Embedded Based Injector to Control the Flow of Anesthesia

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Abstract- When a critically ill patient is in a surgical procedure, a powerful dosage of general anesthesia is given to the patient so that he/she doesn't wake up in the middle or experience any pain. The anesthetist administers the level or rate of anesthesia based on the various parameters like type of procedure performed, duration of procedure, previous medical history and performance of the patient's vital parameters like heart rate, blood pressure, oxygen saturation, end-tidal carbon dioxide (ETCO2), and body temperature. Henceforth if the dosage of anesthesia fails to deliver, it leads to potential complications like cardiac arrest, hypertension, respiratory depression and inadequate pain. To overcome this traditional risk, an automated anesthesia injector is designed with an Arduino UNO.

Indexed Terms- Anesthesia, Automated, Arduino Uno, Dosage, General Anesthesia, Potential Complications, Vital Parameters.

I. INTRODUCTION

The dosage of a drug, anesthesia will make the patient temporarily lose sensation or consciousness when they are undergoing any type of surgical or medical procedure. The types of anesthesia and dosage of anesthesia varies from one patient to another as each patient undergoes a different medical procedure and has different medical history. Anesthesia is commonly given to the patient through two methods, gas inhalation and intravenous (IV) drug. The focus is on the intravenous drug system as gas inhalation is already controlled through different setups. Anesthesia also has three types which include general, local and regional anesthesia. General anesthesia is typically administered through a combination of inhaled gasses and intravenous (IV) methods whereas other two, regional and local anesthesia are mostly used in intravenous methods.

The dosage of anesthesia is determined by several factors like the patient's age, weight, previous medical history, current health status, type of procedure performed and importantly the time that takes to operate the procedure. Patient's vital parameters like heart rate, blood pressure, oxygen saturation, end-tidal carbon dioxide (ETCO2), and body temperature are also taken into account. Medical procedure that is operating through anesthesia over a long period of time like 3 to 4 hours might look normal but it is not. In the real scenario, an anesthetist or for matter of fact any training professional cannot continuously monitor the level of anesthesia due to the limitation of monitoring equipment or professional resources as anesthetists will also be nurses in most of the cases. Therefore, patients who require prolonged anesthesia exposure may require additional monitoring and management to minimize the risk of complications such as cognitive dysfunction, postoperative delirium, and other adverse events.

It would even become worse when there is change in the rate of vital parameters during medical procedure as these parameters provide important information about the patient's condition and may indicate that changes need to be made to the anesthesia or other aspects of the patient's care. This is such a huge downside of injecting anesthesia in traditional methods. Even though anesthesia cases have relatively come down all these years, there are still some cases adding up due to human error or carelessness. For completely administering the anesthesia in a single stroke and to conquer the problems and blunders that are happening because of miscalculation in determining the dosage of anesthesia, an automated anesthesia injector can be seen as a solution. Anesthesia injector is automated using a microcontroller (Arduino UNO), which controls the received signal from clinical vital parameters such as heartbeat and temperature. These parameter signals determine the rotation of the stepper motor which then initiates the movement of the syringe setup in forward at a certain cause. Anesthesia loaded inside the syringe will start to inject and the level or dosage of anesthesia will be determined from the proceedings of body reactant i.e, the change in heartbeat or temperature will correspond to the rate of change in anesthesia. All the data that is required to operate a medical procedure and required to analyze postoperative will be recorded and submitted to the hospital server so that the doctor or patient can view the data in a web page for any future analysis. This setup also includes an alert feature, which will beep or alarm when the level of anesthesia for a particular dosage is low. By successfully implementing this method, the job of anesthetist can be eliminated and they can be used in the workforce that require critical ability like infection control, medical diagnosis and medical support, instead of doing the same repetitive process. This method will also enable the anesthetist or other medical staff to work in remote areas and work simultaneously for more surgical procedures. The goal is to administer enough anesthesia to keep the patient comfortable and pain-free during the procedure while minimizing the risks of side effects or complications and this whole setup can be seen as a small inch towards advanced medical technology.

II. OBJECTIVE

- To revamp the already existing anesthesia injector with automation so that the risk of human error is reduced and the safety and efficiency of the whole procedure is significantly improved.
- To deliver precise and controlled dosage of anesthesia to patients during medical procedure.
- To control and set up the dosage of anesthesia for any medical procedure using a human-friendly web interface.
- To produce alarm or beep when the level of anesthesia is low for every determined dosage.

III. LITERATURE REVIEW

"A Comparative Study of the Efficacy of Anesthesia Injectors in Pediatric Dentistry" by B. Gowri, R. Kavitha, and M. Kumar. This study compared the effectiveness of two anesthesia injectors in pediatric dentistry. The authors found that both injectors were effective in delivering local anesthesia, but one injector was preferred by the patients due to its reduced pain.

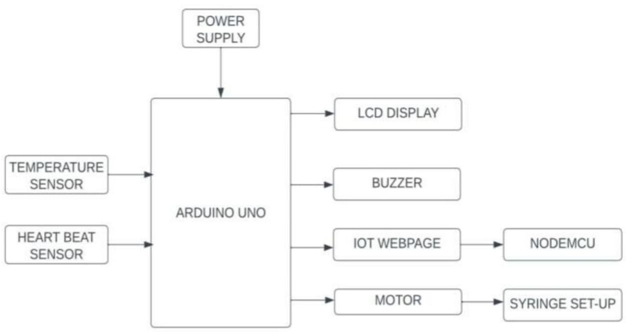
"The Effect of Injection Rate on Pain During Anesthesia Delivery: A Randomized Clinical Trial" by C. D. Bekker, R. P. Bell, and D. K. Lee. This study investigated the effect of injection rate on pain during anesthesia delivery. The authors found that a slower injection rate resulted in less pain for the patient.

"A Comparative Study of Two Computer-Controlled Anesthesia Delivery Systems for Maxillary Infiltration Anesthesia" by S. M. Miller and C. E. Knudson. This study compared the effectiveness of two computer-controlled anesthesia delivery systems for maxillary infiltration anesthesia. The authors found that both systems were effective in delivering local anesthesia, but one system was preferred by the patients due to its reduced pain.

"Comparison of Two Types of Local Anesthesia Injectors for Maxillary Infiltration Anesthesia" by Y. Zhang, X. Wang, and Y. Ma. This study compared the effectiveness of two types of local anesthesia injectors for maxillary infiltration anesthesia. The authors found that both injectors were effective in delivering local anesthesia, but one injector was preferred by the patients due to its reduced pain.

"Effectiveness of a Computer-Controlled Local Anesthesia Delivery System in Mandibular Block Anesthesia: A Randomized Controlled Trial" by S. Srivastava, R. Tiwari, and V. Gupta. This study investigated the effectiveness of a computer-controlled local anesthesia delivery system in mandibular block anesthesia. The authors found that the computer-controlled system resulted in less pain and discomfort for the patient compared to a conventional syringe.

IV. WORKING



Just like other modernized industries, healthcare also uses embedded systems. By using the embedded system in healthcare we can improve patient outcomes, patient safety, cost-efficiency, and personalized care. Similarly, traditional methods of anesthesia injector can be revamped into automation by using a microcontroller - Arduino UNO, which can be described as the heart of any modern system. Other components that are required additionally to the Arduino UNO are sensors such as temperature and heartbeat, stepper motor, syringe setup, NODEMCU, and piezoelectric buzzer.

Microcontroller, Arduino UNO is programmed with a set of instructions that dictate how the anesthesia should be injected. Injector is connected to the patient via an intravenous (IV), which allows the anesthesia to directly deliver to the patient's bloodstream. Thus the microcontroller is responsible for delivery as it contains all the necessary instructions. Microcontroller receives input from the temperature and heartbeat sensor which then reads and processes the data resulting in stimulating the flow of anesthesia according to the rate of changes in vital parameters. The stimulation behind the precise flow of anesthesia is the stepper motor as it is responsible for moving the syringe plunger in the forward direction for given abnormality. It is all possible as the syringe setup is connected to the stepper motor and controlled by the Arduino UNO. The movement of the syringe plunger is determined by the data the microcontroller has i.e, microcontroller sends the flow of electrons to move in a given direction. The flow will adjust, maintain and even stop based on the sensor data. Buzzer is used for the safety purpose, which produces a beep or alarm sound for medical personnel or anesthetists when the anesthesia is a few millimeters before the dosage gets over or outside the safe parameters. All the details such as the value of heartbeat, temperature, timer, and the determined dosage level are displayed in LCD and also allows the medical professionals to adjust or modify the setting of the injector. Dosage of anesthesia will keep changing for different medical procedures, duration of the procedure and the response of vital parameters, though the size of syringe remains same. Dosage is controlled by sending the command from webpage to anesthesia injector and then the anesthetist will input the desired dosage and flow rate of anesthesia after pre analysis.

NodeMCU, a Wi-Fi enabled microcontroller is responsible for data logging all the details that are submitted to the hospital server, which can be later seen by the patient and doctor so that these data are used for postoperative analysis. NodeMCU is connected wirelessly to the whole system through Arduino UNO. Overall, the microcontroller helps the anesthesia injector to inject anesthesia precisely and in a controlled manner in real-time so that the patient's safety and postreactions are improved during long medical procedures. In simple terms, the working of an automatic anesthesia injector can be seen as a feedback control system that regulates the flow of anesthesia to the patient during the long medical procedure.

V. FUTURE ENHANCEMENT

- Can introduce many more biomedical parameters such as blood pressure, oxygen saturation, End-tidal carbon dioxide (EtCO2), Electrocardiogram (ECG).
- Can be equipped with advanced wireless communication capabilities so that the communication between the system is seamless.
- Can use the latest technology like artificial intelligence (AI) so that the accuracy and precision of anesthesia delivery are improved

largely.
- Can use mobile applications instead of the webpage at the same time can store the data that is received to the cloud instead of databases as it is more efficient.

VI. EXPERIMENTAL RESULT

Microcontroller, Arduino UNO controls the whole setup of the anesthesia injector and the received vital parameter data result in the flow of anesthesia and rotation of syringe. If the patient's temperature increases to more than the normal and heartbeat increases to more than the normal then the speed of the stepper motor increases as the Arduino UNO increase the flow rate of the anesthesia to maintain the desired level of sedation.

CONCLUSION

Just like other domains, healthcare is also modernizing its instrument by using various latest technologies. In the same way, an embedded based anesthesia injector will not only revolutionize the delivery of anesthesia but also help move an inch forward in modern medicine. The best part of using technologies is that it goes well with other technologies. Hence we can develop and integrate the automatic anesthesia with other technologies like artificial intelligence, machine learning, internet of things and cloud technologies. The goal of this system is to produce precise, control and efficient delivery of anesthesia to the patient in the long medical procedure. However with any technology, there are drawbacks and limitations like technical failures, cyber security risks but this can be tackled in the coming future with the rapid technology improvement.

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