Robots Will Perform Anesthesia in the Near Future: Comment

To the Editor:

It was a pleasure to read the editorial by Dr. Hemmerling, and it was very promising to see open discussion about technological innovation affecting the field.[1] I agree that automated robotic systems appear inevitable. However, I would wish to comment that it is important to highlight both artificial intelligence and robotics as two distinct innovations that work synergistically together in this context. In a future where robots are responsible for delivery of anesthesia in theater, both innovations will require substantial development to ensure that the system can adequately learn from and respond to variation. Assuming any rate of improvement to these systems, they may soon begin to outperform humans, and the input of the human anesthetist may gradually shift toward a supervisory role.

One of the main advantages of machine learning algorithms is that they are capable of outperforming human decision-making, provided that their datasets are reliable and their decision-making has been refined appropriately before use. Dr. Hemmerling illustrates a good example of what anesthesiology in theater may look like in 2030, assisted by a robot. In this example, it is the human who offers the instructions and the robot executes them. This contrasts with other specialties, such as radiology and dermatology, where deductive artificial intelligence systems may offer diagnoses for the human to confirm and then act upon. If artificial intelligence systems are trained on large, diverse, and clean datasets, they should, in theory, be able to make decisions on the type of anesthesia to be performed and the various target parameters. Moravec's paradox dictates that programming artificial intelligence systems to complete these complex cognitive tasks is often relatively straightforward when compared to simple physical robotic tasks.[2] Before we see robots take over the delivery of anesthesia, they may begin to take over the instruction of what to deliver. Dr. Hemmerling compares the technology to the emergence of self-driving cars, which require similar alliance between artificial intelligence and robotics. This is a particularly appropriate comparison considering that issues of data homogenization, accountability, and unrepresentative datasets must be resolved before both of these technologies populate our highways and operating theaters. The timescales are uncertain, but that does not make them impossible.

Competing Interests

The author declares no competing interests.

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Robots Will Perform Anesthesia in the Near Future: Reply

In Reply:

I thank Mr. Arora for his interest and comment[1] concerning an editorial I had written depicting robotic anesthesia as the future of anesthesia.[2]

There are four distinct terms that are important: artificial intelligence, machine learning, big data, and robotics.

According to the Oxford English Dictionary, artificial intelligence describes "the study and development of computer systems that can copy intelligent human behavior"; machine learning "a type of artificial intelligence in which computers use huge amounts of data to learn how to do tasks rather than being programed to do them." Big data

is defined as "sets of information that are too large or too complex to handle, analyze or use with standard methods." Finally, a robot is considered as "a machine that can perform a complicated series of tasks by itself."

Once reading the definitions, one understands that artificial intelligence is the overall entity that researchers have used to build robots, and that machine learning enables the robot to "evolve" itself, adapting and adjusting to perform better using its own experiences. In a recent review article on artificial intelligence,[3] the importance of input by practicing clinicians in the further development of devices using artificial intelligence was pointed out: one could imagine that future robots will be put into use and that they might "improve" on the job, as humans should do, using machine learning based on experiences, feedback from the clinicians, and program changes. Big data will be helpful because the more "data" are available, the more the robot can use to improve: big data are the computer equivalent of years of experience of a human anesthesiologist.

Obviously, robots improving on their own using machine learning will be a significant challenge not only for the developers but also for regulatory entities, which will have to "recertify" or "re-evaluate" these robots. It is also important to notice that machine learning is still in its infancy with some research in anesthesia showing promising results. Arora[1] states that machine learning algorithms are capable to outperform human decision-making provided that their data set is reliable. I personally believe that machine learning will "take off" with the widespread creation of big data and its use to develop appropriate machine learning algorithms. The more data can be fed into a machine learning system, the better this system can adapt. To repeat the former analogy, the more experience an anesthesiologist has, the more he or she has experienced, and his or her techniques have been able to evolve and change. I believe that future developmental strategies should adopt a concept where new big data are constantly fed into a robot in order for it to improve itself, similar to anesthesiologists who grow wiser and better with years of training, training in simulation, reading books and articles… This concept could be a sort of "continuous medical education" for robots!

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The author declares no competing interests.

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Methadone and Chronic Pain: Comment

To the Editor:

I read with interest the article by Murphy *et al.*[1] Their study was thought provoking in the context of reducing postoperative medication requirements in the midst of our nation's opioid crisis. I was most interested in the results of the complex back surgery patients and their postoperative pain medication use.

Preoperative opioid use is not documented in their study. Previous studies have shown that preoperative use of opioids is one of the most important risk factors in long-term opioid use postoperatively.[2] Without knowing which patients were taking preoperative opioids, it is difficult to interpret their postoperative analgesic requirements and frequency of use results.

This study examines the very interesting idea of adding perioperative methadone to reduce postoperative analgesic requirements. I am encouraged that the authors are pursuing innovations in enhanced recovery after surgery protocols to minimize postoperative pain and opioid use.

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The author declares no competing interests.

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