The Introduction of Closed-Loop Anesthesia Systems in Surgical Practice

Ryan Pearson

Oregon Institute of Technology

Writing 345: Science Writing

Dr. Michael Lucas

10/24/22

The Introduction of Closed-Loop Anesthesia Machines in Surgical Practice

The introduction of anesthesia was monumental in the field of medicine. Prior to this development, patients would resort to other extreme measures to reduce pain during surgery such as alcohol, the opium poppy, and herbal remedies. These methods have been traced back to the early civilizations of people. Furthermore, the idea to inhale nitrous oxide by William T.G. Morton in 1848 led the way to the field of anesthetics, which would eventually help many people (Robinson & Toledo, 2012). The initial discovery by Morton in 1848 had a snowball effect as many other improvements and developments were quickly made to this medicine. Joseph O'dwyer created the first endotracheal tube in 1884. Following this, the first nitrous oxide, oxygen, and ether anesthesia machine were built by Henry E. G. Boyle 1917. The addition of a cuff to the ventilation tube was credited to Ralph M. Waters in 1932. Lastly, using barbiturates as an intravenous anesthetic was also coined in 1932 (History of Anesthesia*,* 2015). The following literature review will evaluate the differences between open vs closed-loop control and the prospect of introducing closed-loop anesthesia delivery systems into live surgery.

The current way anesthesia is administered is referred to as 'open loop control'. This means that the anesthesiologist is responsible for manually checking and maintaining the parameters of the patient. These parameters consist of heart rate, blood pressure, breathing, the depth of anesthesia the patient is in, and the number of drugs that the patient receives to ensure they stay unconscious (American Society of Anesthesiologists, n.d.). Prior to surgery, the anesthesiologist will create a pre-specified patient pharmacokinetic (PK) or pharmacokinetic-pharmacodynamic (PK-PD) model to use this system. These models are adjusted for each patient depending on the age, weight, allergies, or underlying medical conditions the patient may have.

The anesthesiologist has to observe changes in a patient's vitals and then manually input them into the open-loop system (American Society of Anesthesiologists, n.d.).

The other way in which anesthesia is delivered is via the ‘closed-loop control’. This method offers a great deal of advantages over the traditional open-loop system set up. These advantages include a reduction human error, higher precision over targeted outcomes, and also more time for the anesthesiologist to focus on more pressing matters during surgery (Radius Anesthesia, 2020). However, the largest difference between the two systems is as follows: the closed-loop system generates updated values (of parameters) every eight to ten seconds, whereas the anesthesiologist has to check manually every so often by themselves in the open-loop system. Additionally, the closed-loop system does not require pre-specified patient pharmacokinetic (PK) prior to surgery (Brog, n.d.).

A large question that faces may practitioners and patients is, which delivery system of anesthesia is more effective? The answer is quite clear cut. In their article “Closed-loop anesthesia: Ready for prime time?” medical doctors Robert G. Loeb and Maxime Cannesson assess the performances of each system. In this article, they review 2 meta-analyses focused on anesthesia and sedation, that included 744 patients to find the answer to this question. According to the two medical doctors, “the automated [closed-loop] systems increased by 17.4% the proportion of time that a set variable (eg, Bispectral IndexTM [BISTM]) was maintained within a desired range: 40–60” (Loeb & Cannesson, 2017). This discovery shows that patients under the closed-loop control spent a greater time between the ideal level of sedation, or the bispectral index, which means that the care of anesthesia was better and less harmful to the body. In addition, Loeb and Canneson state, “that closed-loop intravenous anesthetic delivery was associated with a 0.37 mg/kg lower per-weight dose of propofol administered for anesthesia induction and a 1.67-minute faster recovery time" (2017). This statement by the two doctors show that the closed-loop system was also able to dispense less anesthetics during surgery which also correlated to a faster recovery time; two signs of improved care compared to the open-loop system.

It appears that the real question at hand is not whether the closed-loop control is more effective than open-loop control, but rather if it is safe and reliable enough to deploy in live surgeries. As of now, the closed-loop systems have not been approved for use. In the same article, Loeb and Canneson look to delve into this question. They discovered a discussion paper published by the Food and Drug Administration that reviewed the possibility of closed-loop control systems being deployed in the US. In this paper by the FDA, Loeb and Canneson came away with these points: the system approval depends upon a positive benefit to risk ratio, the experience with closed-loop control is still small, and the risks of these systems need to be further investigated (2017). Overall, this paper published by FDA alludes to the possibility that there is hope for the future of closed-loop systems in the United States.

There is still much ahead in the field of anesthesiology. However, it looks as though the biggest improvement for the future lies in the closed-loop system. In order to keep developing and improving with the rest of medicine, the approval for these devices must be attained. What lies next is ironing out the risks of the devices, in hope that the FDA will approve them for use in the United States.

References

Brog, E. (n.d.). Open- and closed-loop control with TCI. Retrieved May 31, 2022, from https://cran.r-project.org/web/packages/tci/vignettes/open-closed-loop-control.html

General anesthesia: Definition & side effects - made for this moment. American Society of Anesthesiologists | Anesthesia, Pain Management & Surgery. (n.d.). Retrieved May 31, 2022, from https://www.asahq.org/madeforthismoment/anesthesia-101/types-of-anesthesia/general-anesthesia/#:~:text=During%20surgery%20or%20the%20procedure,unconscious%20and%20free%20of%20pain

History of Anesthesia - Interactive Timeline. (2015). Woodlibrarymuseum.org. https://www.woodlibrarymuseum.org/history-of-anesthesia/

Loeb, R., G., & Cannesson, M. (2017). Closed-loop anesthia: Ready for prime time? *Internation Anesthesia Research Society, 124*(2), 381-382. DOI: 10.1213/ANE.0000000000001640

Radius Anesthesia. (2020, September 14). *Closed-loop systems in anesthesia - ambulatory anesthesia services: OBS Anesthesia Management Groups*. Ambulatory Anesthesia Services | OBS Anesthesia Management Groups. Retrieved May 31, 2022, from https://radiusanesthesia.com/closed-loop-systems-anesthesia/