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Editorial

Artificial Intelligence in Anesthesia and Perioperative Medicine is Coming

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Artificial intelligence in medicine (AIM) will grow in importance in the decades to come and will change anesthesia practice, surgical practice, perioperative medicine in clinics, and the interpretation of imaging. AI is already prevalent in our daily life. Smartphones verbally direct us to our destination through mazes of highways and traffic. Self-driving cars are in advanced testing phases. The Amazon Echo brings us Alexa, an AI-powered personal assistant who follows verbal commands in our homes. AIM advances are paralleling these inventions in three clinical arenas:

1. **Operating rooms:** Anesthesia robots fall into two groups: manual robots and pharmacological robots. Manual robots include the Kepler Intubation System intubating robot, designed to utilized video laryngoscopy and a robotic arm to place an endotracheal tube [1], the use of the DaVinci surgical robot to perform regional anesthetic blockade [2], and the use of the Magellan robot to place peripheral nerve blocks [3,4]. Pharmacological robots include the McSleepy intravenous sedation machine, designed to administer propofol, narcotic, and muscle relaxant [5], and the iControl-RP machine, described in *The Washington Post* as a closed-loop system intravenous anesthetic delivery system which makes its own decisions regarding the IV administration of remifentanil and propofol [6]. This device monitors the patient's EEG level of consciousness via a BIS monitor device as well as traditional vital signs [7]. One of the machine's developers, Mark Ansermino MD stated, "We are convinced the machine can do better than human anesthesiologists." The current example of surgical robot technology in the operating room is the DaVinci operating robot. This robot is not intended to have an independent existence, but rather enables the surgeon to see inside the body in three dimensions and to perform fine motor procedures at a higher level. The good news for procedural physicians is that it's unlikely any AIM robot will be able to independently master manual skills such as complex airway management or surgical excision. No device on the horizon can be expected to replace anesthesiologists. Anesthetizing patients requires preoperative assessment of all medical problems from the history, physical examination, and laboratory evaluation; mask ventilation of an unconscious patient; placement of an airway tube; observation of all vital monitors during surgery; removal of the airway tube at the conclusion of most surgeries; and the diagnosis and treatment of any complication during or following the anesthetic.
2. **Clinics:** In a clinic setting a desired AIM application would be a computer to input information on a patient's history, physical examination, and laboratory studies, and via deep learning establish a diagnosis with a high percentage of success. IBM's Watson computer has been programmed with over 600,000 medical evidence reports, 1.5 million patient medical records, and two million pages of text from medical journals [8]. Equipped with more information than any human physician could ever remember, Watson is projected to become a diagnostic machine superior to any doctor. AIM machines can input new patient information into a flowchart, also known as a branching tree. A flowchart will mimic the process a physician carries out when asking a patient a series of increasingly more specific questions. Once each diagnosis is established with a reasonable degree of medical certainty, an already-established algorithm for treatment of that diagnosis can be applied. Because anesthesiology involves preoperative clinic assessment and perioperative medicine, the role of AIM in clinics is relevant to our field.

3. **Diagnosis of images**: Applications of image analysis in medicine include machine learning for diagnosis in radiology, pathology, and dermatology. The evaluation of digital X-rays, MRIs, or CT scans requires the assessment of arrays of pixels. Future computer programs may be more accurate than human radiologists. The model for machine learning is similar to the process in which a human child learns--a child sees an animal and his parents tell him that animal is a dog. After repeated exposures the child learns what a dog looks like. Early on the child may be fooled into thinking that a wolf is a dog, but with increasing experience the child can discern with almost perfect accuracy what is or is not a dog. Deep learning is a radically different method of programming computers which requires a massive database entry, much like the array of dogs that a child sees in the example above, until a computer can learn the skill of pattern matching [9]. An AIM computer which masters deep learning will probably not give yes or no answers, but rather a percentage likelihood of a diagnosis, i.e. a radiologic image has a greater than a 99% chance of being normal, or a skin lesion has a greater than 99% chance of being a malignant melanoma. In pathology, computerized digital diagnostic skills will be applied to microscopic diagnose. In dermatology, machine learning will be used to diagnosis skin cancers, based on large learned databases of digital photographs. Imaging advances will not directly affect anesthesiologists, but if you're a physician who makes his or her living by interpreting digital images, you should have real concern about AIM taking your job in the future.

There's currently a shortage of over seven million physicians, nurses and other health workers worldwide [10]. Can AIM replace physicians? Contemplate the following: All medical knowledge is available on the Internet; most every medical diagnosis and treatment can be written as a decision tree algorithm; voice interaction software is excellent; the physical exam is of less diagnostic importance than scans and lab tests which can be digitalized; and computers are cheaper than the seven-year post-college education required to train a physician. There is a need for cheaper, widespread healthcare, and the concept of an automated physician is no longer the domain of science fiction. Most sources project an AIM robot doctor will likely look like a tablet computer. For certain applications such as clinical diagnosis or new image retrieval, the AIM robot will have a camera, perhaps on a retractable arm so that the camera can approach various aspects of a patient's anatomy as indicated. Individual patients will need to sign in to the computer software system via retinal scanners, fingerprint scanners, or face recognition programs, so that the computer can retrieve the individual patient's EHR data from an Internet cloud. It's possible individual patients will be issued a card, not unlike a debit or credit card, which includes a chip linking them to their EHR data.

What will be the economics of AIM? Who will pay for it? America spends 17.8% of its Gross National Product on healthcare [11] and this number is projected to reach 20% by 2025. Entrepreneurs realize that healthcare is a multi-billion dollar industry, and the opportunity to earn those healthcare dollars is a seductive lure. Companies are looking to merge increasing computing power, electronic health information data from large patient populations, and artificial intelligence devices, with the eventual aim of driving *down* the healthcare costs while increasing effectiveness.

It's inevitable that AIM will change current medical practice. Vita is the Latin word for "life." I coin the name "Doctor Vita" for the AIM robot which will someday do many of the tasks currently managed by human physicians. Doctor Vita machines will breathe new life into our present healthcare systems. In all likelihood these improvements will be more powerful and more wonderful than we could imagine. A bold prediction: AIM will change medicine more than any development since the invention of anesthesia in 1849. How physicians interact with these machines will be a leading question for the twenty-first century.

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