Automatic Anaesthesia Injector

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Abstract- In operating theatres, anaesthetists usually adopt a specific regime to administer anaesthetic drugs during the different stages of the operation. The amount of drug varies from person to person depending on various factors such that age, weight, gender, etc. There might be emergency cases when the anaesthetist might not be available immediately and therefore it becomes important to design a system which will calculate the amount of anaesthetic drug required for that surgery depending on the various factors of the patient. The second important factor is to continuously monitor the state of consciousness patient during the surgery.

Keywords- anaesthetists, anaesthetic drugs, surgery.

Introduction

Anaesthesia in the operating room consists mainly of the administration of anaesthetics to patients in order to produce unconsciousness and to ensure safe surgery without an undesirable incidence. Some of these processes and procedures are fixed and predetermined and others are based on the patients' response to interventions, such as changing infusions of anaesthetics or inhaled concentrations, administering drugs and infusions to maintain hemodynamics, etc. The processes are repeating and require constant attention. The anaesthetists are always prone to human error. Establish an intravenous line, check the machine and equipment, monitor, administer anaesthetic medication, assess the airway, maintain breathing and hemodynamics, and administer intravenous fluids and blood products. Change the dose of effective medication based on the needs and responses of the patients. These are some of the activities an anaesthetist should perform daily while anesthetizing patients. Although the error rate is low, the risk is high. For this reason, automation has been introduced in these industries as a security measure. It is necessary to automate some of the anaesthesia processes to minimize human error, to minimize the distractions of repetitive routine activities, and the anaesthetist may have more time for direct patient care. The Department of Anaesthetics and Intensive Care Medicine at Chandigarh Graduate School of Medical Education and Research has made great strides in developing an automated anaesthesia system that is expected to be the future of standard anaesthesia[2][7]. In the development of computers, attempts have been made to automate the supply of anaesthetics and related drugs, using the obvious relationship between anaesthesia depth and changes in the EEG to control the supply of intravenous anaesthetics. The researchers used simple electronic circuits with analog data acquisition systems and transformations into mechanical outputs for delivery of a drug [1][3]. Since the variability of the anaesthetic requirements requires the titration of the drugs according to the patient's response, these objective anaesthesia depth monitors have greatly increased the possibility of automating anaesthesia care based on these parameters and the likelihood of closing the cycle. This drug administration has been increasing recently.

Paper Focus

The major focus of this paper is to calculate the quantity of analgesic, anaesthetic and muscle relaxing drugs required to be given to a patient prior to a particular surgery.

Paper Organization

- In the first part of the paper the literature survey has been discussed.
- The second section consists of the proposed method for calculation the quantity of drug depending on the type of surgery.
- The third part displays the results and the output graphs.
- The future scope of this model has been discussed in the fourth part.
- The fifth includes the conclusion of this paper.
- The references referred for this model are included in the sixth part.

l. Literature Survey

Jheng-Yan Lan and MaysamAbbod provided a detailed review of the clinical aspect and engineering view of how to measure, interpret, model, and control general anaesthesia [1]. Yuan-Chao Chou and MaysamAbbod have designed a system for multivariable self organising fuzzy logic control structure for the consecutive stages of operations[2] Haskins have deviced methods for monitoring anaesthesia during operations for the safety measures of the patients [3] G.D. Puri has designed a automatic closed loop anaesthesia delivering system [4] Stephen M. Ho and Phil M. E. Waite have assessed the excitability of the Hoffman reflex (H reflex) under several commonly used anaesthetics [5] Pleym, H., O. Spigset, E. D. Kharasch, and O. Dale have studied the gender factor for predicting the dosages of anaesthesia [6] Neckebroek, Martine M., Tom De Smet, and Michel MRF Struys have proposed a closed loop system to optimize drug administration during anaesthesia and sedation. [7] Linkens, D. A. has done a brief survey of simple control applications to anaesthesia is given, and this is followed by a description of the use of generalized predictive control and fuzzy logic control for muscle relaxation.[8] Meier, R., J. Nieuwland, A. M. Zbinden, and S. S. Hacisalihzade describes research on a fuzzy logic controller which controls mean arterial pressure (MAP) which was taken as a parameter for depth of anaesthesia.[9] HeloyseUliamKuriki, FábioMícolis de Azevedo, Luciana Sanae Ota Takahashi, EmanuelleMoraes Mello, Rúben de FariaNegrão Filho and Neri Alves calculated the relationship between Electromyography and Muscle Force [10]. S. Hagihira has done a detailed study about how raw EEG changes during anaesthesia To properly appreciate the availability and reliability of EEG-derived indices [11] Omerhodzic, Ibrahim, Samir Avdakovic, Amir Nuhanovic, and Kemal Dizdarevic have designed a wavelet-based neural network (WNN) classifier for recognizing EEG signals is implemented and tested under three sets EEG signals (healthy subjects, patients with epilepsy and patients with epileptic syndrome during the seizure) [12] Xi, Chunhua, Shiyue Sun, Chuxiong Pan, Fang Ji, Xu Cui, and Tianzuo Li have aimed to analyze the EEG dynamics of dexmedetomidine and propofol at comparable sedation levels and to explore EEG changes with increased sedation levels for each agents[13] Lotte, Fabien has presented methods about how to extract relevant and robust spectral, spatial and temporal information from noisy EEG signals (e.g., Band Power features, spatial filters such as Common Spatial Patterns or xDAWN, etc.), as well as a few classification algorithms (e.g., Linear Discriminant Analysis) used to classify this information into a class of mental state. [14] Punt and M. D have tried to obtain solutions to solve the complex process of the detection of seizures and burst-suppression patterns in a neonatal EEG by using wavelet domain analysis.[15] Murphy, Michael and Marie-Aurélie Bruno have provided a detailed study of the relationship between Propofol and EEG of a signal [16]

Proposed Approach

The automatic anaesthesia injector model proposed in this paper will calculate the amount of drug of a particular surgery by using various types of regression functions and extracting the output for a given input.

The EEC signals of the patient are monitored continuously by conducting epoching of 30 sec which is used to check the status of the patient.

ll. Proposed Method

For the induction of anaesthetic drug the initial dose given to the patient is based upon the individual parameters such as :

- Weight
- Age
- Gender
- Type of surgery
- Premedication involved

- Type of drug used
- Concentration of drug

In accordance with the above parameters, range of prescribed drug to be given to the patient is mentioned.

For Propofol, the range of drug is mentioned in mg/ kg unit. As acknowledged by doctor consulted, the lower age patients and old age patients would be given the lowest amount of drug mentioned in the range and the middle aged patients would be given the highest amount of drug. According to this we created the database where the data points were varying according to the trend mentioned above. So for the regression we considered age as an independent parameter and dosage of drug as a dependent parameter.

For Ropivacaine and Bupivacaine the quantity of drug was varying according to the weight and not the age. And the data that we received was the range of total dosage of drug for the patients above the age 12 years and above weight 25 kg. To create the data points we considered the weight of 25 lg as our lower bound and 120 kg as our upper bound. So for our regression model weight was the independent variable and drug dosage was the dependent variable.

The programming language used is python and the platform used is Jupyter notebook. Polynomial Regression is being used to calculate the amount of drug needed for a particular surgery. Polynomial Regression is a form of regression analysis in which the relationship between the independent variable x and dependent variable y is modelled as a n^{th} degree polynomial. This is done by predicting the drug from the given output at a given input point. The program accepts 3 inputs from the user namely age, gender and weight. The output is calculated considering age and weight. The gender parameter is considered rarely only for specific body parts[6].

For top-up two random arrays are being generated which represents pulse rate and non invasive blood pressure (NIBP) of the patient. If the time of the surgery extends above 1 hour and if the value of pulse rate or NIBP extends a particular threshold value a particular amount of top-up is given which is 50% of premedication drug and 25% atracurium is given along with 50% premedication if propofol is given as the major drug.

For EEG signal Monitoring

In this paper the EEG of a person is also monitored. The EEG obtained is in time domain and is then converted into frequency domain using Discrete Fourier Transform.

The obtained graph is then divided into 5 parts namely

- Delta (0.2 Hz – 3 Hz)
- Theta (3 Hz – 8 Hz)
- Alpha (8 Hz – 12 Hz)
- Beta (12 Hz – 27 Hz)
- Gamma (27 Hz and above)

The graphs obtained [Fig.1, Fig.2, Fig.3] are then converted back to time domain using Inverse Discrete Fourier Transform and individual energies of the signals are calculated.

The graph with maximum energy tells the current state of the person

- Delta (0.2 Hz – 3 Hz) which signifies that the person is asleep
- Theta (3 Hz – 8 Hz) which signifies that the person is deeply relaxed
- Alpha (8 Hz – 12 Hz) which signifies that the person is relaxed
- Beta (12 Hz – 27 Hz) which signifies that the person is alert and focused
- Gamma (27 Hz and above) which signifies that the person is in high performance state

This EEG monitoring is done for knowing the current state of the person during a surgery and whether any top up dosage is required or not.

lll. Results

Results calculated for some cases using the model:

Case 1: weight = 70kg

Age =25yrs

Surgery type = Caesarean

Output: The amount of fentanyl to be given is [2.42466831] mg
The amount of Midazolam to be given is [2.0210087] mg
The amount of ropivacaine to be used is [130.92233482] mg
The amount of bupivacaine to be used is [111.32906236] mg

The amount of top up to be given is
fentanyl [84.86339092] mg
Midazolam [70.73530453] mg

Case 2 : Patient Age : 10

Patient Weight : 20

Type of Surgery: Lower Body Surgery

Output: The amount of fentanyl to be given is
[1.71125802] mg
The amount of Midazolam to be given is
[1.42338971] mg
The amount of ropivacaine to be used is
[109.90786146] mg
The amount of bupivacaine to be used is
[71.90785959] mg

The amount of top up to be given is
fentanyl [17.11258024] mg
Midazolam [14.23389707] mg

Case 3 : Patient Age : 50

Patient Weight : 80

Type of Surgery: General Major Surgery

Output : The amount of fentanyl to be given is
[2.42424976] mg
The amount of Midazolam to be given is
[2.22933782] mg

The amount of drugs that need to entered is
Propofol [1.00477514] mg
Atracurium [0.48353424] mg

The amount of top up to be given is
fentanyl [96.96999049] mg
Atracurium [9.67068472] mg
Midazolam [89.17351265] mg

The graphs obtained for EEG monitoring are as follows:

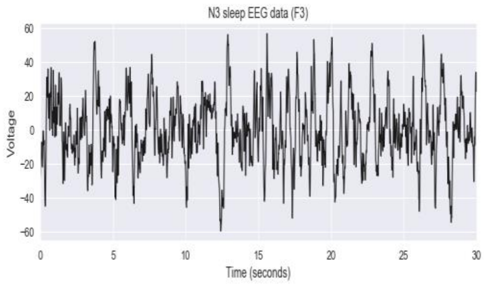

Figure 1 : N3 sleep EEG data

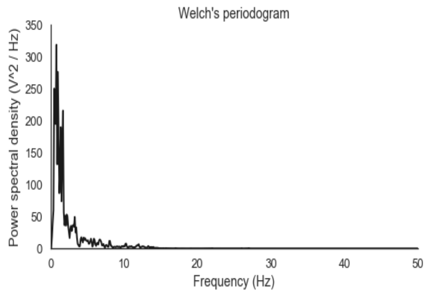

Figure 2 : Welch's periodogram

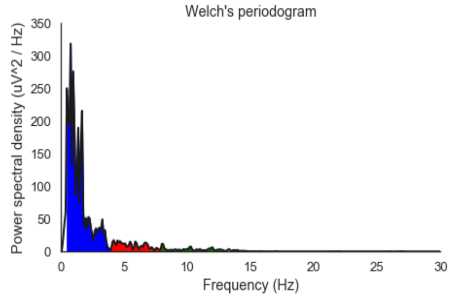

Figure 3 : Welch's periodogram

IV. Future Scope

This system has been proved to be beneficial but there is still scope of following improvements in order to make the system more effective

- Reduce response time delay of system
- Boost precision of the system
- More input parameters can be considered
- More safety measures can be incorporated for the patient's well being
- Improve accuracy and expertise of result under extreme or exceptional conditions
- More effective method can be developed for patient's physiological data collections
- To show full clinical worthiness the system still needs to be tested in real time environment.

V. Conclusion

From the obtained results it can be observed that the amount of drugs needed for a particular surgery is calculated accurately. Also using actual parameters like pulse rate and NIBP we can calculate the amount of top-up required. The continuous monitoring of EEG gives a precise idea of the state of the patient. The outputs obtained are quite accurate and are approved by the doctor.

Vl. References

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