ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 1, January 2015

A Review on Model Based Neuromuscular Blockade Control System with Injector

Dr. S.M. Deshmukh[1], Prof. A.S. Patharkar[2], Roshan M. Bodile[3]

Professor, Dept. of Electronics & Telecomm., P.R.M.I.T & R, Badnera, Amravati, Maharashtra, India[1]

Assistant Professor, Dept. of Electronics & Telecomm., P.R.M.I.T & R, Badnera, Amravati, Maharashtra, India[2]

PG Student, Dept. of Electronics & Telecomm., P.R.M.I.T & R, Badnera, Amravati, Maharashtra, India[3]

ABSTRACT: In surgeries by provision of substantial amount of drug to the patients a proper neuromuscular blockade level is achieved. Although each patient's physique may differ from one another, but after some span of time even though same patient is considered the same drug results will be different. The factors taken under consideration include age, weight, sex and other physical attributes. The traditional practice of providing drug especially in long surgeries put the patients in risk. It is because of trial and error process comes into the pictures of Anaesthesia. The system aims to develop the controller which provides robustness against the variability of patient's response to drug dosage under uncertain circumstances. The proposed system aims to satisfy different important goals as: Optimizing the amount of drug (atracurium) required which induces an adequate level of relaxation; the drug (isoflurane) required to provide unconsciousness and also the analgesia (lack of pain).

KEYWORDS: Depth of Anesthesia, Injector, Control System, NMB, ASA.

I. INTRODUCTION

Anesthesia is a temporary state consisting of unconsciousness, lack of pain and muscle relaxation. It aims to determine the muscle to be relaxed, hypnosis and analgesia. Absence of muscular movements is required in surgical interventions in the area under consideration. The muscle movements can be restrained by providing drugs blocking the neuromuscular transmission, hence producing muscular paralysis. Traditionally, this is administered by anesthetists; with their personal experience decide the proper amount of drug for initial bolus (fast injection given in a short period of time with the aim to reach a high level of relaxation) as well as the appropriate amount of doses so that the patient maintains an adequate level of relaxation during surgery. The major problem with drug delivery systems is the large uncertainty with different patients and within the patient under consideration of factors like age, weight, sex and other physical attributes and metabolism of drugs. As a result, the same drug provided to different patients and the same patient after a span of time will result differently. Sometimes anesthetists cannot handle this task properly considering different factors of patients. During the anesthesia drugs are given to patients on the trial and error basis. This may induce severe risk to the patients. Also providing drug at a time may lead to overdose. This may give rise to instability in the level of relaxation and also over paralysis in patients. The instability in the level of relaxation have direct implications in the clinical state of the patient while the over paralysis (excessive drug amount given) may result in residual paralysis finally come to delay in recovery. By providing anatagonist drugs the problem can be overcome which indirectly leads to undesirable over drug consumption.

Electromyographies (EMG), Mechanomyography (MMG) or Acceleromyography (AMG) are used to register muscle responses. The neuromuscular blockade level is obtained by electrical stimulation. The amount of infusion and depth of anesthesia can be determined on the basis of the level of relaxation and also the desired target (set point) defined by the anesthetist. Measurement methods based on the power spectrum and bispectral index (BIS) are used.

The depth of anesthesia is estimated using different parameters defined by the anesthetist, some of them are tearing and sweating which cannot be measured. A direct measurement of the hypnosis is not yet available. Since, automatic control of depth of anesthesia needs measurable outputs. Electroencephalogram (EEG) is expected source for reflecting

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 1, January 2015

depth of hypnosis. Different algorithms are deployed for estimation of residuals to give depth of anesthesia from the raw EEG. The main disadvantage of the EEG measurement is that it varies with different anesthetic agents.

In past years, many closed loop systems are proposed varying from simple, static to complex and adaptive to overcome the problems (excessive drug consumption and small recovery time). Two main problems were identified in open loop system: the controller was highly sensible to set point changes and to open-loop gain variations. The deployment of an automatic control system for infusion of drug dosage in operation theater poses several difficulties. Firstly robustness, reliability, and performance of the system are critical in the operating theater. On the other hand, the anesthetist deals comfortably with a control system which gives fast explanatory and transparent decisions, which can be validated online and suggest alternatives if and when needed. And also it is clear that the control system will give benefit from the introduction or modification of control rules in an anesthetist-friendly way for allowing her/him to use her/his own clinical knowledge and experience.

A classical tool provided by engineering is feedback (closed-loop) control, a topic that is receiving attention for drug delivery in clinical pharmacology. Feedback control can also significantly contribute for understanding the effects of pharmacology agents and provide progress in drug delivery systems. Automatic control of anesthesia is helpful to the anesthetist in his activities. The closed-loop control of the depth of anesthesia suppresses the danger of awareness or drug overdoses. A constant neuromuscular block leads to good working conditions for the surgeons and also provides low risk of patient’s health. A shorter stay time of the patient in the postoperative care unit helps saving money.

II. RELATED WORK

In last decades, many closed loop systems are proposed to overcome the problems (excessive drug consumption and small recovery time) varying from simple, static to complex and adaptive. These variations in control loop system are based on the calculation of different parameters (muscle response, depth of anesthesia) under consideration during anesthesia. Calculation using bispectral index (BIS) is one of the most popular method discussed in different papers.

Olov Rosen, Margarida M. Silva *et al* [1]: The recursive estimation of a parsimonious nonlinear Wiener model for the neuromuscular blockade (NMB) in closed-loop anesthesia is addressed in this paper. Taking advantage of the model parameters that were recursively estimated from clinical data, also the main source of intra-patient variability lies in the nonlinear pharmacodynamic part of the model is demonstrated. Evaluation of the distance to a bifurcation phenomenon leading to nonlinear oscillations of the Wiener model under PID feedback is done.

Margarida Martins da Silva, Torbjorn Wigren,and Teresa *et al* [3]: This brief presents new modeling and identification strategies to address many difficulties in the identification of dynamics of anesthesia. For the effect of muscle relaxants during general anesthesia the most commonly used models comprise a high number (greater than eight) parameters such as pharmacokinetic and pharmacodynamic. The input signals (drug dose profiles to be administered to the patients) in clinical practice vary too little to provide a sufficient excitation of the system, is the main issue concerning the neuromuscular blockade system identification. There is a need of new identification strategies as the limited amount of measurement data is available.

Teresa Mendonca, Joao M. Lemos *et al* [4]: This paper states a major issue in drug delivery systems is the high level of uncertainty due to inter and intra patient variations in the dynamics of drug absorption and metabolism. They proposed an approach based on supervised multi model adaptive control (SMMAC) to tackle this problem. Although the specific case of neuromuscular-blockade-level control of patients subject to general anesthesia is considered, other physiological variables can be controlled by application of overall procedure. Guidelines of Design to implement SMMAC are presented, along with clinical cases of patients undergoing general anesthesia using atracurium as the blocking agent.

Paulo Fazendeiro, Jose Valente de Oliveira *et al* [5]: This paper deployed of a fuzzy controller that was aimed to satisfy two important goals: 1) an optimization of the amount of drug (atracurium) required for inducing an adequate level of relaxation and 2) a compatible ability to explain the undertaken control decision at the level of natural language. This aim was set using the fact during surgeries; patients are subject to a substantial amount of drug dosage required for

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 1, January 2015

achieving the required neuromuscular blockade level. The system stated that a small quantity of drug infusion should be currently applied as the difference between the target and the current blockade level is near zero. Here "near zero" and "small" are linguistic terms that were represented as fuzzy sets. Hence, this controller was constructed that was human friendly and highly transparent. The effectiveness of the approach was demonstrated through experiments involving 100 simulated patients (used for training) and 500 patients (forming the test set), approving the approach for application in the operating theater.

O. Simanski, R. Kahler *et al* [8]: This paper discussed the control problems for neuromuscular blockade and depth of anaesthesia. For controlling the main parts of general anaesthesia (muscle response, depth of aneasthesia) the control system was forced. The applied measurement techniques to the system with different experimental conditions and control strategies were presented. The combination of an on-off controller and GPC showed the neuromuscular blockade was controlled with a satisfying accuracy. The study was performed on a total of 31, classified in ASA 1-3 (American Society of Anesthesiologists), patients aged 33 to 63 which had to undergo a pancreas operation to achieve control of the neuromuscular blockade at a set point of 90% within a tolerance range of ± 3% using the drug Mivacurium.

III. **PROPOSED SYSTEM**

The controlled drug is the goal that can be obtained by measuring muscle relaxation and depth of anaesthesia. The muscle responses from neurostimulation are registered by using MMG, EMG, and AMG etc. From this there is measurement of muscle relaxation. This can be model by interaction between drug dose and drug concentration in the blood plasma and in other parts of the body. The use of power spectrum and bispectral index (BIS) gives the systematic analysis in depth of anaesthesia. Depth of anaesthesia is measured by sensors such as the bispectral of the EEG (BIS), state entropy of the EEG, or auditory evoked potentials. The BIS sensor provides an index between 0% (deepest level of hypnosis, corresponding to an isoelectric EEG line) and 100% ("full-awake" state). This information helps to determine different states of patients. On the basis of this information appropriate amount of drug to patients is target. The simple representation is shown in figure 1.

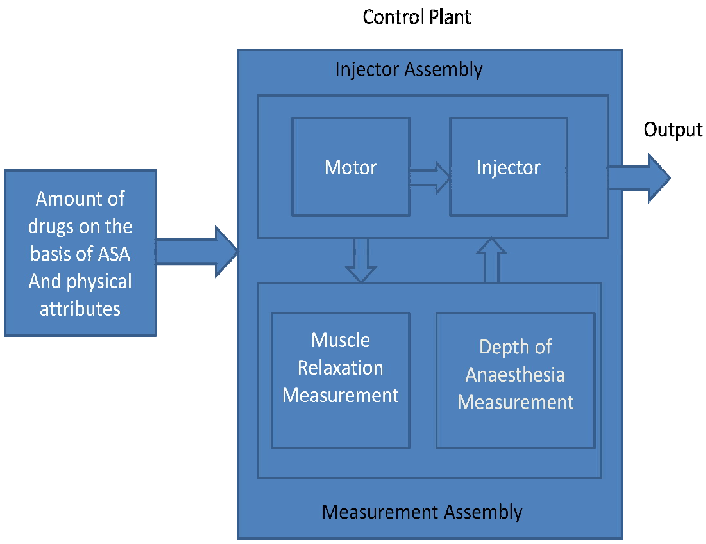

Fig. 1 Model for Controller

Controller model consist of prior information patients, ASA and Control Plant. Control plant works on measurement assembly (Measurement of muscle relaxation and Depth of Anaesthesia) with injector assembly have motor and injector.

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 1, January 2015

The physical attributes and ASA calculate the amount of drugs on traditional basis. But for controlled case it should taking care of proper muscle relaxation, depth of anesthesia and analgesia.
Design Steps:-

1. The physical attributes and ASA calculate the amount of drugs (Traditional way).
2. Measurement of muscle relaxation and Depth of Anaesthesia.
3. Send signal to motor if achieved proper condition (for muscle relaxation and Depth of Anaesthesia).
4. Injector delivered the amount of drugs.
5. Final stage will be depth anaesthesia calculation to know the awaken state of patients.

IV. CONCLUSION

The Model based system represented will be a possible efficient system. The implementation used is Control system with a review of muscle relaxation technique and depth of anesthesia. The experimental output in terms of drugs is achieved by the injector system.

ACKNOWLEDGEMENT

I am very much thankful to my guides Dr. S.M. Deshmukh and A.S. Patharkar for their constant support and encouragement throughout the work. I would also like to present my honest gratitude to Dr. Dinesh Lalwani for his immense help and support.

REFERENCES

1. Olov Rosen, Margarida M. Silva and Alexander Medvedev, “Nonlinear Estimation of a Parsimonious Wiener Model for the Neuromuscular Blockade in Closed-loop Anesthesia”, IEEE Transactions, pp. 9258-9264, 2014.
2. Joeeta Anurag Tomer, Dr.R.P Dubey ,Dr.Ashok Sonkar,” A Hierarchical Self- Organizing fuzzy logic Control to Control Anesthesia using Weiner Models”, International Journal of Advanced Research in Computer Science and Software Engineering, Vol.3, No. 11, 2013.
3. Margarida Martins da Silva, Torbjörn Wigren and Teresa Mendonça, “Nonlinear Identification of a Minimal Neuromuscular Blockade Model in Anesthesia”, IEEE Transactions on Control Systems Technology, Vol. 20, No. 1, pp.181-188, 2012.
4. Teresa Mendonça, Joao M. Lemos, Hugo Magalhaes, Paula Rocha, and Simao Esteves, “Drug Delivery for Neuromuscular Blockade With Supervised Multimodel Adaptive Control”, IEEE Transactions on Control Systems Technology, Vol. 17, No. 6, pp.1237-1244, 2009.
5. Paulo Fazendeiro, Jose Valente de Oliveira and Witold Pedrycz, “ A Multiobjective Design of a Patient and Anaesthetist-Friendly Neuromuscular Blockade Controller”, IEEE Transactions on Biomedical Engineering, Vol. 54, No. 9, pp.1667-1678, 2007.
6. Teresa Mendonça , Hugo Magalhaes, João M. Lemos, and Rui Dionísio, “Control of Neuromuscular Blockade in the Presence of Sensor Faults”, IEEE Transactions on Biomedical Engineering, Vol. 52, No. 11, pp. 1902-1911, 2005.
7. Erik van Lunteren and Michelle Moyer, “CombinationofVariableFrequencyTrainStimulation and K+ Channel Blockade to Augment Skeletal Muscle Force”, IEEE Transactions on Neural Systems and rehabilitation Engineering , Vol. 12, No. 2, pp. 288-294, 2004.
8. O. Simanski, R. Kahler, B. Pohl, R. Hofmockel, R. Friedrich, B. P. Lampe, “Measurement And Control Of Neuromuscular Blockade and Depth Of Anaesthesia” .