

## MONITORED ANAESTHESIA CARE

Verghese T Cherian\* and Tony Thomson Chandy

Department of Anaesthesia, Christian Medical College, Vellore 632004, India

\*Corresponding author E-mail: [vtcherian@cmcvellore.ac.in](mailto:vtcherian@cmcvellore.ac.in)

**Key words:** monitored anaesthesia care; pharmacology

Monitored Anaesthesia Care (MAC) refers to a clinical service wherein an anaesthesiologist provides analgesia and sedation for a diagnostic or therapeutic procedure, and the patient is able to protect his airway for the majority of the procedure.<sup>1</sup> It involves the administration of medication that can potentially lead to loss of consciousness and normal protective reflexes. There is possibility of a deeper plane of sedation compared to 'sedation/analgesia' which is provided by a non-anaesthesiologist.<sup>2</sup> Therefore, the ASA recommends that the standards of care be same as for general or regional anaesthesia, with regard to pre-operative evaluation, intra-operative monitoring of the cardio-respiratory system, the physical presence of an anaesthesiologist at all time, and the administration of oxygen and other medications to keep the patient safe and comfortable.<sup>1</sup>

MAC should invoke less physiological disturbance and allow a more rapid recovery compared to a general anaesthetic. Therefore, it is not surprising to note that it is the technique of choice in up to 30% of the surgical procedures.

The three essential components of MAC are – *safe sedation, anxiolysis and analgesia*.<sup>3</sup> However, **patient comfort, cardio-respiratory stability, good operating conditions and minimal side effects** are equally important.

### Preoperative assessment

The preoperative evaluation (history, examination and review of investigations) and optimization should be as for a general or regional anaesthetic. However, there are certain factors unique for MAC.

Oriented and cooperative  
Ability to remain motionless – tremors, parkinson's, spasms

Persistent cough  
Psychological preparation  
Ability to communicate

Verbal communication during the procedure is vital, as it monitors the level of sedation, is a means of reassurance for the patient and essential when the active participation of the patient is required for the procedure.

### Pharmacology

Understanding the pharmaco-kinetics and the pharmaco-dynamics of the drugs used is essential to titrate the required clinical effect. Distribution, elimination and context-sensitive half-time, effect-site equilibration time and drug interactions are important concepts to remember. To avoid excessive levels of sedation, drugs should be titrated in small increments administered as 'adjustable rate' continuous infusion. Fluctuations in drug concentrations are avoided by continuous infusions, thus reducing periods of excessive or inadequate sedation.

Elimination half-time was the commonly used parameter to predict the duration of action of drugs.<sup>2</sup> However, this would represent the time needed for the drug to reach half its initial concentration in single compartment models wherein elimination is the only mechanism that changes drug concentration. In clinical situation, most drugs used by the anaesthesiologists are lipophilic and follows a multi-compartment model, wherein the change in plasma concentration does not depend only on metabolism and excretion. During the initial phase of an intravenous infusion of a lipophilic drug it gets distributed to extravascular sites and later after the infusion is stopped it would return to the central circulation. The amount that returns would depend on various factors but definitely on the duration of infusion of

drug. In 1992, Hughes et al introduced the concept of 'Context-sensitive half-time' which describes the time required for the plasma concentration to decrease by half after the infusion is terminated at different time periods.<sup>3</sup> This is a dynamic concept and reflects the combined effect of distribution and metabolism on plasma drug concentration and hence it's clinical effect. (Figure 1)

Certain interesting facts are linked to context-sensitive half-time such as:

1. Context-sensitive half-time increases as the duration of drug infusion increases
2. Context-sensitive half-time bear no constant relationship to elimination half-times

Fentanyl which is eliminated by hepatic clearance is replaced by drug returning from the peripheral compartments. Although, fentanyl has a shorter elimination half-time than that of sufentanil, its c-s half-time is longer than that of sufentanil after infusion duration of longer than 2 hours.

The c-s half-times of thiopentone and propofol are comparable following brief infusions, but that of thiopentone increases rapidly thereafter. This difference is due to high metabolic clearance of propofol compared to thiopentone and the relatively slow rate of return of propofol from the periphery. This proves that thiopentone is not ideal for continuous infusion during ambulatory procedures.

Sufentanil has a much longer (five times) elimination half-time compared to alfentanil, but its c-s half-time is shorter for infusions up to 8 hours. Sufentanil has a large volume of distribution and the decay in the plasma level is due to elimination and redistribution, while alfentanil has a small volume of distribution. Therefore, despite its short elimination half-time, alfentanil may not necessarily be superior to sufentanil for ambulatory sedation.

Context-sensitive half-time is a reflection of plasma drug decay, while awakening from anaesthesia is a function of concentration decay at the effect-site (brain).

Plasma concentration and effect-site concentration when a drug is administered intravenously there is a delay before the onset of clinical effect. This is the time lag for the drug to develop the effective concentration at the site of action (brain).<sup>2</sup> If a parameter of drug effect can be

measured (e.g. BIS for a sedative drug) then the half-time of equilibration between drug concentration in the plasma and the drug effect can be determined. This is referred to as  $t_{1/2k_{e0}}$ . Drugs with short  $t_{1/2k_{e0}}$  will equilibrate faster with brain and have a faster onset of clinical effect. While using drugs with long  $t_{1/2k_{e0}}$  the boluses should be spaced far apart to allow the effect of a dose to act to avoid inadvertent overdosing. A good example is midazolam with a  $t_{1/2k_{e0}}$  of 0.97-5.6 minutes. Even with the shortest time it would take 2.7 minutes for the effect-site concentration to equilibrate.

Another important factor to consider is low cardiac output which will delay drug arrival at the effect-site and also delay the termination of effect by restricting redistribution due to poor cardiac output.

### Techniques of MAC

A variety of drugs can be used to provide MAC. The important point is to ensure patient comfort, maintain cardio-respiratory stability, and provide good operating conditions. It is also equally important to avoid or minimize side effects such as cardio-respiratory depression, nausea and vomiting, excessive sedation, and delayed recovery. It is a well accepted fact that there is considerable variability, between patients, in the response to sedative and analgesic medication. The ideal level of sedation should allow verbal communication with a comfortable and cooperative patient.

Most anaesthesiologists would agree that an infusion regimen is better to provide a MAC. This is based on a) a correlation exists between plasma drug level and clinical effect, b) bolus administration of drug in response to clinical signs does not provide a smooth clinical effect that is hoped for and c) bolus drug administration induces wide variation in drug concentration at the effect-site.

Drug infusion regimens can be administered in four forms<sup>3</sup>

- a. a continuous infusion – clinician based
- b. a patient-controlled sedation – patient based
- c. a target-controlled infusion – pharmacokinetic based
- d. a feedback-controlled infusion – effect-site concentration based

## Drugs commonly used for MAC

*Analgesics* – opioids, NSAIDS, nerve blocks

*Sedative* – propofol, ketamine

*Anxiolytics* – benzodiazepines

*Adjuvants* –  $\beta$ -blockers, dexmedetomidine, anti-emetics

## Salient points about a few of these drugs:

*Propofol* – propofol has many properties which make it suitable for MAC, such as good pharmacokinetic profile (short C-s half-time and effect-site equilibration time), excellent recovery and low incidence of PONV.

Dose – 50-75  $\mu$ g/kg/min

*Midazolam* – C-s half-time twice that of propofol. It has anxiolytic, amnestic and hypnotic properties. It reduces the requirement of opioids.

*Opioids* - Opioids form the mainstay of analgesia during the procedure especially at the initial injection of local anaesthetic and at periods of intense patient discomfort. However, the adverse effects include respiratory depression, muscle rigidity and emesis.

Remifentanyl is predominantly metabolized by nonspecific esterases resulting in its rapid clearance and cessation of effect. The c-s half-time is 3-5 minutes and the effect-site equilibration time ( $t_{1/2k_{e0}}$ ) of 1-1.5 minutes.

*Ketamine* – ketamine is a phencyclidine derivative with intense analgesic properties.

## Monitoring during MAC

The basic anaesthetic monitoring standard needs to be followed. An observant anaesthesiologist is perhaps the most important monitor. Clinical monitoring and verbal communication with the patient during the procedure is vital. A precordial stethoscope, pulse oximetry, capnography, electrocardiogram and blood pressure recording is essential. Invasive haemodynamic monitoring may be required depending on the co-morbidity and invasiveness of the procedure.

## Comfort of the patient

Care should be taken to keep the patient comfortable during the procedure. A small pillow under the knees to flex the thighs, maintaining moderate room temperature, and inserting a urinary catheter if the procedure is long or a diuretic is required (e.g. awake craniotomy) will

ensure a comfortable and co-operative patient. Alveolar hypoventilation leading to hypoxia is possible if the patient gets too sedated. It is prudent to administer oxygen by mask.

## Supplemental Oxygen

Administration of sedatives and opioids is associated with hypoventilation which can lead to hypoxia. This can be corrected effectively by supplementing modest amounts of oxygen. E.g. let us compare the alveolar oxygen level with and without oxygen supplementation, in a situation where the alveolar  $CO_2$  rises to 80 mmHg due to hypoventilation.<sup>2</sup>

$PAO_2 = PIO_2 - PACO_2 / R$  (alveolar gas equation)

$(PIO_2 = FIO_2 \times (PB - PH_2O))$

$PACO_2$  80 mmHg

$FIO_2 - 0.21;$

$PIO_2 = 0.21 \times (760-47) = 150$  mmHg

$PAO_2 = 150 - 80 / 0.8 = 50$  mmHg

$FIO_2 - 0.28;$

$PIO_2 = 0.28 \times (760-47) = 200$  mmHg

$PAO_2 = 200 - 80 / 0.8 = 100$  mmHg

*Point to note:* Adequate oxygenation may mask alveolar hypoventilation. Therefore, measure the oxygen saturation while patient is breathing room air, before shifting them to a less well-monitored ward without oxygen supplementation.

## Use of MAC

Ophthalmology – cataract surgery

Neurosurgery – awake craniotomy

Radiology – MRI, cardiac catheterization, CT guided biopsy

Pain Therapy – radio frequency thermo-coagulation of trigeminal ganglion

Day-care – inguinal herniorrhaphy, circumcision

## References

1. Novak LC. ASA position on Monitored Anaesthesia Care. ASA newsletter 62; Dec 1998
2. Hillier SC, Mazurek MS. Monitored anesthesia care, In Barash PG, Cullen BF, Stoelting RK (eds) Clinical Anesthesia, Lippincott Williams & Wilkin 2006; 1246-61
3. Ghisi D, Fanelli M, Tosi M, Nuzzi M, Panelli G. Monitored anaesthesia care. Minerva Anesthesiologica 2005; 71: 533-38
4. Hughes MA, Glass PSA, Jacobs JR. Context sensitive half-time in multi-compartment pharmacokinetic models for intravenous anesthetic drugs. Anesthesiology 1992; 76: 334-41

**Figure 1:** Context-sensitive half-time.

