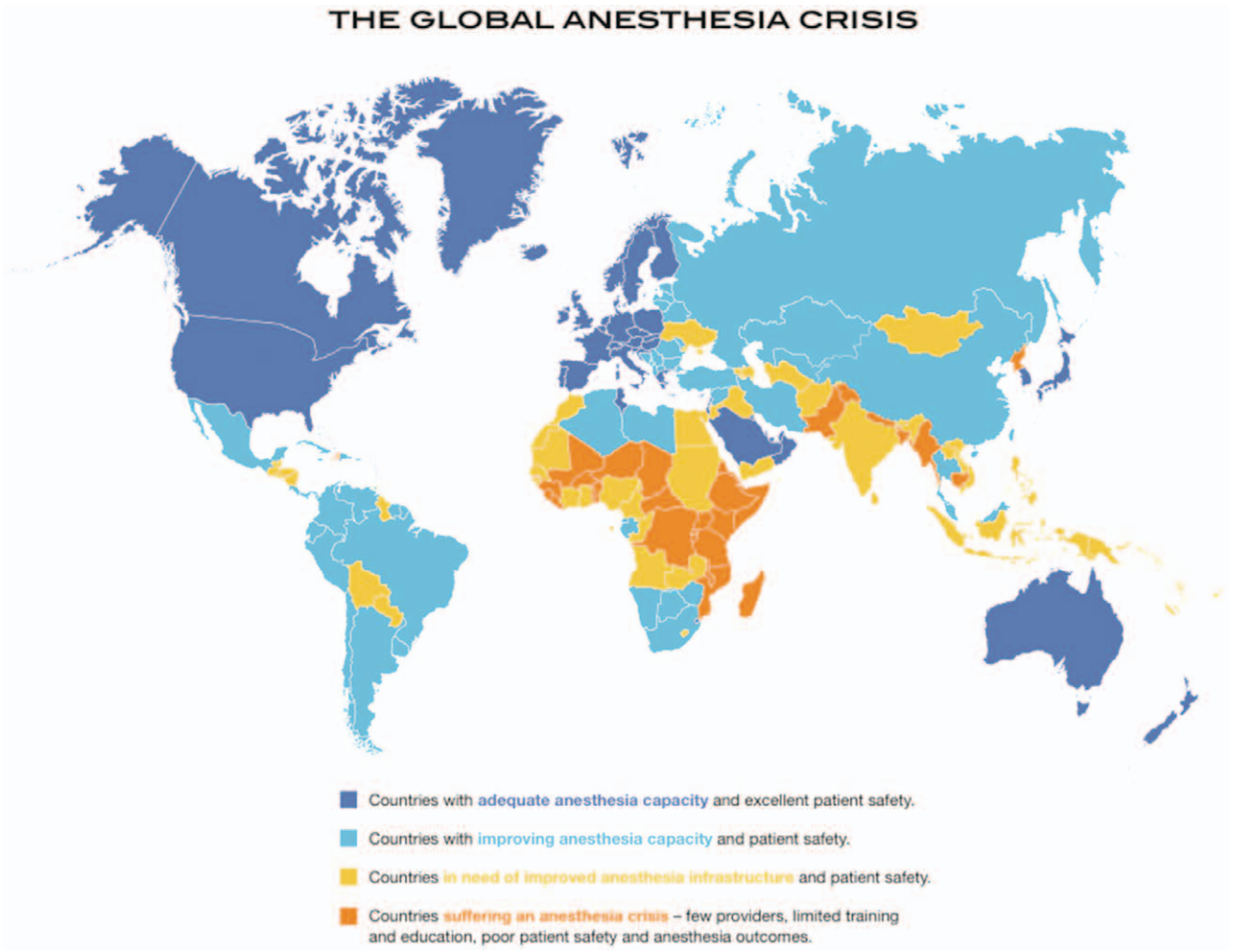

Figure 1. The stark reality of anesthesia capacity and patient safety.[7] Dark blue: Countries with adequate anesthesia capacity and excellent patient safety. Light blue: Countries with improving anesthesia capacity and patient safety. Gold: Countries in need of improved anesthesia infrastructure and patient safety. Orange: Countries suffering an anesthesia crisis—few providers, limited training and education, poor patient safety, and anesthesia outcomes. The Global Anesthesia Crisis/2015 is reprinted with permission of the American Society of Anesthesiologists, 1601 American Lane, Schaumberg, Illinois 60173.

pathways, and in evidence-based treatment algorithms. We cannot sit back and let patients around the world die or suffer unnecessary disability for lack of surgery. We cannot allow surgery to be performed without safely delivered anesthesia.

Some of us can be actively engaged in improving standards of care around the world, some of us can teach and provide education for safe anesthesia around the world, and some of us can move to a low- and middle-income country and be actively engaged in these efforts on the ground. We realize that not everyone can do these things.

What we can ALL do is recognize that the standards of care, that we not only embrace, but also insist upon, are not considered standards of care everywhere. In fact, in many places what we consider "standards of care" either don't exist at all or are rare and when present might actually be disruptive technologies. We can support the efforts of Lifebox both by spreading the word and supporting the work with our financial support and by embracing the need for pulse oximeters around the world. We can educate ourselves about the dire need for safe surgery and anesthesia around the world. We can join societies that promote these efforts and advocacy. We can advocate for those around the world who have not benefitted from what is commonplace and essential for us.

Two landmark articles[6,7] and a World Health Assembly resolution[e] in 2015 called attention to the need for access to surgery and safe anesthesia. The map of the Global Anesthesia Crisis puts this concept into a startling visual (Fig. 1).[8]

In 1963, John F. Kennedy, then President of the United States, borrowed the words of George Bernard Shaw and said in an address to the Irish Parliament: "We need men who can dream of things that never were, and ask why not."[f,8]

Our dream must be that no one has surgery or anesthesia without the use of a pulse oximeter. And let's not stop

[e]Sixty-Eighth World Health Assembly. Strengthening Emergency and Essential Surgical Care and Anaesthesia as a Component of Universal Health Coverage: WHA68.15. Geneva: World Health Organization; May 26, 2015. Available at: http://www.who.int/surgery/en/. Accessed February 19, 2016.

[f]Available at: http://www.jfklibrary.org/Asset-Viewer/lPAi7jx2s0i7kePPd-JnUXA.aspx. Accessed February 19, 2016.

[8]GEORGE BERNARD SHAW, Back to Methuselah, act I, Selected Plays with Prefaces, Vol. 2, p. 7 (1949). Available at: http://www.bartleby.com/73/465.html. Accessed February 19, 2016.

there. Here is my next dream: that we take the model of Lifebox and develop a small, hand-held, reliable end-tidal CO_2 monitor. I for one would not want to have surgery or anesthesia without a pulse oximeter AND end-tidal CO_2 monitor. Why should so many around the world not have these essential safety monitors?

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