Entropy: Monitoring Anesthesia Depth.. A Recent Trend

Dr Saurav Shekhar[1],Dr. Ranjeet Rana De[2],Dr. Ajit Gupta[3],Dr. Mumtaz Hussain[4]

Department Of Anesthesia and Critical Care, Indira Gandhi Institute Of Medical Sciences, India

I.   Introduction

In recent times, intraoperative awareness during anesthesia has gained lot of discussion due to rise in medico legal problems and a cause of embarrassment for anaesthesiologists. Various monitoring are in use for assessing anesthesia depth and with the passage of time significant advancement has been made. Now a days, electroencephalogram (EEG) based monitoring has been under use and lot of discussion has been underway for them (e.g BISpectral index and EEG response to auditory, visual, somatosensory response). But both have inherent disadvantages of having wide inter individual variations, lack of linearity in dose response and different behaviors for different anaesthetic agents.

Recently, concept of entropy has been applied to EEG signals for measuring anaesthesia depth. Entropy as physical concept was defined for first time by Shannon[1] in 1948 and it signifies the amount of disorder in the system. With awake patients, EEG is highly irregular and thus entropy is high whereas with patients under deeper anesthesia, EEG becomes regular and hence entropy lowers down[2]. Therefore, a close relation exists between entropy and the depth of anesthesia and this will reduce drug doses and enhance speed of emergence from anesthesia.[3,4,5]

Entropy module monitors the change in irregularity of EEG and frontal electromyography (FEMG) signals, which changes from irregular to more regular pattern as anesthesia deepens[6]. During lighter plane of anesthesia, facial muscles activity is present which is not abolished by neuromuscular blocking agents used at clinical doses. An abrupt increase in FEMG values denotes lighter plane and together with analysis of EEG helps in generation of entropy values and development of entropy algorithim[7] based on volunteer clinical studies. Individual patients show variations and values are effected by different clinical states such as frequent eye movement, seizures, neurological disorders, trauma, pshycoactive medications, electrocautery, pacemakers etc.The two entropy parameters are fast-reacting Response Entropy (RE) calculated upto 47 Hz and more steady and robust State Entropy (SE) calculated upto 32 Hz.

Response entropy (range from 0–100) signifies activation of facial muscles (FEMG). Facial muscles give an early indication of emergence or awake stage which causes rapid rise in RE. State entropy (range 0-91) is always less than or equal to RE and estimates the hypnotic effect of anesthetic drugs on the brain based on EEG. The entropy range guidelines[7] based on entropy validation studies shows correlation with patient's clinical status. It measures activity of brain which is the site of action of various anesthetic drugs[8] and thus it helps in titrating drug doses[9] and helps in smooth and rapid patient turnover. However, these monitors are still in evolving phase and more studies based on different anesthetic agents with variety of surgical stimuli are needed to establish its conclusivity and authenticity.

II.   Conclusion

Amnesia, Analgesia, Unconsciousness and muscle relaxation together with autonomic stability are mainstay of safe anesthesia for the patients. Thus, entropy used together with other parameters monitoring such as haemodynamic parameters, NMT monitoring etc. can give you a complete picture of intraoperative patient's status.

References

[1]. Bruhn J, Lehmann LE, Ropcke H, Bouillon TW, Hoeft A. Shannon entropy applied to the measurement of the electroencephalographic effects of desflurane. Anesthesiology. 2001;95:30–5.
[2]. Vanluchene AL, Vereecke H, Thas O, Mortier EP, Shafer SL, Struys MM . Spectral entropy as an electroencephalographic measure of anesthetic drug effect: a comparison with bispectral index and processed midlatency auditory evoked response. Anesthesiology 2004;101:34-42
[3]. Vakkuri A, Yli-Hankala A, Talja P, et al. Time-frequency balanced spectral entropy as a measure of anesthetic drug effect in central nervous system during sevoflurane, propofol, and thiopental anesthesia. Acta Anaesthesiol Scand2004;48:145-53
[4]. Vakkuri A, Yli-Hankala A, Sandin R, et al . Spectral entropy monitoring is associated with reduced propofol use and faster emergence in propofol–nitrous oxide–alfentanil anesthesia. Anesthesiology 2005;103:274-9
[5]. Vanluchene AL, Struys MM, Heyse BE, Mortier EP. Spectral entropy measurement of patient responsiveness during propofol and remifentanil. A comparison with the bispectral index. Br J Anaesth 2004;93:645-54.
[6]. Johansen JW, Sebel PS. Development and clinical application of elecroencephalographic bispectrum monitoring. Anesthesiology. 2000;93:1336–44.

[7]. Viertio-Oja H, Maja V, Sarkela M, et al. Description of the Entropy algorithm as applied in the Datex-Ohmeda S/5 Entropy Module. Acta Anaesthesiol Scand2004;48:154-61.

[8]. White PF, Boyle WA. Relationship between hemodynamic and electro-encephalographic changes during general anesthesia. Anesth Analg1989;68:177-81.

[9]. Prabhakar H, Ali Z, Bithal PK, Singh GP, Laithangbam PK, Dash HH. EEG entropy values during isoflurane, sevoflurane and halothane anesthesia with and without nitrous oxide. J Neurosurg Anesthesiol.2009;21:108–11.