New Media

Computerized EEG monitoring of anesthetic depth: Quo Vadis?

One particularly promising development in anesthesia monitoring technology based on embedded computer technology is the BIS monitor of anesthetic depth from Aspect Medical Systems (www.aspectms.com). This product is the latest in a series of technical initiatives on electronic processing of the electroencephalogram (EEG) since Bickford first described "servoanesthesia" 50 yr ago while experimenting with animals. (Bickford used an ether anesthesia delivery system on experimental animals that employed feedback control derived from the EEG. He achieved EEG amplification and processing using vacuum tube electronics, as transistors were not even yet invented.)

Since that time EEG technology has become far more sophisticated, and over the years a number of EEG based commercial products to assist in the monitoring of anesthetic depth have come to market and failed. Many people expect that the BIS monitor will be the first to truly succeed.

Clinical use of the device merely involves placing a disposable strip with a 3 gelled electrodes (two active, one ground) on the patient's forehead. This device uses advanced digital signal processing techniques such as Fourier transformation and bispectral analysis applied to the EEG to the end up with a single number known as the bispectral index or BIS. BIS scores range from 0, corresponding to an isoelectric EEG, to 100, corresponding to being "bright eyed and bushy tailed". One useful rule of thumb is that intraoperative awareness under intended general anesthesia is very unlikely as long as the BIS score is under 60.

One difficulty with evaluating this technology is that with inadvertent intraoperative awareness being fairly rare now even without the BIS monitor, it would likely require very large study sizes to compare the frequency of unintended intraoperative awareness in patients randomized to be equipped with or without the use of BIS monitoring. Because of this, the issue as to whether BIS monitoring becomes the eventual standard of clinical care in the future will likely depend

as much on nonscientific factors as on anything else. Already, in the competitive world of American health care, some hospitals are (I am told) publicizing via TV and newspaper advertisements the fact that their operating rooms come equipped with the BIS monitor. There was even an episode of the popular medical drama *Chicago Hope* that involved an episode of intraoperative awareness which, according to the script, could have been prevented had the BIS monitor been used.

I can't imagine that that TV program did not have a tremendously beneficial effect on Aspect's public image. Obviously, getting the BIS monitor into the script was a major marketing coup (and one which happened fortuitously, through a script suggestion apparently provided by Dr. John Tinker.) And as if that wasn't enough good luck, a *Time Magazine* article (November 3, 1997) offered a favourable article entitled "What's Up Doc?", dealing with the issue of unintended intraoperative awareness. The article stated that "unexpected wake-ups occur in at least 40,000 of the nation's 20 million annual surgeries, according to Emory University anesthesiologist Peter Sebel, who has studied the problem." The article then goes on to discuss the potential value of the BIS monitor as a solution to this problem.)

Proponents of BIS monitoring also make the case that this technology can reduce perioperative drug costs. They argue that without BIS monitoring clinicians generally administer a relative overdose of drugs, just to be sure that the patient is asleep. This probably explains why intraoperative awareness remains a relatively rare occurrence. Advocates suggest that when anesthesia is administered using BIS monitoring, this overdose can be avoided while still insuring that the patient is asleep. They argue that there are resulting savings in time, drug costs, recovery costs, etc., that alone should make BIS monitoring worth implementing.

One practical problem everyone finds in all forms of EEG monitoring is when electromyographic (EMG) signals contaminate the EEG signal. The BIS monitor I recently evaluated at our hospital demonstrated large amounts of EMG artifact at the begin-

ning of the case, but soon settled down. In the model I evaluated there is even a signal quality indicator, indicating the degree to which the displayed data was trustworthy.

However, despite its enormous potential, there are many unresolved issues in the field of BIS monitoring. Is a score of 50 under isoflurane anesthesia always the same as a score of 50 under propofol anesthesia? Or, since the EEG of newborns is necessarily different from that of adults (because of maturational effects) how does one interpret BIS scores in the pediatric population? Also, it is not always possible to compare new studies with old studies directly since the monitors released to investigators were periodically upgraded with new software releases which improved the algorithm. These, and many other issues, are the subject of continuing investigation around the world. While only time will tell whether BIS monitoring here to stay, based on the number of publications in the medical literature, this technology looks quite promising.

Of course, Advent Medical Systems is not the only company interested in EEG processing. The biomedical engineers at Datex have ambitious plans to launch a similar technology based on a concept known as signal "entropy". At the World Congress in Montreal in June, Datex offered a number of presentations and handouts that hinted at their new vision in

EEG monitoring. They made it clear that they "want in".

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Erratum

Le May S, Dupuis G, Harel F, et al. Clinimetric scale to measure surgeons' satisfaction with anesthesia services. *Can J Anesth* 2000; 47: 398-405.

In the accompanying Editorial by Drs. R.L. Helmreich and M. Musson, the first author's name was misspelt as McVey and should read Le May. We apologise for any inconvenience caused.