MALAYSIAN SOCIETY OF ANAESTHESIOLOGISTS YEAR BOOK 2018/2019

KESELAMATAN DALAM BIUS

MALAYSIAN SOCIETY OF ANAESTHESIOLOGISTS

Year Book 2018/2019

ISSN 2462-1307

9 772462 130007

MALAYSIAN SOCIETY OF ANAESTHESIOLOGISTS

Year Book 2018/2019

Published by
Malaysian Society of Anaesthesiologists
Unit 1.6, Level 1, Enterprise 3B
Technology Park Malaysia, Jalan Innovasi 1
Bukit Jalil, 57000 Kuala Lumpur, Wilayah Persekutuan
Tel: (603) 8996 0700, 8996 1700, 8996 2700
Fax: (603) 8996 4700
Email : secretariat@msa.net.my

Pusat Kebangsaan ISBN/ISSN Malaysia
ISSN 2462-1307

CONTENTS

2 **Foreword From The President Of The Malaysian Society Of Anaesthesiologists**

3 **Preface From The Editors**

4 **Acknowledgements - Reviewers**

5 **Intraoperative Neurophysiological Monitoring During Brain Surgery: Strategies Of Anaesthesia Management**
Wan Mohd Nazaruddin Wan Hassan

14 **Enhanced Recovery After Surgery (ERAS): The Role Of Anaesthesiologists**
Nadia Md Nor, Siti Nidzwani Muhammad Mahdi

21 **Challenges In Obstetric Anaesthesia - The Pregnant Obese Patient**
Carolyn Yim Chue Wai, Tan Wei Keang

28 **Acupuncture In Anaesthesia**
Liu Chian Yong

33 **Role Of Ultrasound In Central Neuraxial Blockade**
Muhamad Rasydan Abd Ghani, Ariff Osman, Syed Hassan Askri Shah

39 **Anaesthesiology Training In Malaysia: If It Was Good For Me, Why Isn't It Good Enough For The Future?**
Noorjahan Haneem Md Hashim

45 **Pharmacology In Intensive Care Patients: The Role Of Renal Clearance In Antibiotic Dosing**
Mohd Basri Mat Nor, Shahir Asraf Abdul Rahim

55 ***ABCDE* Of Childhood Obesity: An Overgrowing Concern In Anaesthesia**
Nur Hafiizhoh Abd Hamid

67 **End-Of-Life Care In The Intensive Care Unit**
Noor Airini Ibrahim

72 **Challenges As A Cardiothoracic Anaesthesiologist In Government Hospital**
Azmiza Maharani

Foreword

It is my honour to write the foreword for this eleventh edition of the Malaysian Society of Anaesthesiologists (MSA) Year Book 2018/2019. The theme for this edition is "Anaesthesia: Challenges in the 2020s" which is apt as we embark on a new decade of latest techniques, technologies and challenges which will shape the future of our profession. The publication of the year book is part of the activities organised by the MSA to promote continuing education and also to encourage members of our profession to share their knowledge and expertise within the areas of their respective niche.

In this edition, ten topics covering different aspects related to anaesthesia are published. The topics discussed in the current edition not only address challenges in our clinical aspect but also the training of anaesthesiologists and explore our thoughts on complementary medicine such as acupuncture in anaesthesiology.

I would like to express my sincere appreciation to all the authors for their amazing academic literatures and the peer reviewers for their great efforts in reviewing the articles. Last but not least, I would like to thank this year's Editors, Dato' Dr Wan Rahiza Wan Mat and Dr Azarinah Izaham, for their contribution to the production effort of the MSA Year Book 2018/2019.

Professor Dr Marzida Mansor
President
Malaysian Society of Anaesthesiologists 2019-2021

Preface

The Malaysian Society of Anaesthesiologists (MSA) Year Book is here again! We would like to express our gratitude to the MSA for entrusting us with the 11th edition of the MSA Year Book for the year 2018/2019. We would also like to thank the authors and reviewers for taking their time away from their busy schedules to write and review these articles.

It was a great challenge for us to choose this year's theme since the previous 10 editions had covered so many areas of anaesthesiology and critical care. In the end we chose our inspiration from the evolution of our practice from those previous 10 editions and into the new decade. This evolution brings its own challenges which include not just anaesthesia techniques and monitoring, but also in maintaining Malaysia's standards in the practice of anaesthesiology and critical care in the face of changing characteristics in the population of patients.

We, therefore, begin with the current recommendations for monitoring patients, the population of special patients, the techniques that have been refined in our current practice and how the training of an anaesthesiologist has evolved. Additionally, complementary medicine is one of the growing subjects in our field and the recently discovered physiological phenomenon affecting the pharmacology in our daily practice is also discussed in this edition.

We hope that the broad range of topics discussed in this edition will give the readers some perspective of the few challenges that we will face in the decade to come.

Happy reading!

Dato' Dr Wan Rahiza Wan Mat
Dr Azarinah Izaham
Editors
MSA Year Book 2018/2019

Acknowledgements - Reviewers

This Year Book would not have been possible without the contributions from the following reviewers:

Professor Dr Felicia Lim
Senior Consultant Anaesthesiologist
Department of Anaesthesiology and Intensive Care
Hospital Canselor Tuanku Muhriz
Universiti Kebangsaan Malaysia Medical Centre
Kuala Lumpur
Malaysia

Associate Professor Dr Raha Abdul Rahman
Senior Lecturer and Consultant Anaesthesiologist
Department of Anaesthesiology and Intensive Care
Hospital Canselor Tuanku Muhriz
Universiti Kebangsaan Malaysia Medical Centre
Kuala Lumpur
Malaysia

Dr Muhammad Maaya
Senior Lecturer and Consultant Anaesthesiologist
Department of Anaesthesiology and Intensive Care
Hospital Canselor Tuanku Muhriz
Universiti Kebangsaan Malaysia Medical Centre
Kuala Lumpur
Malaysia

Dr Hasmizy Muhammad
Consultant Anaesthesiologist
Pusat Jantung Sarawak
Kota Samarahan
Sarawak
Malaysia

Dr Norliza Mohd Nor
Consultant Anaesthesiologist
Department of Anaesthesiology and Intensive Care
Hospital Selayang
Selangor
Malaysia

Intraoperative Neurophysiological Monitoring During Brain Surgery: Strategies Of Anaesthesia Management

Wan Mohd Nazaruddin Wan Hassan
Associate Professor, Department of Anaesthesiology and Intensive Care, School of Medical Sciences, Universiti Sains Malaysia, Kubang Kerian, Kelantan, Malaysia

INTRODUCTION

Intraoperative neurophysiological monitoring (IONM), an advanced modality of monitoring during surgery, is capable of monitoring the integrity of the neurophysiological system either at the brain, spinal cord or peripheral nervous system levels. The use of multimodal IONMs could improve the precision of targeted surgical excision, prevent potential injury to the nervous system and preserve neural integrity in real time during general anaesthesia. The benefits of multimodal IONMs have been well-described in various types of surgeries, such as complex spine surgery, major vascular surgery and thyroid surgery.[1-3] However, there are limited reviews focusing on IONMs during various types of brain surgery.

The concept of multimodal IONMs is very important during brain surgery because there is no single device that could function as the sole monitor to all complex physiological functions of the brain. In a retrospective study of 240 patients undergoing brain surgery using IONMs, the sensitivity of somatosensory evoked potentials (SSEPs) in motor dysfunction detection was low (33%), while the specificity was relatively high (82%). These characteristics for visual and motor evoked potentials (MEPs) were close to 100%, provided that the parameters of anaesthesia met the corresponding requirements. The most effective methods in respect to prevention of postoperative dysfunctions were the stimulation mapping of functionally significant areas (motor and speech) and motor pathways mapping.[4] In their retrospective study on 31 patients who underwent brain surgery for the resection of lesions located in eloquent areas using IONMs, Brandmeier *et al* concluded that IONM helped the surgeons to maximise resection of lesions in or close to eloquent areas of the brain. However, using only one modality was not sufficient as a combination of modalities was required to obtain a better outcome.[5]

Multimodal IONMs during brain surgery is used not only for monitoring, but also as a tool to guide identification of a targeted focus in surgery. For example, it may be used in epilepsy surgery and as a guide to precisely place the tips of a specific stimulation catheter, as in deep brain stimulation surgery (DBS). There are a variety of brain surgeries that have used IONMs, such as brain oncology surgery, awake craniotomy, neurovascular surgery, epilepsy surgery and paediatric brain surgery.[5-8]

Although the uses of IONMs are mainly for surgical benefits, the anaesthesiologists must also be knowledgeable in those modalities. The reason for this is that anaesthesia management and intraoperative physiological changes could affect the interpretation of the monitoring.

This review aims to highlight the types of IONMs used in specific brain surgeries, the effects of common anaesthetic drugs to IONM and the anaesthesia strategies related to the use of multimodal IONMs during brain surgery.

MODALITIES OF IONMs

Motor Evoked Potentials (MEPs)

MEPs, a method of monitoring the functional integrity of descending motor pathways, can be obtained by transcranial stimulation, either by direct stimulation of the motor cortex or by the stimulation of the descending motor tracts at the spinal cord level. The stimulation can be either magnetic or electrical, but electrical stimulation is only utilised under general anaesthesia.[9,10]

Stimulation of the pyramidal and internuncial cells in the brain generates D (direct) and I (indirect) waves recorded from the epidural space. However, responses are most commonly recorded as compound muscle action potentials (CMAPs) in peripheral muscle groups. For the upper extremity, the adductor pollicis brevis is usually monitored, while the tibialis anterior, lateral gastrocnemius, and/or abductor hallucis are monitored for the lower extremity. Thus, MEPs monitor the integrity of corticospinal tract from motor cortex to peripheral nerve.[11]

Some studies reported the use of MEP monitoring during brain surgery. Shiban *et al* assessed the correlation of continuous stimulation of subcortical MEPs which was attached to an ultrasonic surgical aspirator with standard intermittent monopolar stimulation during resection of motor eloquent lesion in 14 patients. The threshold of stimulation was assessed using both techniques at the same points within the resection cavity. The result showed that both stimulation techniques were identical and correlated in stimulation intensity and the threshold was ranged from 3 to 18 mA. Despite of MEP monitoring, one patient developed new permanent neurological deficit and 28% (4 of 14) of cases had transient new postoperative paresis.[12]

Obermueller *et al* investigated the differences of IONM for cerebral metastases and glioma resection concerning sensitivity, specificity and predictive values when aiming for preservation of motor function. They resected 171 eloquently located tumours (56 metastases, 115 gliomas) associated with the rolandic cortex or the pyramidal tract using IONM via direct cortical MEP. The result showed that MEP monitoring was successful in 158 cases (92.4%) and was more significantly stable in glioma cases (65.2%) than metastases cases (54.7%). After resection of metastases cases, 21.4% of patients improved and 21.9% deteriorated in motor function, whereas in glioma patients, only 5.4% of patients improved and 31.3 % worsened in motor function.[13]

Other than for the surgery of brain tumours, MEPs also have been used in clipping of cerebral aneurysms surgeries. Staarmann *et al* studied the sensitivity and specificity of IONMs, using transcranial MEPs and SSEPs for early detection of ischemic changes during temporary clipping in patients who undergo clipping of cerebral aneurysms surgery. The results showed that of 133 clipped aneurysms, 15 instances of IONM changes occurred, including 12 temporary without new postoperative deficits and three permanent with new postoperative deficits. SSEPs monitoring predicted one of the permanent deficits and MEPs predicted the other two deficits. They concluded that multimodal IONM was highly specific and sensitive for detecting new deficits. Three patients with new deficits had temporary clipping, including two patients with IONM changes not temporally associated with clip placement. Their 1.1% rates of permanent neurologic deficit from temporary clipping support its safety.[14]

Among all types of IONMs, MEPs are the most sensitive to the effect of anaesthetic drugs. All volatile agents, including nitrous oxide, decrease MEPs amplitude, but it is still recordable with a minimum alveolar concentration (MAC) of <0.5. Propofol also decreases MEPs amplitude, but the waveform is recordable within anaesthetic doses. However, with high doses of propofol, MEPs waveform may disappear.[15] Although propofol had a dose-dependent effect on MEP amplitude, anaesthesia could be maintained with remifentanil and propofol from 4 to 8 mg/L to allow recording and interpretation of MEP signals.[16] A study on the effects of various stimulation patterns on MEPs at different levels of cortical suppression by propofol showed that at propofol target plasma concentrations <3 μg/mL, maximal MEP amplitudes were elicited by quadruple stimulation at 100 Hz. When progressive cortical suppression resulting from propofol target plasma concentrations beyond 3 μg/mL, the most effective stimulation frequency shifts to 200 Hz.[17] Scheufler KM *et al* studied modifying effect of different stimulation patterns (300-500 V;

100-1000 Hz; 1-5 stimuli) during different propofol target plasma concentrations (2, 4, and 6 µg/mL) on intraoperatively recorded transcranial electrical MEPs in 12 patients undergoing craniotomy. The result showed that MEP characteristics varied significantly in response to changes in stimulation pattern and less to changes in propofol target plasma concentrations.[18]

Other common IV intraoperative drugs also have been described on their effects to MEPs. Etomidate increased MEPs amplitude at low doses, but decreases it at higher doses. Ketamine has minimal effect on MEPs amplitude, but increases it at low doses. Benzodiazepine also has minimal effect on MEPs amplitude at low doses, but causes a prolonged decrease at higher doses. Opioids have minimal effect on MEPs amplitude even at high doses. Dexmedetomidine also has minimal effect on MEPs amplitude, but decreases it at higher doses. Lignocaine's effect is also minimal to MEPs amplitude and can be used as an intravenous supplement during MEP. Muscle relaxant is always avoided during MEPs recording.[15]

Based on the recommendation from the American Society of Neurophysiological Monitoring, intravenous (IV) anaesthesia usually consisting of propofol and opioid is optimal for muscle MEPs.[19] However the combination of total intravenous anaesthesia (TIVA) with low MAC of volatile agents particularly desflurane is a possible option in patients with intact neurological function. Chong CT *et al* compared the effects of increasing MAC (0.3, 0.5, and 0.7) of desflurane and sevoflurane in a background of propofol (75 to 125 µg/kg/min) and remifentanil (0.1 to 0.2 µg/kg/min) infusion. The study showed that volatile agents (sevoflurane > desflurane) suppress MEP amplitudes in a dose-dependent manner. The use of 0.3 MAC of desflurane (but not sevoflurane) provided good MEP recordings that are acceptable for clinical interpretation for both upper and lower limbs. The study also found that the lower limbs appeared to be more sensitive to anaesthetic-induced depression compared with the upper limbs. However, this study was based on patients with normal neurological examination and hence, these results may not be applicable to those with pre existing deficits.[20]

Somatosensory Evoked Potentials (SSEPs)

SSEPs are the most commonly used evoked potential monitoring modality in the operating room. An electrical stimulus is applied to a peripheral nerve typically the median or ulnar nerve at the wrist for upper extremity SSEPs and the posterior tibial nerve at the ankle for lower extremity SSEPs using a needle or surface electrodes near the nerve. Motor and sensory components of these large, mixed nerves are stimulated in visible muscle twitches in distal musculature (confirming stimulation and lack of significant muscle blockade), while activation of the sensory components result in responses that travel along the sensory pathway and ascend to the brain.[21,22]

The use of SSEPs during brain surgery is usually in combination with MEPs. There are many studies describing the use of SSEPs during brain surgery. Shiban *et al* analysed retrospectively the use of transcranial MEPs and SSEPs for monitoring of microsurgical resection of brainstem cavernomas which carries a high risk of new postoperative morbidity and functional deterioration. The use of these IONMs was technically feasible in this surgery but they encountered high rates of false-positive and negative results which resulted in low positive and relatively high negative predictive values. Therefore, even though the MEPs and SSEPs are helpful, careful interpretation of the IONM results is essential in order to avoid potentially unjustified termination of brainstem cavernoma resection.[23] Furthermore, the use of continuous SSEPs monitoring has also been described for fully awake craniotomy surgery for the resection of primary supratentorial brain tumours near or in eloquent brain areas.[24]

The choice of anaesthetic drugs is also important in facilitating SSEPs recording, but it is slightly less sensitive than during MEPs monitoring. In general, volatile agents decrease SSEPs amplitude but the evoked potentials recording is still acceptable within MAC of <1.0. However, if patients have any degree of baseline neurologic impairment, even at low MAC, the potentials might be eliminated and monitoring might be impossible. Among IV induction agents, only etomidate and ketamine increase SSEPs amplitude at low doses. Otherwise, at high doses, etomidate decreases the amplitude but ketamine shows only minimal effect. Propofol is a commonly chosen drug during SSEPs monitoring as part of TIVA with opioid. Although it also decreases SSEPs amplitude, the waveform is still acceptable within anaesthetic doses. Other drugs for example benzodiazepine (at low doses), opioids (even at high doses), dexmedetomidine and lignocaine have only minimal effect to SSEPs. There is no restriction for using muscle relaxant drugs during SSEPs monitoring.[15]

Brainstem Auditory Evoked Potentials (BAEPs)

BAEPs, also known as brainstem auditory evoked responses or auditory brainstem responses, are specialized sensory evoked potentials. An acoustic stimulus (a loud, repetitive click) is made in the ear canal using an ear insert device. The sound is transduced by ear structures, with information conducted to the brainstem via the eighth cranial nerve. Recording electrodes are placed at the head near the ear (i.e. mastoid process or ear lobe). Five main short-latency peaks (I to V) are usually seen within the first 10 milliseconds after stimulation.[25]

BAEPs are also usually used as part of multimodal IONMs and complement SSEPs and MEPs during surgery. It is used most commonly in cerebellopontine angle (CPA) tumour surgery. Schramm *et al* reported 135 cases of posterior fossa surgery almost exclusively in the CPA, using BAEPs and partly SSEPs. The series consisted of 20 microvascular decompressions, 63 acoustic neurinomas, 7 vascular lesions and 45 other space-occupying lesions, mostly in the CPA. BAEPs monitoring alone was employed in 76 cases, but not as frequently for combined BAEPs and SSEPs monitoring. Analysis showed the presence of technical problems (17 in 135 = 13% of cases) and technical failures (11 of 135 = 8%).[26] Additionally, another retrospective study has described the use of BAEPs as a part of multimodal IONMs in patients who underwent arteriovenous malformation surgery.[7]

In terms of anaesthetic effect, BAEPs are resistant to the effects of inhalation anaesthetics as compared with other forms of IONMs.[25]

Visual Evoked Potentials (VEPs)

VEPs are specialized sensory evoked potentials of the visual pathway recorded from the visual cortex after flash stimulation of the retina through closed eyelids.[27]

The use of VEPs has been described in some of previous studies. Gutzwiller *et al* performed brief monitoring of the visual system with flash visual VEPs during brain lesion resections (white LEDs, protected from the lights of the operating room). The possible decreases in VEPs were analysed relative to electroretinograms, triggering an alarm only if certain criteria were met. VEPs appear to be a reliable intraoperative tool to detect new deficits in visual fields that are more severe than a discrete quadrantanopia. Early changes in VEPs could trigger corrective surgical actions and contribute to preserving vision.[28] San-Juan *et al* reported the case of a patient with optic nerve schwannoma and the first use of IONM of VEPs during the removal of such tumour with no postoperative visual damage. In this case, the epidural direct electrical stimulation of the optic nerve provided stable waveforms during optic nerve schwannoma resection without visual loss.[29]

In terms of anaesthetic effect, VEPs are sensitive to inhalation anaesthetics and their amplitude were reduced with increasing concentration of inhalational anaesthetic agents.[9]

Electromyography (EMG)

EMG is used to monitor muscle activity, either by spontaneous or evoked CMAPs. EMG is monitored in muscles innervated by cranial or spinal nerves that are at risk during surgery.[15]

In neurosurgery, EMG is commonly used for surgery of the lesion at cerebellopontine angle area as described by Duarte-Costa *et al* in their acoustic neuroma removal. They conducted a prospective recording of facial nerve function using EMG and subsequently reviewed the intraoperative neurophysiologic data for predicting long-term facial nerve function. The stimulation of the facial nerve was performed proximal and distal to the tumour locus after tumour removal, using the measurement of amplitude and latency responses in the orbicularis oculi and oris muscles. Their results showed that lower proximal amplitude and proximal-distal amplitude ratio were significant predictors of poor facial nerve function. Additionally, the study also showed a difference in the proximal latency time between the good and poor prognosis groups.[30]

Anaesthetic drugs have no effect on EMG recording, but the use of muscle relaxant should be avoided.[21]

Electroencephalography (EEG)

EEG records electrical activity in the cerebral cortex and can detect ischemia and seizure activity, as well as assess the impact of the anaesthetic agents on the brain.[31]

Skoch *et al* reviewed the history, indications, implementation and foreseeable future of invasive EEG monitoring with implantable subdural electrodes and intraparenchymal depth electrodes in epilepsy surgery. Improved localisation of epileptic foci justifies the secondary procedure and monitoring period in many patients. Informed use of invasive monitoring in conjunction with imaging and functional studies make epilepsy surgery a smaller, safer and more effective endeavor.[32]

Lyu *et al* evaluated and compared the benefits of long-term invasive EEG monitoring and two-stage surgery with the classical approach in order to examine their effect on post-surgical brain function and complications in anterior temporal lobectomy (ATL) for temporal lobe epilepsy in 198 patients. They concluded that preoperative invasive monitoring with long-term EEG helps locate the epileptic foci precisely. Postsurgical complications are rare compared to classical ATL, with better prognosis and seizure freedom after surgery.[33]

All anaesthetic agents affect the EEG; this is the basis for the use of so many monitors on the impact of anaesthesia on the brain. EEG is normally used as IONM for epilepsy surgery to identify the focus of epilepsy before excision. The excision is performed in awake craniotomy surgery.[34] Therefore, during recording of intraoperative EEG, a fully awake state is recommended or light sedation with low doses dexmedetomidine is acceptable.[35]

Microelectrode Recording (MER)

MERs of single unit neuronal activity were used during stereotactic surgery to define the subthalamic nucleus (STN) for chronic deep brain stimulation in the treatment of Parkinson's disease. By using five parallel trajectories, often two to three microelectrodes allow us to recognize STN neuronal activity. STN neurons were easily distinguished from cells of the overlying zona incerta and the underlying substantia nigra. During a typical exploratory track, we can observe a very low background noise in the zona incerta and almost complete absence of single cell recording. Penetration of the electrode tip into the STN is characterized by a sudden increase in background activity and single cell activity of spontaneously active neurons. The exit of the electrode tip out of the STN corresponds to a decrease in background noise and a loss of single cell activity. The use of microelectrode recording of the subthalamic area improves the accuracy of targeting the STN.[36]

Andrade-Souza *et al* reviewed 14 patients with Parkinson's disease treated with bilateral STN DBS (28 STN targets). Electrode implantation was based on direct and indirect targeting using two-dimensional magnetic resonance imaging (MRI), which was refined by microelectrode recording. Optimal settings, including the contacts used, were determined during the clinical follow-up. The position of the best contact was defined with postoperative MRI. This location was compared with the modified direct, indirect and red nucleus (RN) based targets. The mean distances between the targets and the final position of the optimal contact were calculated. The accuracy and variance of each target were analyzed. The data concluded that the use of the RN as an internal fiducial marker for targeting the optimal region of STN stimulation was reliable and closely approximates the position of the electrode contact that provides the optimal clinical results.[37]

The DBS surgery for electrode placement is always performed in awake craniotomy. During MERs, normally the patient is kept fully awake without sedation in order to prevent any effects of drugs to the recording.[38] Dexmedetomidine has been reported to provide interpretable STN MERs. The result of the study by Elias *et al* suggested that the administration of dexmedetomidine infusions should be without a loading dose, at relatively low infusion rate, and discontinued after completion of the bur holes for interpretable MERs.[39]

Recommendation for Anaesthesia Strategies

In any brain surgery which requires IONMs, the consideration of anaesthetic strategies are based on the indication of surgery; the type of craniotomy, whether general anaesthesia or awake surgery; the co-morbidities of the patient; and the types of IONM planned to be used. Table 1 shows the options of anaesthetic strategies based on common brain surgeries with IONM.

Conclusion

The use of IONMs during brain surgery is not as common as their uses in spine surgery, and there are also only few reviews that have specifically focused on it. However, with the advancement of brain surgery and more availability of IONM facilities, the use of multimodal IONMs might be more common during brain surgery in the future. Basic knowledge of each of the monitoring systems, common surgeries indicated with IONM and drug effects on IONM are important to strategize the anaesthetic management for the patient.

Table I: Anaesthesia strategies for brain surgery with IONMs

TYPES OF IONMs	EXAMPLE OF TYPE OF SURGERY	PRESENCE OF BASELINE NEUROLOGICAL DYSFUNCTION OR INTRACRANIAL HYPERTENSION	ANAESTHESIA STRATEGIES
SSEP, MEP, ±VEP	Supratentorial brain surgery under general anaesthesia (GA)	Yes	- TIVA/TCI with propofol-remifentanil with restriction of muscle relaxant for intubation
SSEP, MEP, ±VEP	Supratentorial brain surgery under GA	No	Options: - TIVA/TCI with propofol-remifentanil with restriction of muscle relaxant for intubation - Combine TIVA/TCI with propofol-remifentanil with < 0.5 MAC of inhalational agent (desflurane is preferable) with restriction of muscle relaxant only for intubation
SSEP, ±VEP	Supratentorial brain surgery under GA	Yes	- TIVA/TCI with propofol-remifentanil ± muscle relaxant

TYPES OF IONMs	EXAMPLE OF TYPE OF SURGERY	PRESENCE OF BASELINE NEUROLOGICAL DYSFUNCTION OR INTRACRANIAL HYPERTENSION	ANAESTHESIA STRATEGIES
SSEP, ±VEP	Supratentorial brain surgery under GA	No	Options: - TIVA/TCI with propofol-remifentanil ± muscle relaxant - Combine TIVA/TCI with propofol-remifentanil with < 1.0 MAC of inhalational agent ± muscle relaxant - Inhalational anaesthesia < 1.0 MAC ± muscle relaxant
SSEP, BAEP, EMG	Posterior fossa surgery under GA	Yes	- TIVA/TCI with propofol-remifentanil with restriction of muscle relaxant for intubation
SSEP, BAEP, EMG	Posterior fossa surgery under GA	No	Options: - TIVA/TCI with propofol-remifentanil with restriction of muscle relaxant for intubation - Combine TIVA/TCI with propofol-remifentanil with < 1.0 MAC of inhalational agent with restriction of muscle relaxant only for intubation - Inhalational anaesthesia < 1.0 MAC with TCI remifentanil with restriction of muscle relaxant only for intubation
EEG	Awake craniotomy for epilepsy surgery	No	Options: - Monitored anaesthesia care with dexmedetomidine ± TCI remifentanil ± scalp block - Monitored anaesthesia care with TCI propofol ± TCI remifentanil ± scalp block
SSEP, MEP	Awake craniotomy for lesion excision at eloquent area	No	Options: - Monitored anaesthesia care with dexmedetomidine ± TCI remifentanil ± scalp block - Monitored anaesthesia care with TCI propofol ± TCI remifentanil ± scalp block
Microelectrode recording	Awake craniotomy for DBS surgery	No	- Monitored anaesthesia care with dexmedetomidine ± TCI remifentanil ± scalp block

TIVA/TCI = Total intravenous anaesthesia/target-controlled infusion

References

1. Ando K, Kobayashi K, Ito K, et al. Wave Change of Intraoperative Transcranial Motor-Evoked Potentials During Corrective Fusion for Syndromic and Neuromuscular Scoliosis. *Oper Neurosurg (Hagerstown)* Jan 1 2019;**16**(1):53-58

2. Crowther JE, Ali DB, Bamford J, Kang SW, Kandil E. Intraoperative Neuromonitoring During Thyroid Surgery: The Effect of Surgical Positioning. *Surg Innov* Feb 2019;**26**(1):77-81

3. So VC, Poon CC. Intraoperative neuromonitoring in major vascular surgery. *Br J Anaesth* Sep 2016;**117** Suppl 2:ii13-ii25

4. Vasyatkina AG, Levin EA, Orlov KY, Kobozev VV. [An experience of neurophysiological monitoring in neurosurgery]. *Zh Nevrol Psikhiatr Im S S Korsakova* 2017;**117**(7):21-27

5. Brandmeier S, Taskiran E, Bolukbasi FH, Sari R, Elmaci I. Multimodal Intraoperative Neurophysiological Monitoring in Neurosurgical Oncology. *Turk Neurosurg* 2018;**28**(2):204-210

6. Eseonu CI, Rincon-Torroella J, ReFaey K, Lee YM, Nangiana J, Vivas-Buitrago T, Quinones-Hinojosa A. Awake Craniotomy vs Craniotomy Under General Anesthesia for Perirolandic Gliomas: Evaluating Perioperative Complications and Extent of Resection. *Neurosurgery* Sep 1 2017;**81**(3):481-489

7. Zhou Q, Li M, Yi L, He B, Li X, Jiang Y. Intraoperative neuromonitoring during brain arteriovenous malformation microsurgeries and postoperative dysfunction: A retrospective follow-up study. *Medicine (Baltimore)* Sep 2017;**96**(39):e8054

8. Dias S, Sarnthein J, Jehli E, Neidert MC, Regli L, Bozinov O. Safeness and Utility of Concomitant Intraoperative Monitoring with Intraoperative Magnetic Resonance Imaging in Children: A Pilot Study. *World Neurosurg* Jul 2018;**115**:e637-e644

9. Jameson LC, Sloan TB. Monitoring of the brain and spinal cord. *Anesthesiol Clin* Dec 2006;**24**(4):777-791

10. Kawaguchi M, Furuya H. Intraoperative spinal cord monitoring of motor function with myogenic motor evoked potentials: a consideration in anesthesia. *J Anesth* 2004;**18**(1):18-28

11. MacDonald DB. Safety of intraoperative transcranial electrical stimulation motor evoked potential monitoring. *J Clin Neurophysiol* Oct 2002;**19**(5):416-429

12. Shiban E, Krieg SM, Obermueller T, Wostrack M, Meyer B, Ringel F. Continuous subcortical motor evoked potential stimulation using the tip of an ultrasonic aspirator for the resection of motor eloquent lesions. *J Neurosurg* Aug 2015;**123**(2):301-306

13. Obermueller T, Schaeffner M, Shiban E, Droese D, Negwer C, Meyer B, Ringel F, Krieg SM. Intraoperative neuromonitoring for function-guided resection differs for supratentorial motor eloquent gliomas and metastases. *BMC Neurol* Oct 20 2015;**15**:211

14. Staarmann B, O'Neal K, Magner M, Zuccarello M. Sensitivity and Specificity of Intraoperative Neuromonitoring for Identifying Safety and Duration of Temporary Aneurysm Clipping Based on Vascular Territory, a Multimodal Strategy. *World Neurosurg* Apr 2017;**100**:522-530

15. Shils JL, Sloan TB. Intraoperative neuromonitoring. *Int Anesthesiol Clin Winter* 2015;**53**(1):53-73

16. Nathan N, Tabaraud F, Lacroix F, Moulies D, Viviand X, Lansade A, Terrier G, Feiss P. Influence of propofol concentrations on multipulse transcranial motor evoked potentials. *Br J Anaesth* Oct 2003;**91**(4):493-497

17. Scheufler KM, Zentner J. Motor-evoked potential facilitation during progressive cortical suppression by propofol. *Anesth Analg* Apr 2002;**94**(4):907-912, table of contents

18. Scheufler KM, Reinacher PC, Blumrich W, Zentner J, Priebe HJ. The modifying effects of stimulation pattern and propofol plasma concentration on motor-evoked potentials. *Anesth Analg* Feb 2005;**100**(2):440-447

19. Macdonald DB, Skinner S, Shils J, Yingling C, American Society of Neurophysiological M. Intraoperative motor evoked potential monitoring - a position statement by the American Society of Neurophysiological Monitoring. *Clin Neurophysiol* Dec 2013;**124**(12):2291-2316

20. Chong CT, Manninen P, Sivanaser V, Subramanyam R, Lu N, Venkatraghavan L. Direct comparison of the effect of desflurane and sevoflurane on intraoperative motor-evoked potentials monitoring. *J Neurosurg Anesthesiol* Oct 2014;**26**(4):306-312

21. Jameson LC, Sloan TB. Neurophysiologic monitoring in neurosurgery. *Anesthesiol Clin* Jun 2012;**30**(2):311-331

22. Toleikis JR, American Society of Neurophysiological M. Intraoperative monitoring using somatosensory evoked potentials. A position statement by the American Society of Neurophysiological Monitoring. *J Clin Monit Comput* Jun 2005;**19**(3):241-258

23. Shiban E, Zerr M, Huber T, Boeck-Behrends T, Wostrack M, Ringel F, Meyer B, Lehmberg J. Poor diagnostic accuracy of transcranial motor and somatosensory evoked potential monitoring during brainstem cavernoma resection. *Acta Neurochir (Wien)* Nov 2015;**157**(11):1963-1969; discussion 1969

24. Pereira LC, Oliveira KM, L'Abbate GL, Sugai R, Ferreira JA, da Motta LA. Outcome of fully awake craniotomy for lesions near the eloquent cortex: analysis of a prospective surgical series of 79 supratentorial primary brain tumors with long follow-up. *Acta Neurochir (Wien)* Oct 2009;**151**(10):1215-1230

25. Legatt AD. Mechanisms of intraoperative brainstem auditory evoked potential changes. *J Clin Neurophysiol* Oct 2002;**19**(5):396-408

26. Schramm J, Watanabe E, Strauss C, Fahlbusch R. Neurophysiologic monitoring in posterior fossa surgery. I. Technical principles, applicability and limitations. *Acta Neurochir (Wien)* 1989;**98**(1-2):9-18

27. Thirumala PD, Habeych ME, Crammond DJ, Balzer JR. Neurophysiologic intraoperative monitoring of olfactory and optic nerves. *J Clin Neurophysiol* Dec 2011;**28**(6):538-542

28. Gutzwiller EM, Cabrilo I, Radovanovic I, Schaller K, Boex C. Intraoperative monitoring with visual evoked potentials for brain surgeries. *J Neurosurg* Mar 30 2018;**130**(2):654-660

29. San-Juan D, Escanio Cortes M, Tena-Suck M, Orozco Garduno AJ, Lopez Pizano JA, Villanueva Dominguez J, Fernandez Gonzalez-Aragon M, Gomez-Amador JL. Neurophysiological intraoperative monitoring during an optic nerve schwannoma removal. *J Clin Monit Comput* Oct 2017;**31**(5):1059-1064

30. Duarte-Costa S, Vaz R, Pinto D, Silveira F, Cerejo A. Predictive value of intraoperative neurophysiologic monitoring in assessing long-term facial function in grade IV vestibular schwannoma removal. *Acta Neurochir (Wien)* Nov 2015;**157**(11):1991-1997; discussion 1998

31. Chen H, Koubeissi MZ. Electroencephalography in Epilepsy Evaluation. *Continuum (Minneap Minn)* Apr 2019;**25**(2):431-453

32. Skoch J, Adelson PD, Bhatia S, Greiner HM, Rydenhag B, Scavarda D, Mangano FT. Subdural grid and depth electrode monitoring in pediatric patients. *Epilepsia* Apr 2017;**58** Suppl 1:56-65

33. Lyu YE, Xu XF, Dai S, Dong XB, Shen SP, Wang Y, Liu C. Intracranial electrodes monitoring improves seizure control and complication outcomes for patients with temporal lobe epilepsy - A retrospective cohort study. *Int J Surg* Mar 2018;**51**:174-179

34. Nagahama Y, Schmitt AJ, Nakagawa D, et al. Intracranial EEG for seizure focus localization: evolving techniques, outcomes, complications, and utility of combining surface and depth electrodes. *J Neurosurg* May 25 2018:1-13

35. Bindra A, Kaushal A, Prabhakar H, et al. Neuroprotective role of dexmedetomidine in epilepsy surgery: A preliminary study. *Neurol India* Jan-Feb 2019;**67**(1):163-168

36. Benazzouz A, Breit S, Koudsie A, Pollak P, Krack P, Benabid AL. Intraoperative microrecordings of the subthalamic nucleus in Parkinson's disease. *Mov Disord* 2002;**17** Suppl 3:S145-149

37. Andrade-Souza YM, Schwalb JM, Hamani C, Eltahawy H, Hoque T, Saint-Cyr J, Lozano AM. Comparison of three methods of targeting the subthalamic nucleus for chronic stimulation in Parkinson's disease. *Neurosurgery* Feb 2008;**62** Suppl 2:875-883

38. Chui J, Alimiri R, Parrent A, Craen RA. The Effects of Intraoperative Sedation on Surgical Outcomes of Deep Brain Stimulation Surgery. *Can J Neurol Sci* Mar 2018;**45**(2):168-175

39. Elias WJ, Durieux ME, Huss D, Frysinger RC. Dexmedetomidine and arousal affect subthalamic neurons. *Mov Disord* Jul 15 2008;**23**(9):1317-1320

Enhanced Recovery After Surgery (ERAS): The Role Of Anaesthesiologists

Nadia Md Nor, Siti Nidzwani Muhammad Mahdi
Senior Lecturer & Consultant Anaesthesiologist, Department of Anaesthesiology and Intensive Care, Universiti Kebangsaan Malaysia Medical Centre, Kuala Lumpur, Malaysia

INTRODUCTION

Enhanced recovery after surgery is an evidence-based multimodal perioperative care protocol which aims for early postoperative recovery by preserving organ function preoperatively, and reducing the postoperative stress response.[1] Inspired by Danish Professor of Surgery, Dr Henrik Kehlet, its concepts and guidelines is a significant part of care to various surgical patients in Europe and UK.[2-4] The traditional perioperative care in colon surgery including prolonged fasting, bowel preparation, routine drain use, immobility and delayed oral intake was questionable and not scientifically proven.[3,4] A collaborative perioperative care group was initiated, and this led to the formation of the ERAS® Society in 2010 (https://www.erassociety.com).

Consensus guidelines of perioperative care for various surgeries including colorectal, gastric, pancreas, liver, bariatric, urology, gynaecology, head and neck, cardiac and thoracic, which focused on preoperative counselling, optimising nutrition, electrolyte and fluid balance, minimally invasive surgical techniques, non-opioid multimodal analgesia, early ambulation and oral intake were developed.[4] Implementation of the ERAS protocol requires multidisciplinary involvement of surgeons, anaesthesiologists, physicians, nurses, nutritionists, physical and occupational therapists and social workers.[4]

EFFECTS OF THE STRESS RESPONSE TO SURGERY

Surgery activates the metabolic, hormonal, haematological, immunological and sympathetic nervous systems, leading to the stress response. Consequently pituitary hormone secretion, fat and protein catabolism increases, resulting in substrate mobilisation for energy sources, with salt and water retention to maintain fluid volume and cardiovascular homeostasis.[5] The pathophysiology of this stress response forms the basis of therapeutic interventions in the ERAS protocol.

Sympathetic Nervous System

Activation of sympathetic autonomic nervous system results in increase secretion of catecholamines and release of noradrenaline. This increase in sympathetic activity is responsible for hypertension, tachycardia, renin and glucagon release. Renin causes peripheral vasoconstriction, and aldosterone leads to sodium and water retention. Glucagon promotes liver and muscle glycogenolysis, increasing glucose and lactate concentrations, and free fatty acid mobilisation.[5,6]

Adrenocorticotrophic Hormones and Cortisol

Anterior pituitary adrenocorticotrophic hormones stimulate adrenal cortex cortisol secretion within minutes of surgical commencement. The magnitude and duration of increased levels of these hormones correlate with the severity of insult.[5] These hormonal levels remain high postoperatively since the physiological hypothalamic-pituitary-adrenal axis (HPA) feedback control mechanism is still ineffective.[5,6]

The enhanced metabolic effects of cortisol on protein, fat and carbohydrate, promotes protein breakdown, lipolysis and liver gluconeogenesis. Impaired cell utilisation of glucose ('anti-insulin effect') causes hyperglycaemia.[6]

Hormonal Changes

The increase in growth hormone secretion is proportionate to the severity of tissue injury. It promotes glycogenolysis and lipolysis, inhibits cell uptake and utilisation of glucose, prevents protein breakdown, and promotes tissue repair.[5,6]

Posterior pituitary secretion of arginine vasopressin, an antidiuretic hormone, is increased intraoperatively. It acts as a vasopressor and promotes haemostasis.[5,6]

The secretion of insulin, an anabolic hormone, may be reduced intraoperatively with <-adrenergic inhibition of catecholamine on pancreatic ®-cells. The body fails to increase insulin secretion to match catabolic and hyperglycaemic responses.[5] In addition, cellular insulin resistance, which is precipitated later, contributes further to perioperative insulin deficiency.[6]

Postoperatively, thyroid (T_4 and T_3) hormone levels are inversely correlated with sympathetic stimulation, with reduced production. Testosterone and oestrogen concentrations are also reduced for several days in both male and female patients. Conversely, ®-endorphin and prolactin secretion is increased and may alter immune function.[5,6]

Immunological and Haematological Changes

The effects of cytokines and acute phase proteins include fever, granulocytosis lymphocytosis, leucocytosis, haemostasis, limitation of tissue damage and promotion of healing.[5-7]

Surgery and Nociception

Cell disruption during surgical incision and tissue manipulation leads to various intracellular chemical mediator release. These include cytokines, bradykinin, prostanoids, adenosine, potassium and nerve growth factors that are responsible in activating peripheral pain A™ and c-fibres (primary hyperalgesia).[6,7] The release of pro-inflammatory substances and substance P also sensitises inactive A™ nociceptors of adjacent non-injured tissues (secondary hyperalgesia). Both primary and secondary hyperalgesia increased firing at dorsal horn neurons of the spinal cord (central sensitisation).[7]

Sympathetic nervous system stimulation, activation of the HPA and systemic release of pro-inflammatory cytokines are major determinants of postoperative insulin resistance, which if not attenuated, may lead to multiorgan dysfunction.[7]

Role of Anaesthesiologists in Implementing ERAS

The anaesthesiologist's role is vital in many aspects of the ERAS protocol. It begins from the pre-hospital admission at the anaesthesia clinic, for risk assessment, education, preoperative optimisation and referrals to other specialties.[7,8] During the immediate preoperative period, anaesthesia technique and perioperative care is planned. Intraoperatively, anaesthesiologists manage fluid therapy and perioperative analgesia, monitor vital parameters and prevent hypothermia.[1,3,7] Postoperative patient care continues in the recovery area, general wards, post-anaesthesia care unit/ high dependency unit or intensive care unit. Anaesthesiologists contribute in the implementation of ERAS as part of team leadership, and ensuring protocol compliance, regular audit and continuous education.[7,8]

Recommendations by ERAS and Anaesthesia Consideration

A. Preoperative Care

Preoperative counselling, education and information about anaesthesia reduce patient anxiety and emotional distress. This improves postoperative recovery and pain control, increase patient adherence to care plan, hence promote early recovery and discharge. Preoperative optimisation of chronic diseases like cardiovascular diseases, diabetes mellitus and chronic obstructive pulmonary disease should be initiated at primary care level during pre-admission.[8,9] Risk stratification and identification of patients at higher risk of morbidity and mortality following major surgery is prudent as they constitute 80% of postoperative mortality.[9-11] Preoperative risk reduction through "pre-rehabilitation" by preoperative cardiovascular conditioning, or training by muscle strengthening reduces frailty and disability of elderly patients, who with accompanying geriatric physiological changes face greater challenge withstanding surgical stress.

Concurrent co-morbidities impact greater on post-operative mobility and morbidity, than age alone.[7,9] Long acting anxiolytics may delay discharge and short acting benzodiazepines should be avoided in elderly patients.[9-11] The ERAS guidelines benefit the elderly, however data remains limited.[12]

Smokers have increased risk of poor wound and tissue healing. Alcohol abusers have an impaired metabolic stress response, cardiac, and immune function towards surgery. Four weeks of abstinence from smoking and alcohol reduce the risk of perioperative bleeding and wound infection, and improve wound healing.[9,10]

Preoperative overnight fasting increases patient discomfort and insulin resistance.[9] The usual 2 hour clear fluid and 6 hour solid food fast applies, prior anaesthesia induction.[9,13,14] The added allowance of oral complex carbohydrates (CHOs), the night before surgery and 2 hours prior anaesthesia induction, reduce the catabolic state induced by fasting and surgery.[9,10]

B. Intraoperative Care

Minimal invasive surgery is advocated when the expertise is available, and when patient factors and surgical conditions permit.[9-11] It reduces neurohumoral activation by minimising the access wound and release of postoperative inflammatory factors.

Postoperative nausea and vomiting (PONV), a most unpleasant perioperative experience, occurs in 30-70% of patients.[9,14,16] Patients with increased risk of PONV which include female gender, history of motion sickness or PONV, non-smoker and opioid use, are recommended to receive two or three antiemetics.[16-17] Total intravenous anaesthesia (TIVA) and opioid sparing strategies are encouraged.[9,17]

Maintenance of anaesthesia with end tidal concentration ranging 0.7-1.3 MAC, guided with bispectral index (BIS) values between 40 to 60, will prevent awareness, minimise anaesthetic side effects and facilitate rapid awakening and recovery. A minimal BIS of 45 is advocated for elderly patients to avoid deep anaesthesia.[8,9,11,12,15] Hyperoxia is avoided with inspired fractional oxygen concentration (FiO_2) titrated to normal arterial oxygenation, and FiO_2 1.0 reserved for pre-oxygenation prior to anaesthesia induction, or to overcome hypoxia.[9-12]

Neuromuscular monitoring is advocated when using neuromuscular blocking agents, to ensure adequate depth of muscle relaxation intraoperatively. The restoration of satisfactory neuromuscular function postoperatively is confirmed by a train of four (TOF) ratio of 0.9.[9,12,14,15] Use of sugammadex, a selective cyclodextrin binding reversal of neuromuscular blockade, is supported in obese patients and bariatric surgery.[15]

Active warming devices are highly recommended for surgeries with duration exceeding 30 minutes. Perioperative hypothermia is of concern, typically amongst the elderly and paediatric patients. Rewarming to a core body temperature of 35.5-36ºC should be initiated before emergence of anaesthesia. The maintenance of normal glucose levels intraoperatively is highly recommended.[9-12]

Preoperative fluid deficit varies depending on patient co-morbidity. The reduced use of bowel preparation and preoperative carbohydrate loading result in patients coming to theatre in an euvolaemic state. Physiological interventions during anaesthesia such as the administration of positive pressure ventilation, vasoactive drugs and neuraxial blocks may affect vasomotor tone and intravascular volume. Intraoperative fluid management employs goal-directed fluid therapy, aiming for near zero fluid balance, where balanced crystalloids is used and 0.9% saline is avoided.[9,10,14] Extremes of fluid balance risks reduced tissue oxygen delivery, either by poor cardiac output (inadequate fluid) or oedema (excess fluid).

Pain management aims towards optimal analgesia with minimal side effects, to facilitate early mobilisation and oral intake.[8-11] Multimodal, procedure specific and opioid sparing anaesthetic regimens including regional analgesic techniques should be implemented.[14] Thoracic epidural analgesia provides excellent analgesia for open colorectal surgery, in addition to contributing to a reduction in the duration of ileus, incidence of pulmonary thromboembolism, blood loss, postoperative chest complications, and modification of the stress response. Use of other techniques, such as rectus sheath blocks, transversus abdominis plane blocks, and surgical site ('wound') catheter analgesia with preperitoneal local anaesthetic infusions have also been described.

Intraoperative mechanical ventilation strategy, which is a critical aspect of care, is often overlooked. Conventional high tidal volume (VT) ventilation at 10-15 mL/kg may be associated with increased lung injury which results from direct mechanical trauma to the pneumocyte through excessive pressure (barotrauma), overinflation (volutrauma), or shear stress from cyclic derecruitment (atelectrauma).[18,19] Subsequently, there is conversion of mechanical stimuli into a biochemical response (mechanotransduction), with release of cytokine mediators where alveolar epithelium or vascular endothelium may be secondarily injured (biotrauma).[20-22]

A meta-analysis of all available randomised controlled trials of low tidal volume (LTV) ventilation at VT 6-8 mL/kg, compared with conventional strategy in healthy patients, was associated with a reduction in pulmonary infections. However protective lung ventilation (PLV) strategy comprising the combination of LTV, increased positive end expiratory pressure (PEEP) and recruitment maneuvers was associated with significant reduction in atelectasis, acute lung injury and length of hospital stay in addition to a further reduction in pulmonary infection.[23]

LTV alone theoretically increases cyclic alveolar collapse of dependent lung regions, increasing the risk of atelectrauma. The concomitant use of PEEP and intermittent recruitment maneuvers may counteract this undesired effect. The latter involves stepwise increase in tidal volume and PEEP to targeted plateau pressures, or inflations of the anaesthesia reservoir to targeted peak inspiratory pressures, performed intermittently for periods of 30 to 45 seconds at varying intervals.[23] A recent systematic review confirmed reduction of atelectasis, and improved pulmonary oxygenation and compliance with recruitment strategies.[24]

C. Postoperative Care

Opioid sparing analgesic strategies is further emphasised postoperatively to avoid opioid dose dependent side effects which contribute to delayed recovery and prolonged stay.[8,10,11] Opioids are reserved as a last resort.

Intravenous fluid should be ceased early postoperatively and oral fluids is encouraged as soon as tolerated, with resumption to normal food soon after surgery.[11] It may not be possible to perform goal-directed fluid therapy postoperatively, hence indirect markers of hypovolaemia such as decreased central venous oxygen saturation or increased lactate levels are utilised.

Early removal of drains and tubes and early mobilisation will minimise the risk of infection, orthostatic pneumonia, venous thromboembolism, worsening insulin resistance and muscles weakness.[9-12,15]

The impact of surgical trauma and anaesthesia results in reduced lung volumes, respiratory muscle dysfunction, and atelectasis, which predispose to hypoxaemia.[25] Patients at risk such as smokers, those with chronic obstructive disease, congestive cardiac failure, obesity, the elderly and prolonged surgery beyond 3 hours, may need postoperative respiratory care. This includes oxygen supplement, physiotherapy, incentive spirometry, continuous positive airway pressure (CPAP), and other techniques.[25]

Postoperatively obese patients without obstructive sleep apoea (OSA) should receive prophylactic oxygen supplement with the head end elevated, or in a semi-sitting position. A low threshold for initiation of CPAP should be considered in patients with body mass index > 50 kg/m^2, severe OSA or oxygen saturation < 90% on oxygen supplement. Patients who were on home CPAP therapy, if not surgically contraindicated, should be started on their device immediately postoperative. Prophylactic non-invasive positive pressure ventilation should be considered postoperatively for patients with obesity hypoventilation syndrome.[15,25]

Controversies Surrounding ERAS

Preoperative benzodiazepines are avoided even in patients with significant anxiety, as sedative hypnotics increase cognitive and pharyngeal/ laryngeal dysfunction, where the latter predispose to microaspiration.[26,27]

There is limited data supporting oral CHOs administration in patients at higher aspiration risk during anaesthesia induction such as those with diabetes, gastro-oesophageal reflux or are morbidly obese.[9,10,15]

The role of cardiac output monitors looking at dynamic indicators in ERAS remains questionable. Patients need to be followed up postoperatively, and weight gain limited to < 1 kg.

Traditionally, thoracic epidurals were employed for postoperative analgesia after liver surgery. However concerns of hindered mobility, coagulopathy, hypotension and its consequent fluid management have led to its decrease use. Epidural failure is common, leaving patients with inadequate analgesia. Alternatively, surgical site ('wound') catheter analgesia with preperitoneal local anaesthetic infusions via elastomeric pumps has been used. A meta-analysis of studies compared analgesia and hospital length of stay between the two techniques concluded that epidural analgesia was superior on the first postoperative day, however patients with wound catheters suffered fewer postoperative complications.[28]

ERAS - New Perspectives of Application and the Future

The latest ERAS protocol was implemented in emergency surgeries, where the mortality rate is at least ten times higher than many similar elective procedures However, the emergency setting may limit compliance with the entire protocol.[29]

In obstetric surgery, the early return to normal function is of priority for several reasons. There has been a substantial increase in hospital discharge the day after elective Caesarean section, without any increase in readmission rates.[30]

There is also the role for cancer-specific ERAS protocols in the future. Surgery for cancer is associated with tumour cell release.[31] The anticancer immune response primarily determines cancer progression, hence interventions aimed at reducing exposure to immunosuppressive factors would improve patient outcomes after potentially curative cancer resection.[32]

Pain activates the HPA and sympathetic system, giving rise to immunosuppression.[31] Laparoscopic resection for primary hepatocellular cancer results in a lower inflammatory response and reduced circulating tumour cells.[33] In colorectal oncological surgery, this translated to a shorter time interval before starting adjuvant chemotherapy postoperatively.[34] Gustafsson *et al* reported improved 5-year cancer-specific survival after colorectal cancer surgery in patients with > 70% adherence to ERAS items.[35]

Analgesic strategy is crucial, as the benefit of pain control may be overcome by some drugs with tumour promoting effects. Opioid μ-receptor agonists are immunosuppressive. Morphine and fentanyl suppress the innate and acquired immunity, thus may impair the host defence against circulating tumour cells postoperatively.[36] Morphine in clinical relevant doses enhanced angiogenesis hence increased breast cancer progression.[37] However despite this, there is no definitive evidence that opioids worsen outcomes in cancer patients.[38] Early nutrition impacts positively on nutritional status, the immune system, and on speeding intestinal recovery in patients with gastric cancer.

The UK ERAS programme has revolutionised inpatient elective major surgery. Although envisaged to accelerate recovery, reduce length of stay and costs, there are other potential benefits, such as reduced complications and increased long-term survival. The concept of enhanced survival rather than enhanced recovery may be on the horizon.

References

1. Bartosz Horosz, Katarzyna Nawrocka, Malgorzata Malec-Milewska. Anaesthetic perioperative management according to the ERAS protocol. *Anaesthesiol Intensive Ther* 2016;**48**(1):49-54
2. Adam B. king, Bret D. Alvis, and MatthewD. McEvoy. Enhanced recovery after surgery, perioperative medicine, and the perioperative surgical home: current state and future implications for education and training. *Curr Opin Anesthesiol* 2016;**29**:727-723
3. Kehlet H, Wilmore DW. Multimodal strategies to improve surgical outcome. *Am J Surg* 2002;**183**:630-641
4. Michał P dziwiatr, Judene Mavrikis, Jan Witowski, Alexandros Adamos, Piotr Major, Michał Nowakowski, et al. Current status of enhanced recovery after surgery (ERAS) protocol in gastrointestinal surgery. *Med Oncol* 2018;**35**(6):95
5. J.P. Desborough. The stress response to trauma and surgery. *BJA* 2000;**85**(1):109-117
6. Deborah Burton. Endocrine and metabolic response to surgery. *Continuing Education in Anaesthesia, Critical Care & Pain* 2004;**4**(5):144-147
7. M.J. Scott, G Baldini, K.C.H. Fearon, A. Feldheiser, L.S. Feldman, T.J. Gan, et al. Enhanced Recovery After Surgery (ERAS) for gastrointestinal surgery, part 1: pathophysiological considerations. *Acta Aneasthesiol Scand* 2015;**59**:1212-1231
8. Abdelazeem Eldawlatly. Is enhanced recovery after anaesthesia is synonym to enhanced recovery after surgery? *Saudi J Anaesth* 2016;**10**(2):119-120
9. A. Feldheiser, O. Aziz, G. Baldini, B.P.B.W. Cox, K.C.H Fearon, L. S. Feldman, et al. Enhanced Recovery After Surgery (ERAS) for gastrointestinal surgery, part 2: consensus statement for anaesthesia practice. *Acta Aneasthesiol Scand* 2016;**60**:289-334
10. Joseph C. Carmichael, Deborah S. Keller, Gabriele Baldini, Liliana Bordeianou, Eric Weiss, Lawrence Lee, et al. Clinical Practice Guidelines for Enhanced Recovery After Colon and Rectal Surgery From the American Society of Colon and Rectal Surgeons and the Society of American Gastrointestinal and Endoscopic Surgeons. *Dis Colon Rectum* 2017;**60**:761-784
11. U.O. Guftasson, M.J Scott, W. Schwenk, N. Demartines, D. Roulin, N. Francis, et al. Guidelines for Perioperative Care in Elective Colonic Surgery: Enhanced Recovery After Surgery (ERASÆ) Society Recommendations. *World J Surg* 2013;**37**:259-284
12. Olle Ljunqvist and Martin Hubner. Enhanced recovery after surgery-ERAS-principles, practice and feasibility in the elderly. *Aging Clin Exp Res* 2018;**30**:249-252
13. Smith I, Kranke P, Murat I, Smith A, O'Sullivan G, Soreide E, et al. Perioperative fasting in adults and children: guidelines from the European Society of Anaesthesiology. *Eur J Anaesthesiol* 2011;**28**:556-69
14. American Society of Anesthesiologists C. Practice guidelines for preoperative fasting and the use of pharmacologic agents to reduce the risk of pulmonary aspiration: application to healthy patients undergoing elective procedures: an updated report by the American Society of Anesthesiologists Committee on Standards and Practice Parameters. *Anesthesiol* 2011;**114**:495-511
15. A. Thorell, A. D. MacCormick, S. Awad, N. Reynolds, D. Roulin, N. Dermatines, et al. Guidelines for Perioperative Care in Bariatric Surgery: Enhanced Recovery After Surgery (ERAS) Society Recommendations. *World J Surg* 2016;**40**:2065-2083
16. Tong J. Gan. Risk factors for postoperative nausea and vomiting. *Anesth Analg* 2006;**102**:1884-98
17. Christian C Apfel, Kari Korttila, Mona Abdalla, Heinz Kerger, Alparslan Turan, Ina Vedder, et al. A Factorial Trial of Six Interventions for the Prevention of Postoperative Nausea and Vomiting. *N Engl J Med* 2004;**350**:2441-51

18. Lellouche F, Dionne S, Simard S, et al. High tidal volumes in mechanically ventilated patients increase organ dysfunction after cardiac surgery. *Anesthesiol* 2012;**116**:1072-1082

19. Miller TE, Mythen M. Successful recovery after major surgery: moving beyond length of stay. *Perioper Med (Lond)* 2014

20. Pelosi P, Negrini D. Extracellular matrix and mechanical ventilation in healthy lungs: back to baro/volutrauma? *Curr Opin Crit Care* 2008;**14**:16-21

21. Lionetti V, Recchia FA, Ranieri VM. Overview of ventilator-induced lung injury mechanisms. *Curr Opin Crit Care* 2005;**11**:82-86

22. Melo MF, Eikermann M. Protect the lungs during abdominal surgery: it may change the postoperative outcome. *Anesthesiol* 2013;**183**:1254-1257

23. Dongjie Yang, MD, Michael C. Grant, MD,y Alexander Stone, Christopher L. Wu, MD & Elizabeth C. Wick, MD. A Meta-analysis of Intraoperative Ventilation Strategies to Prevent Pulmonary Complications: Is Low Tidal Volume Alone Sufficient to Protect Healthy Lungs? *Ann Surg* 2016;**263**(5):881-887

24. Hartland BL, Newell TJ, Damico N. Alveolar recruitment maneuvers under general anesthesia: a systematic review of the literature. *Respir Care* 2015;**60**:609-620

25. Richard D Branson. The Scientific Basis for Postoperative Respiratory Care. *Respir Care* November 2013;**58**(11):1974-84

26. Axel Maurice-Szamburski, Pascal Auquier, Velronique Viare-Oreal, Philippe Cuvilon, Michel Carles, Jacques Ripart, et al. Effect of Sedative Premedication on Patient Experience After General Anaesthesia. A Randomized Clinic Trial. *JAMA* 2015;**313**:916-25

27. Anna I. Hardemark Cedborg, Eva Sundman, Katarina Boden, Hanne Witt Hedstrom, Richard Kuylenstierna, Olle Ekberg, et al. Effects of Morphine and Midazolam on Pharyngeal Function, Airway Protection, and Coordination of Breathing and Swallowing in Healthy Adults. *Anesthesiol* 2015;**122**:1253-67

28. Bell R, Pandanaboyana S, Prasad KR. Epidural versus local anaesthetic infiltration via wound catheters in open liver resection: a meta-analysis. *ANZ J Surg* 2014. doi:111/ans.12683

29. Quiney N., Aggarwal G., Scott M., Dickinson M. Survival after emergency general surgery: what can we learn from enhanced recovery programmes? *World J Surg* 2016;**40**(6):1283-1287. doi: 10.1007/s00268-016-3418-0

30. I. J. Wrench, A. Allison, A. Galimberti, S. Radley, and M.J. Wilson, "Introduction of enhanced recovery for elective caesarean section enabling next day discharge: a tertiary centre experience," *IJOA* 2015;**24**(2):124-30

31. F. J.Vogelaar, D. J. Lips, F.R. vanDorsten, V. E. Lemmens, K.Bosscha. "Impact of anaesthetic technique on survival in colon cancer: a review of the literature," *Gastroenterol Rep* 2016;**4**(1):30-34

32. H. Beloeil and K. Nouette-Gaulain, "The perioperative period in cancer surgery: a critical moment! Is there a role for regional anesthesia in preventing cancer recurrence?" *Ann Fr Anesth Reanim* 2016;**31**(6):528-36

33. W. Li, X. Zhou, Z. J. Huang et al., "Laparoscopic surgery minimizes the release of circulating tumor cells compared to open surgery for hepatocellular carcinoma," *Surg Endosc* 2015;**29**(11):3146-53

34. G. S. Simpson, R. Smith, P. Sutton et al., "The aetiology of delay to commencement of adjuvant chemotherapy following colorectal resection," *Int J Surg Oncol* 2014: Article ID670212

35. U. O. Gustafsson, H. Oppelstrup, A. Thorell, J. Nygren, and O. Ljungqvist, "Adherence to the ERAS protocol is associated with 5-year survival after colorectal cancer surgery: a retrospective cohort study," *World J Surg* 2016;**40**(7):741-47

36. L. Gong, Q. Qin, L. Zhou et al., "Effects of fentanyl anesthesia and sufentanil anesthesia on regulatory T cells frequencies," *Int J Clin Exp Patho* 2014;**7**(11):7708-16

37. S. Bimonte, A. Barbieri, D. Rea et al., "Morphine promotes tumor angiogenesis and increases breast cancer progression," *Biomed Res Int* 2015; Article ID 161508

38. J. R. Meserve, A. D. Kaye, A. Prabhakar, and R. D. Urman, "The role of analgesics in cancer propagation," *Best Pract Res Clin Anaesthesiol* 2014;**28**(2):139-151

Challenges In Obstetric Anaesthesia - The Pregnant Obese Patient

Carolyn Yim Chue Wai[1], **Tan Wei Keang**[2]
[1] Senior Lecturer, Consultant Anaesthesiologist & Head, Unit Obstetric Anaesthesia, Department of Anaesthesiology and Intensive Care, University Malaya Medical Centre, Kuala Lumpur, Malaysia
[2] Lecturer & Anaesthesiologist, Department of Anaesthesiology and Intensive Care, University Malaya Medical Centre, Kuala Lumpur, Malaysia

INTRODUCTION

Challenges

In 2016, the World Health Organization (WHO) estimated that more than 1.9 billion adults were overweight, and of this 650 million were obese. The committee on Obstetric Practice in 2013 estimated that one third of women of child-bearing age were obese while 8% were extremely obese. Our neighbours in Australia reported that between the periods of 2009 - 2011, 50% of women who became pregnant were either overweight or obese. Based on the Malaysian National Obstetric Registry during the periods of 2011 - 2015, 29.6% were considered overweight while 20.5% were considered obese.[1]

With regards to the impact of obesity in pregnancy, the Mother and Babies: Reducing Risk through Audits and Confidential Enquiries across the UK (MBRRACE-UK) between 2013 - 2015 revealed that 39 women who died were overweight, while 68 were obese. The total number of deaths during this period was 202 parturients. Recently, in 2017, the MBBRACE report recognized that obese women have poor outcomes, and care providers encounter technical difficulties in providing care for them.

The classification of obesity in pregnancy is based on BMI calculation. A mother is considered normal weight if BMI (kg/m^2) ranges within 18.5-24.9 kg/m^2. BMI of 25.0-29.9 kg/m^2 is considered overweight and > 30 kg/m^2 is known as obesity. The ideal time of measuring their weight is during booking. Obesity also increases the risk of the occurrence of co-morbidities.

Table I: World Health Organisation classification of obesity and related risk of incidence of co-morbidities

Classification	BMI : kg/m^2	Risk of Co-morbidities
Normal	18.5 - 24.9	Average
Overweight	25 - 29.9	Increased
Obese Class 1	30 - 34.9	Moderate
Obese Class 2	35 - 39.9	Severe
Obese Class 3	>40	Very Severe

Maternal Physiological Challenges

Obesity and pregnancy leads to a multisystem of changes, which requires the body to adapt to, in the presence of a growing fetus. Maternal physiological changes are further affected by physiological changes in obesity. This places a greater demand on the body, which results in catastrophic complications if this balance is compromised.

Patients who are obese have a reduction in functional residual capacity. They have a higher closing volume hence augmenting ventilation perfusion mismatch. The effect is further aggravated in pregnancy where the closing volume encroaches during the normal tidal volume. Lung compliance is poor secondary to thickened chest wall and associated restriction of diaphragmatic movement by the intra abdominal organs and the gravid uterus. They have an increased work of breathing resulting in fast and shallow breaths. Obstructive sleep apnoea (OSA) occurs in 50 - 90% of morbidly obese patients, associated risk of pulmonary hypertension and cor-pulmonale. Risk of difficult mask ventilation and intubation is also higher. Moreover, increased breast tissue makes intubation difficult. Pregnancy increases oxygen consumption which is further increased by obesity. Hence detrimental hypoxia sets in earlier and more so when oxygen delivery is compromised.

The cardiovascular requirements are significantly increased in the obese mother. An increased in stroke volume, heart rate, widening pulse pressure are physiological changes related in pregnancy due increased in oxygen demand. In obese parturients, they also experience obesity related risk factors such as hypertension, ischemic cardiac disease, and congestive heart failure. OSA may aggravate right ventricle hypertrophy and systemic hypertension can lead to left ventricle hypertrophy; impairing diastolic function. Risk of arrhythmia is increased due to potential fat deposition over the myocardium. Peripartum cardiomyopathy may result from poorly controlled obesity associated hypertension.[2] Aortocaval compression by the presence of gravid uterus is further compounded by increased intra-abdominal adipose tissue. This leads to a drastic reduction in venous return to an already compensating maternal heart.

The presence of hiatus hernias is common among obese patients. This raises the risk of aspiration and regurgitation which is also partly related to larger resting gastric volume in this category of patients. Fat infiltration worsens liver function leading to abnormal results and fatty liver in pregnancy. The chance of developing gallstones disease is also higher.

Physiological changes in pregnancy in the renal system are marked by significant volume expansion and vasodilatation. This is due to upregulation of renin angiotensin aldosterone system (RAAS). Obesity leads to increased release of leptin by the fat cells, resulting in increased sodium absorption and further renal vasodilation. Overall obese parturient has enhanced glomerular filtration rate and renal plasma flow.

Obesity and pregnancy both increase the risk of deep vein thrombosis and thromboembolic events. Thromboembolism remains the third leading cause of maternal mortality in Malaysia. The increased production of clotting factors and von-Willebrand factors during pregnancy also contribute to hypercoagulability; components in the Virchow's triad. Venous stasis attributed by an increase in adipose tissue intra abdominally, further reduces the venous return. Obese women are also generally less mobile, which further worsens blood flow. Maternal obesity may also lead to endothelial injury and dysfunction.[3]

Overweight or obese women are more prone to develop medical illness, which may be further aggravated by pregnancy itself. Chronic hypertension leading to preeclampsia and gestational diabetes are common pregnancy specific complications present in obese parturients. A Danish study found that the absolute risk for developing GDM was 0.9% in normal-weight women. This increased to 3.1% for overweight women, 6.7% for obese women and 9.3% for severely obese women.[4] A raised booking BMI is also associated with a 50% increased risk of developing preeclampsia and a booking BMI >35 doubled the preeclampsia risk.[5]

Fetal Challenges

Higher risk of miscarriages is commonly encountered after conception.[6] Furthermore, a higher incidence of congenital abnormalities is seen in the neonates of obese mothers. Cardiac and neural tube defects are most commonly noted. This may also be secondarily due to poor detection via ultrasound during the antenatal period as the view may be suboptimal. Chances of premature delivery are also higher compared to non-obese population. Infants born to obese mothers also may be macrosomic or have higher birth weights when compared to women who have normal BMI.[7]

Table II: Risk factors associated with maternal obesity

Maternal Risk	Fetal Risk
Perinatal Death	Miscarriage and stillbirth
Thrombo-embolism	Preterm Birth
Gestational Diabetes	Fetal distress
Pre-eclampsia	Meconium aspiration
Postpartum haemorrhage	Macrosomia
Wound infection	Low Apgar score
Assisted instrumental delivery	Neural tube defects
Induced delivery	Admission to neonatal intensive care
Caesarean section	
Decreased rate of breastfeeding	

FACING THE CHALLENGES

Pre-delivery Consultation

A survey conducted by Tulp found that many obese obstetric patients were unaware of the anaesthetic problems and risks associated with obesity during their pregnancy.[8] This is despite them being aware of both the medical and obstetric implications throughout pregnancy. Hence, pre-delivery consultation would be an opportune time to have this discussion in a relaxed and controlled manner. The aim of such a consult would be to increase the awareness of the main modalities of labour analgesia with special mention of labour epidural They should be encouraged to seriously consider early labour epidural placement in view of underlying risk of the increased need for ceasarean sections and instrumental deliveries. The concerns of difficult placements due to technical difficulties should also be broached.

Furthermore, they should be made aware that due to obesity, they are more likely to suffer adverse events and outcomes when compared to their non-obese counterparts. It should also be further emphasised of the higher risk of aspiration, difficult intubation, and airway trauma if a general anaesthetic technique is needed.

Ultrasound Guided Placement for Regional Anaesthesia

In order to improve the care and outcome of obese pregnant women, many governing bodies have encouraged the use of labour epidurals. This is due to the fact that they have an increased incidence of the need for emergency delivery via caesarean section, the need for instrumental delivery and tend to have macrosomic babies. Obesity itself frequently hinders the identification of anatomical landmarks such as the midline and vertebral interspace. Data has proven the requirements for longer insertion times, higher incidence of epidural venous puncture, higher overall failure and complication rates during placement. A two-fold increase in risk of epidural failure and difficult epidural placement is expected which also increases with increasing BMI.[9]

A simple way when surface anatomy is obscured in the obese patients is to ask the patient to give verbal feedback during placement. She verbalizes whether the place chosen is in the midline and whether it is between the vertebral bodies. This information has been shown to be 76.6% helpful in parturients of BMI > 35.[10]

The use of ultrasound in assisting placement of epidurals and spinal has been studied in the obstetric population in the past decade. It has been proven to improve placement in all aspects and ensures effectiveness. Studies in the obese obstetric population have also shown that it can be used as a reliable tool for cases when technical difficulty is anticipated and as a rescue when anatomical landmarks are difficult to identify.[11]

Algorithms for Airway Management

The first failed tracheal intubation guideline was developed by Michael Tunstall at Aberdeen Maternity hospital in the 1970s. Since then, the incidence rate remains the same. In a literature review done by Kinsella *et al*, the occurrence of a difficult intubation for caesarean section under general anaesthesia is 1 in 443 cases.[12] Maternal mortality from failed intubation is noted as 1 death per 90 cases.[12] Deaths are the result of aspiration or hypoxaemia secondary to airway obstruction or esophageal intubation. On the other hand, the incidence of Cannot Intubate Cannot Oxygenate (CICO) during general anaesthesia for caesarean ranges from 5 to 28 per 100 cases.[12]

Based on MBRRACE-UK 2013 - 2015, anaesthetic advisors highlighted airway management as an important theme in the anaesthetic management of the parturient. Previous years have reported incidences of inability and failure to mask ventilate or to intubate obese partureints, directly implicating this as the cause of maternal death.

In view of this, clinicians taking care of the obese parturients must be familiar with the latest guidelines in the management of the obstetric airway. Conducting drills to familiarise all personnel of equipment to be used and steps to be taken should be considered in all locations caring for this special group of patients.

The use of video-laryngoscope improves the visualization of the glottis opening. A vast number of reviews have proven that they improve laryngoscopic view, improve the success of intubation at first attempt, decrease the time taken to achieve intubation and reduce laryngoscopic complications. At the moment, there is still relatively little obstetric-specific evidence as to the benefit of its use in this specific group of patients. However, as it is recommended as an alternative device in the scenario of rescuing a difficult or failed intubation, clinicians should become more familiar with this equiptment.[13]

THE FUTURE

The Patient

Ideally obese women should be advised to achieve closer to an ideal body mass index prior to pregnancy with lifestyle intervention. Serious discussion on use on pharmacological therapy or bariatric surgery can be considered. After delivery they should be encouraged to lose weight as major weight gain of more than 5 kg can be reduced in all (but the heaviest women). According to Baker *et al*, during the six months postpartum period, exclusive breastfeeding can reduce postpartum weight retention of up to 12 kg.[14]

Blood Pressure (BP) Monitoring

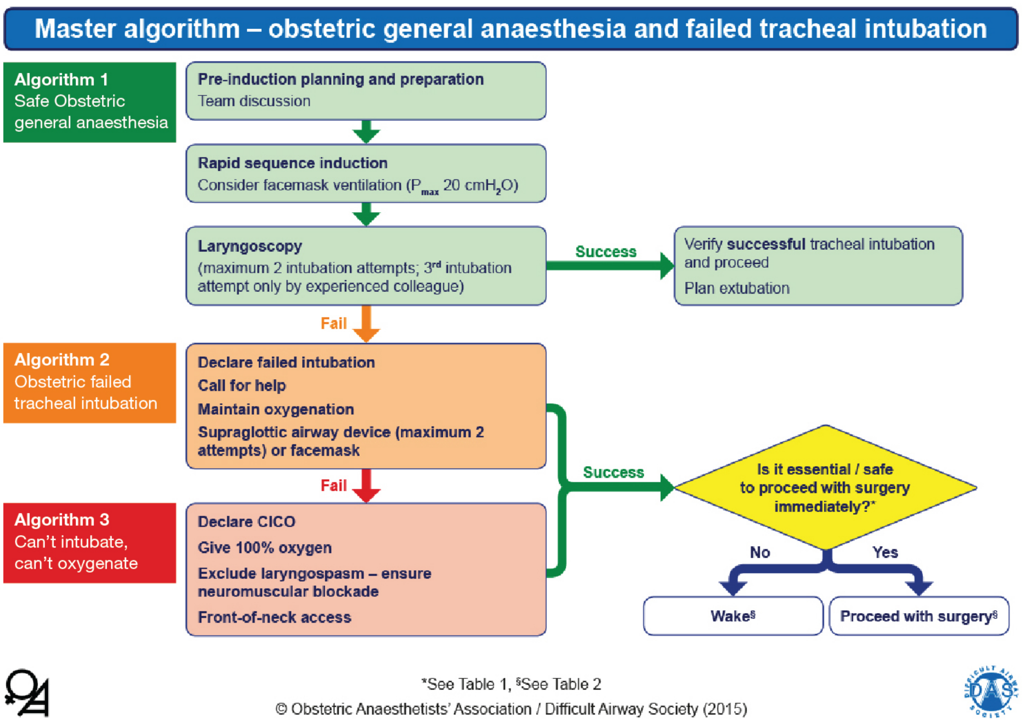
BP monitoring is essential with regards to the care during pregnancy. Timely care is needed for both hypertension and hypotension. As anaesthetists, we are always blessed with the option of placing an intra-arterial line to monitor our patients. However, this modality may not be feasible for all locations and available for every obese pregnant patient during her entire pregnancy. It is already a known fact that fitting an appropriate blood pressure cuff is difficult. Many of us have personal experiences of feeling utterly frustrated in locating the appropriate size cuff for them. Difficulty in finding the right sized cuff is compounded by their odd "conical shape" arm i.e. wide on the upper arm and smaller towards the forearm.

In the 1970s, the volume-clamp method of Penaz was introduced as a non-invasive method of performing continuous blood pressure measurements.[15] At the moment, the two well-known devices using such technology and available for clinical use is the Clear Sight™ device by Edwards Lifesciences and the CNAP™ device by CNSystems Medizintechnik. These devices measure the change in blood volume within the finger using photo-plethysmography. These changes are subsequently converted into a continuous blood pressure waveform. Unfortunately, both these devices have not been validated for use in women with BMIs greater than 40 kg/m^2 or women with pre-eclampsia. Once these devices are validated for use, this may be the future modality whereby we monitor this specialized group of patients.

Combined Spinal Epidural (CSE) for Caesarean Section

The main concern of citing a CSE is always the longer time needed to perform the procedure, hence making this technique unpopular. In obese parturients, spinal anaesthesia can be difficult to site due to thin needles and thicker maternal tissue. Therefore, CSE can be a good option. This technique can be considered in the obese parturient. A previous study, among this group of patients (> 100 kg) for elective caesarean section, showed that there was not a big difference in performance time. It also further concluded that within a 10 minutes period, there was a 100% success rate in the CSE group when compared to 71% in the spinal anaesthesia group.[16]

Annexes



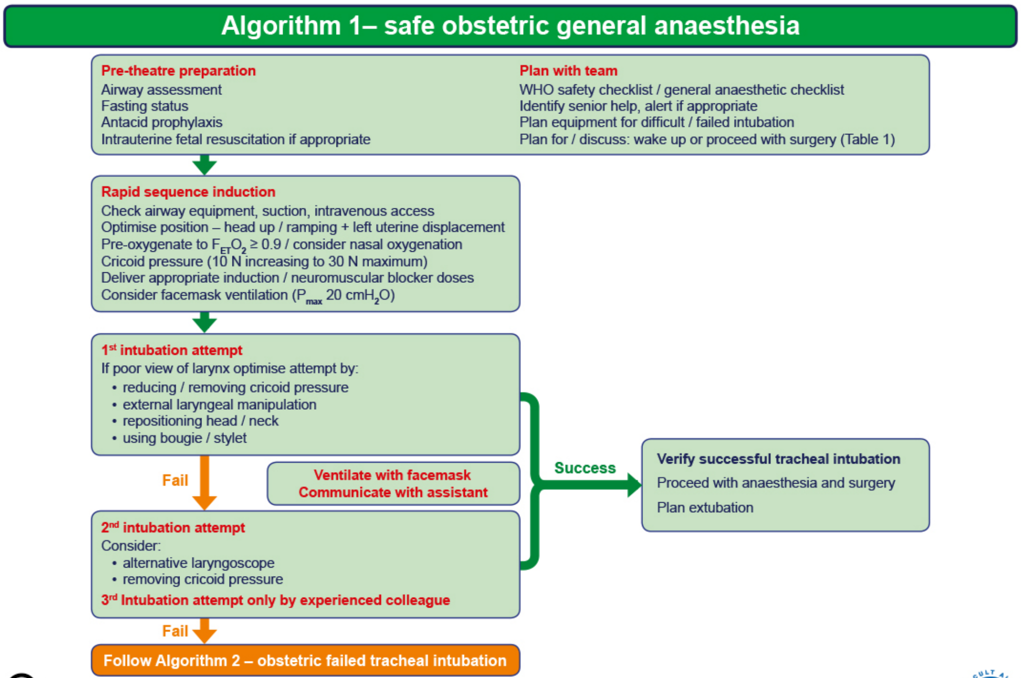


Table 1 – proceed with surgery?

	Factors to consider	WAKE	⟵	⟶	PROCEED
Before induction	**Maternal condition**	• No compromise	• Mild acute compromise	• Haemorrhage responsive to resuscitation	• Hypovolaemia requiring corrective surgery • Critical cardiac or respiratory compromise, cardiac arrest
Before induction	**Fetal condition**	• No compromise	• Compromise corrected with intrauterine resuscitation, pH < 7.2 but > 7.15	• Continuing fetal heart rate abnormality despite intrauterine resuscitation, pH < 7.15	• Sustained bradycardia • Fetal haemorrhage • Suspected uterine rupture
Before induction	**Anaesthetist**	• Novice	• Junior trainee	• Senior trainee	• Consultant / specialist
Before induction	**Obesity**	• Supermorbid	• Morbid	• Obese	• Normal
Before induction	**Surgical factors**	• Complex surgery or major haemorrhage anticipated	• Multiple uterine scars • Some surgical difficulties expected	• Single uterine scar	• No risk factors
Before induction	**Aspiration risk**	• Recent food	• No recent food • In labour • Opioids given • Antacids not given	• No recent food • In labour • Opioids not given • Antacids given	• Fasted • Not in labour • Antacids given
Before induction	**Alternative anaesthesia** • **regional** • **securing airway awake**	• No anticipated difficulty	• Predicted difficulty	• Relatively contraindicated	• Absolutely contraindicated or has failed • Surgery started
After failed intubation	**Airway device / ventilation**	• Difficult facemask ventilation • Front-of-neck	• Adequate facemask ventilation	• First generation supraglottic airway device	• Second generation supraglottic airway device
After failed intubation	**Airway hazards**	• Laryngeal oedema • Stridor	• Bleeding • Trauma	• Secretions	• None evident

Criteria to be used in the decision to wake or proceed following failed tracheal intubation. In any individual patient, some factors may suggest waking and others proceeding. The final decision will depend on the anaesthetist's clinical judgement.

References

1. Karalasingam SD, R Jeganathan JR, Soelar SA. Maternal obesity and pregnancy outcomes - across sectional study from the Malaysian National Obstetrics Registry. *Med J Malaysia* 201873 (Supp 1)13

2. Gupta A, Faber P. Obesity in pregnancy. *BJA Education* 2011;**11**(4):143-6

3. Lim CC, Mahmood T. Obesity in pregnancy. *Best practice & research Clinical obstetrics & gynaecology* 2015;**29**(3):309-19

4. Ovesen P, Rasmussen S, Kesmodel U. Effect of prepregnancy maternal overweight and obesity on pregnancy outcome. *Obstetrics and gynecology* 2011;**118**(2 Pt 1):305-12

5. Duckitt K, Harrington D. Risk factors for pre-eclampsia at antenatal booking: systematic review of controlled studies. *BMJ (Clinical research ed)* 2005;**330**(7491):565

6. Metwally M, Ong KJ, Ledger WL, Li TC. Does high body mass index increase the risk of miscarriage after spontaneous and assisted conception? A meta-analysis of the evidence. *Fertility and sterility* 2008;**90**(3):714-26

7. Dodd JM, Briley AL. Managing obesity in pregnancy - An obstetric and midwifery perspective. *Midwifery* 2017;**49**:7-12

8. Tulp Maartje J, McDermott Laura F, Paech Michael J, Nathan Elizabeth A, *Journal of Obstetric Anaesthesia and Critical care* 2017;**7**:37-42

9. Uyl N, Jonge E. de, Uyl-de Groot C, C. Marel C.Vander, Duvekot J, Difficult epidural placement in obese and non-obese pregnant women - A systematic review and meta-analysis, *International Journal of Obstetric Anaesthesia* (2019) article in press

10. Marroquin BM, Fecho K, Salo-Coombs V, et al. Can Parturients identify the midlines during neuraxial block placement? *Journal Clinical Anesthesia* 2011;**23**:3-6

11. Vallejo Manuel C, Pre-procedure Neuraxial Ultrasound in Obstetric Anesthesia, *Journal of Anaesthesia and Perioperative medicine* 2017; 4

12. Kinsella S. M, Winton A. L, Mushami M.C, Ramaswamy K, Swales H, Quinn A.C., Popat M. Failed tracheal intubation during obstetric general anaesthesia; a literature review. *International Journal of Obstetric Anaesthesia* 2015;**24**:356-374

13. Scott-Brown S, Russell R, Video laryngoscopes and the obstetric airway, *International Journal of Obstetric Anaesthesia* 2015;**24**:137-146

14. Baker JL, Gamborg M, Heitman Bl, et al. Breastfeeding reduces postpartum weight retention *Am J Clini Nutirition* 2008;**88**:1543-51

15. Eley V.A., Christensen R, Kumar S, Callaway L.K, A review of blood pressure measurement in obese pregnant women, *International Journal of Obstetric Anaesthesia* 2018;**35**:64-74

16. Rosss VH, Dean LS, Thomas JA, Et al. A ramdomized controlled comparison between combines spinal-epidural and single-shot spinal techniques in the morbidly obese parturients undergoing cesarean delivery: time for initiation of anaesthesia. *Anesthe Analg* 2014;**118**:168-172

17. Shaikh H, Robinson S, Teoh T.G., Management of maternal obesity prior to and during pregnancy, *Seminars in Fetal & Neonatal Medicine 15* (2010) 77-82

18. Robert Gaiser, Anaesthetic considerations in the Obese Parturient, *Clinical obstetrics and gynecology* 2016;**59**(1):193-203

19. Difficult Airway Society Website - Obstetric General Anaesthesia and Failed Tracheal Intubation

Acupuncture In Anaesthesia

Liu Chian Yong
Senior Lecturer & Consultant Anaesthesiologist, Department of Anaesthesiology and Intensive Care, Universiti Kebangsaan Malaysia Medical Centre, Kuala Lumpur, Malaysia

INTRODUCTION

Acupuncture is the practice of inserting and manipulating specialised fine needles at specific points (called acupoints) on the human body for therapeutic purposes.[1] It is part of the Traditional Chinese Medicine (TCM) practice alongside with herbal therapy, massage, diet and moxibustion that originated from China more than two thousand years ago. This medical knowledge was developed through observation of human subjects and has been clearly documented in many texts, including *The Yellow Emperor's Classic of Internal Medicine* dated 100 BC.[2] According to TCM theory, the human body is made up of vital force or energy called *Qi* which flows around the whole body in twelve main channels called meridians. Each meridian corresponds to one major organ of the body and is associated with the concept of *Yin* and *Yang* that oppose each other.[3] Illnesses happen when the flow of *Qi* energy is disturbed. Interestingly, this flow of *Qi* energy can be altered by stimulating the acupoints which lie along the meridians. These acupoints are described and documented over many ancient medical texts[4] and were standardised by World Health Organization (WHO) in 1991.[5]

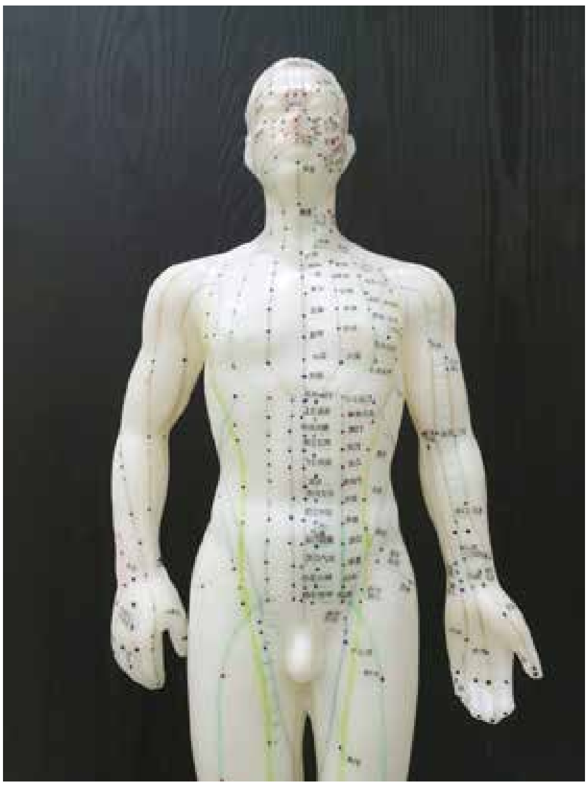


Figure 1: Meridian in traditional chinese medicine

CLINICAL APPLICATION

In TCM practice, acupuncture has been used to treat a variety of conditions. The acupuncturist will apply needle insertion to a group of acupoints along the meridians based on the patient's clinical syndrome. It is common to see needle insertion in the distal area of the limbs to treat condition far away from the intended organs connected by these meridians. However, currently there is not much scientific evidence from the Western medicine point of view to support the existence of *Qi* energy and meridians physically. It was shown that there was a rapid progression of technetium-99 tracer along the pathway of the meridian when it was injected to the acupoints. However, the progression of flow was inconsistent with the lymphatic or vascular flow.[6] Huang *et al* in 2009 reviewed 149 studies which looked into the brain responses to acupuncture by using functional magnetic resonance imaging (fMRI) and concluded that acupuncture can modulate brain activity within specific areas in the brain.[7] There are several postulated mechanisms on how acupuncture works. Many believe needling affects the release of naturally occurring opiate substances like endorphin, encephalin (potent pain modulator from musculoskeletal system) and dynorphin (a powerful modulator of visceral pain).

The insertion of acupuncture needles also believed to cause endogenous corticoid release, increase local blood flow to the surrounding area and release entangled myofibrils within tissue planes.[8] Current studies which are looking for an explanation on how acupuncture therapy produces its effect focuses on the relationship of transient receptor potential V2 (TRPV2) channels, histamine H1 and adenosine A1 receptors in mast cells,[9] and modulation of pain-induced gamma oscillations in the brain.[10]

To date, there have been many researches that study the effect of acupuncture in the management of acute pain,[11] musculoskeletal pain,[12] palliative care for cancer,[13] and obesity.[14] There were also systematic reviews on the efficacy and safety of acupuncture in children.[15] In 2002, WHO has acknowledged the efficacy of acupuncture in the management of 28 medical conditions as significantly superior to that of control groups.[16] There a few hospitals in Malaysia that practise TCM that offer acupuncture as a modality to treat chemotherapy-induced nausea and vomiting, post stroke and chronic pain.[1]

Figure 2: The acupuncture needle insertion

The use of acupuncture in Western medicine has grown over the years, especially in the anaesthesia practice. The first documented report of acupuncture in anaesthesia was for a tonsillectomy in August 1958. The invention of electro-acupuncture has further propelled the use of acupuncture to provide anaesthesia in cases such as pneumomectomy, cardiac surgery, Caesarean sections and many more.[17] As acupuncture anaesthesia failed to produce complete analgesia for most surgical pain, it is currently used as an additional modality to the modern anaesthesia. This method known as acupuncture-assisted anaesthesia uses the acupuncture effects to complement analgesic or sedative effects of modern anaesthesia drugs, hence reducing complications and medical costs.[18] Zhou *et al* have reported the use of acupuncture-assisted anaesthesia in open heart surgery with their patients breathing spontaneously without the need for intubation and assisted ventilation. They reported significant less usage of narcotics, less postoperative pulmonary infections, shorter intensive care unit stay and overall lower medical cost.[19] In Malaysia, thyroidectomy and breast lump excisions performed under acupuncture-assisted anaesthesia have been practised since 2012.[20] There was also a local report on craniotomy performed on an awake patient using electroacupuncture.[21] However, acupuncture-assisted anaesthesia is not widely used as it is technically difficult to perform. Furthermore, the current techniques of anaesthesia offer better and safer possibilities.[22]

Looking from a broader perspective, acupuncture has proven to help in many aspects of perioperative medicine. Acupuncture or acupressure to PC6 *Neiguan* acupoint was extensively studied and has been proven to alleviate post-operative nausea and vomiting (PONV).[23] Similarly, acupuncture to *Yintang* acupoint on the forehead was also shown to have anti-anxiety effects on patients preoperatively.[24] Acupuncture has also been shown to be able to control hemodynamic responses to treat both hypotension[25] and hypertension[26] intra-operatively. Fleckenstein *et al* had proven that acupuncture was able to reduce post-anaesthesia recovery time and their patients were discharged back to ward within a significantly shorter time in their study.[27] The effects of acupuncture to reduce postoperative ileus after bowel surgeries were investigated with positive results.[28,29] Other aspects such as perioperative glycaemic control and treatment of post-dural puncture headache treated with acupuncture were also reported. These perioperative usages of acupuncture have been termed "perioperative acupuncture modulation" by Lu *et al*.[30]

Figure 3: Acupuncture points at the elbow area

Like any other medical procedure, acupuncture may also cause complications. Although the filiform acupuncture needles that are inserted subcutaneously rarely cause serious complications, deeper insertion of acupuncture needles at certain dangerous acupoints may result in serious complications. For example, acupuncture to the acupoints which are in close vicinity to major vessels and organs carries a higher risk. The reports on adverse events following acupuncture in British National Health Service from 2009 to 2011 by Wheway *et al* included retained needles, dizziness, loss of consciousness, falls, bruising or soreness at needle site, and pneumothorax. Fortunately, 95% of the reported incidents were categorised as low or no harm to patients.[31] Ernst reviewed 86 reported cases of fatalities following acupuncture across the world in 2009. Pneumothorax was the most frequent cause of death, along with puncture to the heart, large blood vessels, central nervous structures and liver, and various type of infections.[32] Similar reports on acupuncture complications were also published by the WHO, which attributed these complications to inappropriate techniques. The report concluded that acupuncture was generally a safe procedure in the hands of well-trained practitioners[33] and patient safety should be a core part of acupuncture education.[34] Locally, traumatic optic neuropathy following acupuncture was reported in 2018.[35]

As acupuncture gains popularity, more evidence-based research on acupuncture are sought after. Globally, publications on acupuncture have increased tremendously.[36] The first research on acupuncture in the Western world can be traced back as early as the year 1683. Newer research on acupuncture focus on finding clinical evidence of acupuncture in the treatment of various clinical conditions and also to investigate the nature of acupoints, meridians and its underlying mechanisms of action.[37] One of the main challenges in designing clinical randomised controlled trials (RCT) on acupuncture is finding the method to blind either the patients or the researchers.[38] For acupuncture to be effective, the interaction between the acupuncturist and the patient is important to obtain maximal sensation of *de qi*.[39] There have been many methods used in studies to blind the control groups, such as using sham acupuncture, utilising placebo acupuncture devices[40] and using true acupuncture needle piercing at wrong points. However, the use of such methods may lead to false negative results as sham acupuncture may have the potential in activating acupoints without even piercing the skin and stimulation at wrong acupuncture sites could possibly produce its own efficacy.[41] Locally, the research on acupuncture is lacking as the knowledge and the practice of acupuncture is not familiar to Western medical practitioners. Perhaps the first step of this integration of both worlds of medical practices can be done through education as envisioned by Zhou in 2012.[42] The integration of acupuncture into Western medical practice will be sure to develop research in acupuncture locally.

As conclusion, acupuncture has shown potential to be integrated as part of cost-effective and safe non-pharmacological methods in a vast variety of treatments for patients, especially in pain management and its use during peri-anaesthesia period. The initiative by the WHO to develop training and safety guidelines in acupuncture[43] and the efforts to make practices of acupuncture more evidence-based[44] could propel this ancient knowledge as an alternative treatment modality.

References

1. Ministry of Health. Traditional and Complementary Medicine Practise Guideline on Acupuncture 2017
2. White A, Ernst E. A brief history of acupuncture. *Rheumatology* 2004;**43**(5):662-3
3. Vickers A, Zollman C. ABC of complementary medicine. Acupuncture. *Br Med J* 1999;**319**(7215):973-5
4. Schnorrenberger C. Morphological foundations of acupuncture: An anatomical nomenclature of acupuncture structures. *Acupunct Med* 1996;**14**(2):89-103
5. The World Health Organization (WHO). WHO Standard Acupuncture Points Locations in the Western Pacific Region 2009
6. Vernejoul P de, Albarede P, Darras J-C. Nuclear Medicine and Acupuncture Message Transmission. *J Nucl Med* 1992;**33**(3):409-12
7. Huang W, Pach D, Napadow V, Park K, Long X, Neumann J, et al. Characterizing acupuncture stimuli using brain imaging with fMRI - A systematic review and meta-analysis of the literature. *PLoS One* 2012;**7**(4):1-19
8. Wilkinson J, Faleiro R. Acupuncture in pain management. *Contin Educ Anaesthesia, Crit Care Pain2* 2006;**7**(4):135-8
9. Huang M, Wang X, Xing B, Yang H, Sa Z, Zhang D, et al. Critical roles of TRPV2 channels, histamine H1 and adenosine A1 receptors in the initiation of acupoint signals for acupuncture analgesia. *Sci Rep* 2018;**8**(1):1-11
10. Hauck M, Schröder S, Meyer-Hamme G, Lorenz J, Friedrichs S, Nolte G, et al. Acupuncture analgesia involves modulation of pain-induced gamma oscillations and cortical network connectivity. *Sci Rep* 2017;**7**(1):1-12
11. Taguchi R. Acupuncture anesthesia and analgesia for clinical acute pain in Japan. *Evidence-based Complement Altern Med* 2008;**5**(2):153-8
12. Yuan QL, Wang P, Liu L, Sun F, Cai YS, Wu WT, et al. Acupuncture for musculoskeletal pain: A meta-analysis and meta-regression of sham-controlled randomized clinical trials. *Sci Rep* 2016;**6**(February):1-24
13. Wu X, Chung VCH, Hui EP, Ziea ETC, Ng BFL, Ho RST, et al. Effectiveness of acupuncture and related therapies for palliative care of cancer: Overview of systematic reviews. *Sci Rep* 2015;**5**(November):1-15
14. Yang C, Hao Z, Zhang L-L, qin. Acupuncture for obesity: A systematic review and meta-analysis. *Int J Obes* 2009;**33**:183-96
15. Yang C, Hao Z, Zhang LL, Guo Q. Efficacy and safety of acupuncture in children: An overview of systematic reviews. *Pediatr Res* 2015;**78**(2):112-9
16. Xiaorui Z. Acupuncture: Review and Analysis of Reports on Controlled Clinical Trials. *The World Health Organization* 2003
17. Sidney Hamilton, Percy Brown, Mary Hollington KR. *Anaesthesia by Acupuncture* 1972
18. Wu GC. Acupuncture anesthesia in China: Retrospect and prospect. *Chin J Integr Med* 2007;**13**(3):163-5
19. Zhou J, Chi H, Cheng TO, Chen TY, Wu YY, Zhou WX, et al. Acupuncture anesthesia for open heart surgery in contemporary China. *Int J Cardiol* 2011;**150**(1):12-6

20. Avineshwaran T. Advances in the use of radioisotopes. [Internet]. *Thestar* 2016. Available from: https://www.thestar.com.my/metro/community/2016/11/19/advances-in-the-use-of-acupuncture-ipoh-hospital-among-first-in-country-to-use-method-to-supplement

21. Sidhu A, Murgahayah T, Narayanan V, Chandran H, Waran V. Electroacupuncture-Assisted Craniotomy on an Awake Patient. *JAMS J Acupunct Meridian Stud* 2017;**10**(1):45-8

22. Litscher G. Anesthesia and acupuncture. *World J Anesthesiol* 2015;**4**(1):1

23. Cheong KB, Zhang JP, Huang Y, Zhang ZJ. The effectiveness of acupuncture in prevention and treatment of postoperative nausea and vomiting - A systematic review and meta-analysis. *PLoS One* 2013;**8**(12):1-17

24. Acar HV, Cuva Ö, Ceyhan A, Dikmen B. Acupuncture on yintang point decreases preoperative anxiety. *J Altern Complement Med* 2013;**19**(5):420-4

25. Arai YCP, Ito A, Ohshima K, Hibino S, Niwa S, Kawanishi J, et al. Transcutaneous electrical nerve stimulation on the PC-5 and PC-6 points alleviated hypotension after epidural anaesthesia, depending on the stimulus frequency. *Evidence-based Complement Altern Med* 2012;2012

26. Li DZ, Zhou Y, Yang YN, Ma YT, Li XM, Yu J, et al. Acupuncture for essential hypertension: A meta-analysis of randomized sham-controlled clinical trials. *Evidence-based Complement Altern Med* 2014;**2014**:1-8

27. Fleckenstein J, Baeumler P, Gurschler C, Weissenbacher T, Annecke T, Geisenberger T, et al. Acupuncture reduces the time from extubation to ‘ready for discharge’ from the post anaesthesia care unit: results from the randomised controlled AcuARP trial. *Sci Rep* 2018;**8**(1):1-12

28. Liu Y, May BH, Zhang AL, Guo X, Lu C, Xue CC, et al. Acupuncture and Related Therapies for Treatment of Postoperative Ileus in Colorectal Cancer: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. *Evidence-based Complement Altern Med* 2018;2018

29. Bik CK, Jiping Z, Yong H. Effectiveness of acupuncture in postoperative ileus: a systematic review and Meta-analysis. *J Tradit Chinese Med* 2016 Jun;**36**(3):271-82

30. Lu Z, Dong H, Wang Q, Xiong L. Perioperative acupuncture modulation: More than anaesthesia. *Br J Anaesth* 2015;**115**(2):183-93

31. Wheway J, Agbabiaka TB, Ernst E. Patient safety incidents from acupuncture treatments: A review of reports to the National Patient Safety Agency. *Int J Risk Saf Med* 2012;**24**(3):163-9

32. Ernst E. Deaths after acupuncture: A systematic review. *Int J Risk Saf Med* 2010;**22**(3):131-6

33. Zhang J, Shang H, Gao X, Ernst E. Acupuncture-related adverse events: A systematic review of the chinese literature. *Bull World Health Organ* 2010;**88**(12):915-21

34. Chan MWC, Wu XY, Wu JCY, Wong SYS, Chung VCH. Safety of Acupuncture: Overview of Systematic Reviews article. *Sci Rep* 2017;**7**(1):1-11

35. Lee W, Teh W, Ramli N, Saad A. Traumatic optic neuropathy secondary to acupuncture treatment for glaucoma: A case report. *J Acute Dis* 2018;**7**(3):134

36. Kung YY, Hwang SJ, Li TF, Ko SG, Huang CW, Chen FP. Trends in global acupuncture publications: An analysis of the Web of Science database from 1988 to 2015. *J Chinese Med Assoc* 2017;**80**(8):521-5

37. Zhuang Y, Xing J jing, Li J, Zeng BY, Liang F rong. History of acupuncture research. 1st ed. Vol. 111, International Review of Neurobiology. *Elsevier Inc.*; 2013. 1-23p

38. Han JS, Ho YS. Global trends and performances of acupuncture research. *Neurosci Biobehav Rev* 2011;**35**(3):680-7

39. Kong J, Gollub R, Huang T, Polich G, Napadow V, Hui K, et al. Acupuncture De Qi, from qualitative history to quantitative measurement. *J Altern Complement Med* 2007;**13**(10):1059-70

40. Zhu D, Gao Y, Chang J, Kong J. Placebo acupuncture devices: Considerations for acupuncture research. *Evidence-based Complement Altern Med* 2013;2013

41. Paterson C, Dieppe P. Characteristic and incidental (placebo) effects in complex interventions such as acupuncture. *BMJ* 2005;**330**(May):1202-5

42. Zhou W. Developing a Chinese Medicine programme in a western medical university. *Int e-Journal Sci Med Educ* 2012;**6**(supp1):S155-8

43. WHO. Guidelines on Basic Training and Safety in Acupuncture 1999

44. Fung FY, Linn YC. Developing traditional Chinese medicine in the era of evidence-based medicine: Current evidences and challenges. *Evidence-based Complement Altern Med* 2015;2015

Role Of Ultrasound In Central Neuraxial Blockade

Muhamad Rasydan Abd Ghani[1], Ariff Osman[2], Syed Hassan Askri Shah[3]
[1] Assistant Professor, Department of Anaesthesiology and Intensive Care, Kulliyyah of Medicine, International Islamic University Malaysia, Kuantan, Pahang, Malaysia
[2] Professor, Department of Anaesthesiology and Intensive Care, Kulliyyah of Medicine, International Islamic University Malaysia, Kuantan, Pahang, Malaysia
[3] Department of Anaesthesiology and Intensive Care, IIUM Medical Centre, Kuantan, Pahang, Malaysia

INTRODUCTION

Standard practice central neuraxial blocks (CNB) commonly performed in sitting position involves using surface landmark technique (identification of Tuffier's line), operators feeling of tactile sensation and or seeing free flow of cerebrospinal fluid (CSF). Although identification of spinous process are very reliable, surface anatomy landmarks sometimes are not always easily identified, especially in patients with spinal deformity, for example kyphoscoliosis, obesity, oedema or previous back surgery.[1,2]

Tuffier's line, a line drawn between the highest point of iliac crests is widely used as estimation of L3 - L4 interspace, but the correlation is inconsistent.[3] The precision of identification varies and inaccurate in many patients may end up needle placement one or two spinal levels higher.[1,2,4-7] Surface landmark technique does not give the anaesthesiologist reliability to locate the space for needle insertion, predict ease of needle placement and avoiding accidental dural puncture during epidural insertion.

Ultrasound imaging can be used to preview the underlying spinal anatomy (pre-procedural scan) or guide the spinal needle in real-time during performing CNB. The ultrasound can 60% correctly identified L2 - L3 interspace, with margin of error 7 - 9% either one space above or below, in comparison with clinical assessment 9 - 18% up to 2 spaces higher or lower (more significant variability).[10] With pre-procedural ultrasound scan, the reliability of identification of the L3-L4 interspace increases to almost 70 - 80%. An anaesthesiologist can identify the midline of the spine accurately, identify the correct lumbar interspace, measure and predict skin to space distance and identify patients with potentially difficult CNB.[1,2,8,9,11]

ULTRASOUND IMAGING OF THE SPINE

There are at least three ultrasound scan planes; median, transverse and coronal. The median plane is a plane that cuts through the body vertically into two halves. The sagittal plane is another longitudinal plane parallel to the median plane and perpendicular to the ground. Thus, the median plane is also known as the sagittal plane that is in the middle of the body (median sagittal plane). The transverse plane is parallel to the ground and is also known as axial or horizontal plane. The frontal plane or coronal plane is vertical plane perpendicular to the ground and right angles to the sagittal plane dissecting the body into anterior and posterior segments. Ultrasound imaging of the lumbosacral spine can be performed in the transverse scan or longitudinal scan. The images obtained complement each other to make a visual 3D view and help the anaesthesiologist imagine the spine and surrounding structures.

The transverse interspinous view is the most easily obtained in the lumbar region (Figure one) but is very challenging in the mid-thoracic (T4 - T8) because of the acute caudal angulation of the spinous process. If the operator sees dark shadow of the spinous process, the ultrasound probe needs to be tilted cephalad or caudad to have a better view (translaminar view) of the neuraxial structures. A good typical view in this translaminar view is to see the spinous process, the lamina of the vertebra, the posterior complex and anterior complex (Figure one). In difficult patient, by seeing at least the posterior complex, the operator can measure the depth and estimate the distance needed to reach the epidural space.[1,2]

The sagittal scan can be performed through the midline (median sagittal spinous process view) or paramedian plane. From the experts' point of view, ultrasound image visibility can be further improved when the spine is scanned in the paramedian sagittal oblique (PMSO) plane (Figure two).[1,2] A good view will see the anterior complex, the posterior complex, and the transverse process of the vertebra. Usually the operator can count the vertebra starting from the sacral (usually a flat hyperechoic structure) until the desired vertebra level (Figure two). From this view, if both the posterior and anterior complexes visualized, there is a high chance the CNB is successful.[1,2]

In ultrasound for CNB, it is advisable to perform pre-procedural scan (scout scan) before any intervention, as this scan will assist in previewing the spine anatomy, identify the midline, determine the optimal site for needle insertion; the depth that is the measured distance from the skin to the desired space, usually has an error of ± 1 cm; the angulation and the trajectory for needle insertion before performing the puncture. The appropriate marking done on patient's skin involves marking at each end of the probe, identifying the midline from the transverse interspinous view; counting and marking the desired interspinous spaces as S1 - L5, L5 - L4, L4 - L3 from the PMSO view (Figure three). After the pre-procedural scan, the CNB should be performed in strict asepsis technique.[1,2]

Performing real-time CNB needle insertion under ultrasound is very challenging; the anaesthesiologist must have good knowledge of ultrasound basics, be familiar with the sonoanatomy of the spine and scanning techniques and possesses a combination of high degree of manual dexterity and hand-eye coordination. Most of the time a real-time performance of CNB under ultrasound needs two operators, one to hold the probe and another operator to do the needling.[1,2]

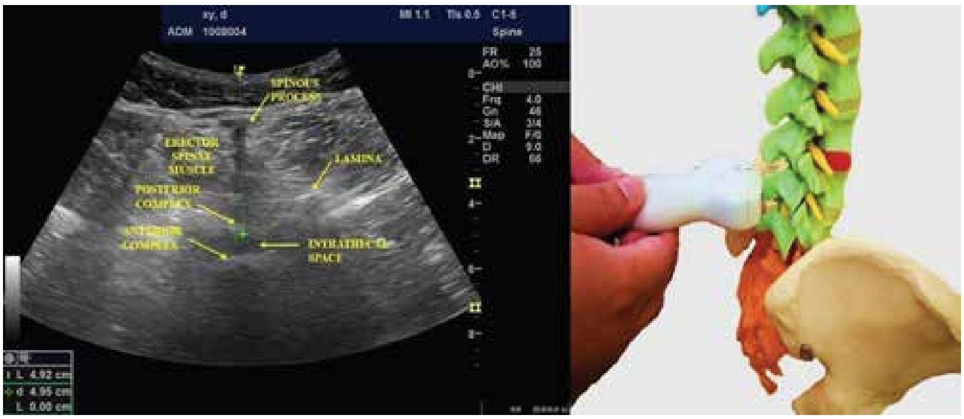


Figure 1: Ultrasound scan of transverse interlaminar view

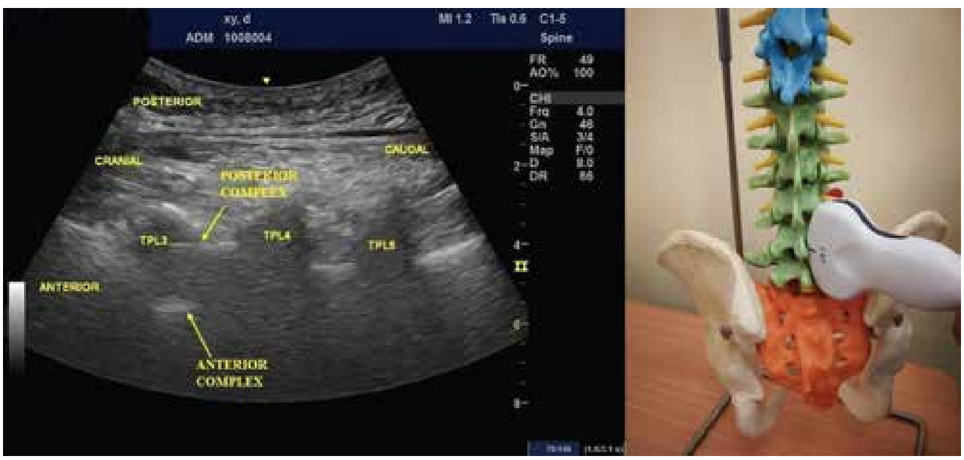


Figure 2: Ultrasound view of paramedian sagittal oblique view (PMSO)

Figure 3: Skin marking during pre-procedural scan

CLINICAL APPLICATION OF ULTRASOUND FOR CENTRAL NEURAXIAL BLOCKADE

A. Identification of Specific Lumbar Intervertebral Levels

Current evidence stipulates that ultrasound is more reliable and precise than clinical assessment of intervertebral level.[1,2] Margin of error for ultrasound was low at most 9% for one space above and 7% for one space below. A comparison with clinical assessment showed tremendous variability with margin of error up to two spaces higher (9%) or lower (18%).[11] Identification of intervertebral space is more precise by using ultrasound compared with landmark technique alone.[12] In obese patient, despite the possibility of poor imaging using ultrasound, it still minimally can identify the midline via transverse view and interspinous process in the PMSO view.[1,2]

B. Measuring Depth to the Epidural and Intrathecal Space

Using ultrasound can identify and measure the depth to the ligamentum flavum in the longitudinal neuraxial scan. A meta-analysis addressing the correlation between measured ultrasound depth and actual needle insertion depth confirmed that the correlation was high regardless of which view was used.[12] The correlation coefficient was 0.91, with a depth of insertion difference between ultrasound and actual was only 0.5 cm or less. This difference is commonly attributed to soft tissue compression by ultrasound probe.

For the obese patients, measuring the distance can help us in choosing between the standard length of spinal needle and the long spinal needle, reducing wastage in using inappropriate length of the spinal needle.

C. Reducing the Number of Needle Passes

Shaikh *et al* did a systematic review comparing ultrasound-guided and non-ultrasound guided neuraxial procedures, of 1334 patients and found that the use of ultrasound significantly reduced both skin punctures and needle redirections required for a successful CNB.[13] Perlas *et al* also did a similar systematic review involving 14 randomised controlled trials and also found that ultrasound significantly reduced overall number of needle puncture.[12]

D. Improved Block Success and Efficacy

The systematic reviews by Shaikh *et al* and Perlas *et al* mentioned above provided evidence that ultrasound increases block success. Shaikh *et al* found that ultrasound reduced the risk of procedural failure by 79% with 16 number needed to treat to avoid one failure. Perlas *et al* also showed similar results but more modest with a risk reduction of 49% and the number needed to treat 34% for procedural failure.

E. Increased Procedure Duration Time

Studies conducted by an experienced sonographer in a cohort of healthy obstetric patients with normal spine anatomy reported that ultrasound scanning added 60 - 75 seconds ultrasound scanning.[14-17] More time is needed in less-experienced hands, severely obese patients and patients with complicated spinal anatomy. With proper training and regular use of the ultrasound, it will reduce the procedure time and increase safety.

F. Reducing the Risk of Complications

The risk of accidental dural puncture may be reduced by the ability to measure depth to epidural space. There is no direct supporting evidence to say in reducing more serious complications like hematoma or neurological deficit.[15] However, decreased technical difficulty associated with ultrasound usage may reduce the risks in a few ways, such as less traumatic procedure and inaccuracies in identification of intervertebral space.[18-20]

G. Predicting Feasibility and Ease of Performing Central Neuraxial Blockade

Ultrasound of the CNB can be used as a pre-operative assessment tool to guide decision making. Pre-procedural ultrasound can show if there is a patent acoustic window, especially if the patient had an operation before and has implants at the back. It will allow planning on the best intervertebral space, maybe use a bigger gauge needle and the trajectory of the needle in performing spinal anaesthesia.

The ability of the ultrasound to visualise the vertebral canal should correspond to the size of the interlaminar space and this will reflect the improved performance and ease the needle may be punctured. In two different papers from Chin *et al* and Weed *et al*, the authors concluded that if both anterior complexes and posterior complexes are visible (good quality view) on transverse interspinous view and or PMSO view, the puncture and performance will be much easier.

LEARNING CURVES

Learning ultrasound for CNB will take much of the anaesthesiologist's time and patience.

Using water-based spine phantom makes the process of learning sonoanatomy of the spine simpler and easier. The model is prepared by immersing lumbosacral spine model in a water bath. Using a curved array transducer, the practitioner is able to learn and recognise the sonographic patterns and images of the spine.

It is advisable for anaesthesiologists to attend workshops or courses in this particular field, acquire knowledge of basic sonoanatomy with image optimisation and interventional skills. To obtain good knowledge and competence in spinal sonography, the anaesthesiologist may need to perform 40 scanning or more of normal lumbar spine.[21,22]

Make a good habit in doing pre-procedural scan before attempting to perform CNB. It will make life much easier despite time-consuming. Real time ultrasound CNB is challenging as it needs a high degree of manual dexterity with 3D conceptualisation. Real-time epidural performance by far is the most difficult compared with real-time spinal puncture and may not be done routinely.[1]

However, this real-time CNB skill must be developed as part of training because it might be the only way to do CNB safely in instrumented or operated backs and scoliosis patients.[1]

KEY POINTS

1) Using ultrasound to assist CNB is an advanced technique. Use the low-frequency curvilinear probe (5 - 2 MHz) to have a wider visual field and increase the depth of penetration usually around 5 - 10 cm.

2) For early adopter or novice, learn to do pre-procedural USG of the spine before doing the puncture, mark on the patient's skin the important landmark (intervertebral spaces) and measure the distance skin to space.

3) Strict asepsis must be maintained during real-time procedure of CNB.

4) Regular ultrasound gel should not be used while performing CNB using ultrasound; the gel is an irritant to the spinal cord.

5) Ergonomics, patient positioning, skilful helper are important factors ensuring success in doing USG CNB.

6) Anaesthesiologist should use the non-dominant hand to hold the probe and dominant hand to insert and adjust the needle.

7) Preferably needle Gauge 25 and above with introducer needle makes it easier to do the CNB (spinal anaesthesia) real-time.

8) L5 - S1 lumbosacral junction is the biggest interlaminar space and may provide a safe route to do spinal anaesthesia.

CONCLUSION

Ultrasound for CNB is a new tool that carries an excellent alternative to landmark-based techniques. It is safe, non-invasive, simple, can be quickly performed with adequate training that will provide real-time images of the spine. Anaesthesiologists should familiarise with the use of ultrasound for central neuraxial blockade in healthy individuals before doing it in patients with complicated anatomy, post spine operation and spine deformity.

Despite this new technique being technically demanding with a steep learning curve, it will unlikely replace the traditional well-established landmark technique for most patients. As more anaesthesiologists acquire this skill, it may become the standard of care in the future. With an increasing number of complications associated with CNB, adding a handy tool such as ultrasound will reduce complications such as accidental dural puncture and improve patient satisfaction by reducing the number of needle puncture attempts.

References

1. Manoj Kumar Karmakar. Musculoskeletal Ultrasound for Regional Anaesthesia and Pain Medicine, 2nd edition, Department of Anaesthesia and Intensive Care, The Chinese University of Hong Kong, 2016

2. Manoj K. Karmakar, Edmund Soh, Victor Chee, Kenneth Sheah. Atlas of Sonoanatomy for Regional Anaesthesia and Pain Medicine, McGraw-Hill Education, 2018

3. Hogan QH. Tuffier's line: the normal distribution of anatomic parameters. *Anesth Analg* 1994;**78**:194-5

4. Broadbent CR, Maxwell WB, Ferrie R, Wilson DJ, Gawne-Cain M, Russel R. Ability of anaesthetists to identify a marked lumbar interspace. *Anesthesia* 2000;**55**:1122-6

5. Furness G, Reilly MP, Kuchi S. An evaluation of ultrasound imaging for identification of lumbar intervertebral level. *Anesthesia* 2002;**57**:277-80

6. Holmaas G, Frederiksen D, Ulvik A, Vingsnes SO, Ostgaard G, Nordli H. Identification of thoracic intervertebral spaces by means of surface anatomy: a magnetic resonance imaging study. *Acta Anaesthesiol Scand* 2006;**50**:368-73

7. Reynolds F. Damage to the conus medullaris following spinal anaesthesia. *Anaesthesia* 2001;**6**:238-47

8. Chin KJ, Karmakar MK, Peng P. Ultrasonography of the adults thoracic and lumbar spine for central neuraxial blockade. *Anesthesiology* 2011;**114**:1459-85

9. Carvalho JC. Ultrasound-facilitated epidurals and spinals in obstetrics. *Anesthesiol Clin* 2008;**26**:143-58

10. Furness G, Reilly MP, Kuchi S. An evaluation of ultrasound imaging for identification of lumbar intervertebral level. *Anaesthesia* 2002;**57**:277-80

11. Chin KJ, Ramlogan R, Arzola C, Singh M, Chan V. The utility of ultrasound imaging in predicting ease of performance of spinal anesthesia in an orthopaedic population. Reg Anesth. *Pain Med* 2013;**38**:34-8

12. Perlas A, Chappro LE, Chin KJ. Lumbar Neuraxial Ultrasound for Spinal and Epidural Anesthesia: A Systematic Review and Meta-Analysis. *Reg Anesth Pain Med* 2016;**41**:251-60

13. Shaikh F, Brezinski J, Alexander S, Arzola C, Carvalho JC, Beyene J, Sung L. Ultrasound imaging for lumbar punctures and epidural catheterisations: systematic review and meta-analysis. *BMJ* 2013;**346**:f1720

14. Grau T, Leipold RW, Conradi R, Martin E, Motsch J. Ultrasound imaging facilitates localisation of the epidural space during combined spinal and epidural anesthesia. *Reg Anesth Pain Med* 2001;**26**:64-7

15. Grau T, Leipold RW, Conradi R, Martin E, Motsch J. Efficacy of ultrasound imaging in obstetric epidural anesthesia. *J Clin Anesth* 2002;**14**:169-75

16. Chin KJ, Perlas A, Chan V, Brown-Shreves D, Koshkin A, Vaishnav V. Ultrasound imaging facilitates spinal anesthesia in adults with difficult surface anatomic landmarks. *Anesthesiology* 2011;**115**:94-101

17. Vallejo MC, Phelps AL, Singh S, Orebaugh SL, Sah N. Ultrasound decreases the failed labor epidural rate in resident trainees. *Int J Obstet Anesth* 2010;**19**:373-8

18. De seze MP, Sztark F, Janvier G, Joseph PA. Severe and long-lasting complications of the nerve root and spinal cord after central neuraxial blockade. *Anesth Analg* 2007;**104**:975-9

19. Vandermeulen EP, Van AH, Vermylen J. Anticoagulants and spinal-epidural anesthesia. *Anesth Analg* 1994;**79**:1165-77

20. Curie JM. Measurement of the depth to the extradural space using ultrasound. *Br J Anaesth* 1984;**56**:345-7

21. Margarido CB, Arzola C, Balki M, Carvalho JC. Anesthesiologists' learning curves for ultrasound assessment of the lumbar spine. *Can J Anaesth* 2010;**57**:120-6

22. Halpern SH, Banerjee A, Stocche R, Glanc P. The use of ultrasound for lumbar spinous process identification: A pilot study. *Can J Anaesth* 2010;**57**:817-22

Anaesthesiology Training In Malaysia: If It Was Good Enough For Me, Why Isn't It Good Enough For The Future?

Noorjahan Haneem Md Hashim
Senior Lecturer & Consultant Anaesthesiologist, Department of Anaesthesiology and Intensive Care, University Malaya Medical Centre, Kuala Lumpur, Malaysia

INTRODUCTION

This is a common question asked whenever we speak of change, especially in postgraduate training. I asked myself this question many times, until it leads me to more questions: was it really good enough, did I learn all I needed to know to function as a day one specialist the day I received my exams results, is it enough to face the challenges in healthcare today?

This article aims to introduce what a group of us has been working on the past few years to improve anaesthesiology training in this country; a work in progress to shift our training from a time-based model towards a competence based one.

Perhaps, to put things into perspective, I will share our past, summarise the current state, with its pros and cons, the pros and cons of competency based training and plans for the future.

The Distant Past

The distant past was divided into three phases:[1]

1. Before 1965: no formal and organised courses in Malaysia; doctors were sent on government sponsored scholarships to train and sit for the English and Irish examinations in the United Kingdom. Studying and training prior to going abroad was self-directed.

2. 1965 - 1975: this era began with the establishment of the Department of Anaesthesiology, University of Malaya. The practice of sending our doctors abroad was continued until 1973. Anaesthesiology trainees could train, prepare and sit for the Australasian Primary examination from 1973 and Final examination in 1975. Trainees could then be trained and certified without leaving the country.

3. 1975 - 1983: this era began with the establishment of the Faculty of Anaesthesiologists, College of Surgeons of Malaysia. The practice of training anaesthesiologists locally for foreign certification continued. Training was based on example; the content was variable, hampered by service loads and shortage of doctors, especially in government hospitals. There was no protected time for studying and no or very little arrangement for examination preparation. Plans were made to organise a four-year postgraduate local training and certification programme to satisfy the needs of our country. There was strong emphasis on the basic sciences and clinical practice, and three examinations to assess knowledge and its application. Training will be shared by the Ministry of Health (MOH) Hospitals and University Hospital; trainees will be placed in the university prior to the Basic Science examinations and rotated to MOH hospitals after. This proposal was withdrawn after being presented to Parliament.[2]

The Not Too Distant Past: 1985- 2014

In 1985, the Master of Medicine (Anaesthesiology) programme began in Universiti Kebangsaan Malaysia (UKM). A restructuring of the programme, modelled after the Royal Australasian College of Surgeons Fellowship programme, occurred in 1987. University of Malaya (UM) commenced the Master of Anaesthesiology programme in 1987 and Universiti Sains Malaysia in 1993. In December 1998, the examinations were conducted jointly by UKM and UM and by 2008 the Final examination is conjoint between the three universities.[3]

The Present

The Master of Anaesthesiology programmes are offered by five universities. The curriculum content is similar between universities and the examinations are held jointly. Method of delivery and training may differ between centres. It is still a traditional time based programme, with a duration of four years to seven years, though elements of competence based training is incorporated. Trainees rotate between the various subspecialties aimed to provide them with the opportunity to develop competence. There is still a strong emphasis on basic sciences and clinical knowledge. The summative assessments (examinations) are knowledge based, incorporating clinical reasoning in both examinations. There is no formal training and summative assessments on technical and non-technical skills and professionalism. Trainees learn through modelling behaviours and progress are documented in training logbooks and monitored by their supervisors. The programmes are accredited by the Malaysian Qualifications Agency and the graduates of the programmes are eligible to register as specialists to practise in Malaysia.[4,5]

The Academy of Medicine of Malaysia and the Ministry of Health Malaysia have also started a parallel pathway to train anaesthesiologists in Malaysia. It is also a time-based programme, with elements of competency-based training, where trainees rotate between the various subspecialties to develop competence.[6] It provides more flexibility to trainees, allowing up to ten years of training.

In summary, the current system available for training anaesthesiologists in Malaysia follows the time based, with features of competence by random opportunity model, which strongly emphasises basic scientific knowledge and clinical exposure while developing professional behaviours in the shared learning and workplace.

The Assumptions of the Current System and their Implications

There are three basic assumptions in the current time-based, competence by opportunity training model.

1. *Learning requires time and effort, therefore, doctors with similar capabilities who spend similar time and effort will require similar time to attain competence.*[7]

   This assumption is not entirely true, as observed by Carol as early as 1963: students with different aptitudes diverge in their learning performance.[7] The amount of time a trainee requires to learn a particular task will differ. Though this observation is made in school children, and focuses only on individual factors and rather simplistic, it has led to the concept of mastery learning (learners engage in repetitive practice, practising tasks with increasing levels of difficulty while receiving feedback during learning until the expected outcome is reached) and deliberate practice (a focus to develop reproducibly expert performance) at their own time.[7] The essentials for both are clear performance goals, opportunities for practice, feedback, error correction and subsequent learning cycles. This implication supports the case for time-variable training, where time is a resource, rather than the endpoint of training.

   Another important implication of time as a resource awareness is the neurocognitive perspective of time and learning. Learning not only occurs during intentional learning activities, but also during "quiet" periods (during informal interactions, reflections) and memory consolidation during sleep.[7] This knowledge and the knowledge that burnout correlates with poor academic performance adds perspective on the external factors on learning and would help programme coordinators dedicate rest time in the programme.[8]

2. *Every trainee will encounter the entire scenario they need to learn from at enough times and receives equal supervision and feedback at all encounters to attain competence.*[9]

   Again, this assumption is not entirely true. In the current system, centres are accredited to ensure trainees are exposed to diverse case-mix and receive supervision. Though we have data on the procedures done in each centre and the anaesthesia methods, we do not have the patient complexity data.[10] Therefore, whether each trainee has opportunities to manage the entire spectrum of patient care is unknown. The levels of supervision and the frequency and quality of feedback received are also not documented.

3. *Every trainee has the same learning needs, learn the same things the same way regardless of the context of their clinical and personal environment.*

   This assumption must also be challenged. Our trainees learning styles are varied; they have different strengths and weaknesses, and therefore different needs.

   The anaesthesia working environment is a complex and varied one, even in the same institution. As with any clinical learning environments, a tension between student learning and patient care needs occurs.[11] This is due to the specialty working with multiple other disciplines with varied patients' physiological and pathological conditions. To add to the complexity, a Swedish study revealed trainee anaesthesiologists understand their work differently, affecting their ways of performing tasks and learning.[12]

   This is further complicated by trainees varied perspectives and an expectation of good anaesthesia teaching, revealed by Wakatsuki *et al* in Stanford's teaching hospitals.[13] They shared the most common expectations as autonomy during learning, reasoning, context, taking time to teach, assessment of learners needs, specifying learning goals and providing real time feedback and the social aspects of learning: belonging, psychological safety and equanimity.

   The current system is not without benefits. They include streamlined intake into training and exit from training, ease of planning for clinical rotations, scholarship award process and service needs.[14] It also allows time to develop skills that require both time and experience e.g. clinical reasoning skills, non-technical skills and forming professional identity.[7]

   In summary, though the traditional time based, competence by random opportunity training programme serves our nation's previous and current training needs, it can be improved to ensure we train our trainees holistically and efficiently.

Why Change and the Way Forward

Apart from the three highlighted issues above, medical training is faced with the challenges of improving quality, equity, relevance and effectiveness in healthcare delivery; matching societal needs and expectations; redefined roles of healthcare providers. These challenges led 130 organisations and individuals responsible for health education, professional regulations and policy making developed a consensus consisting of ten strategic directions for medical schools to become socially accountable. The aim is to improve response to current and future health needs and challenges in society, reorient education, service and research, accordingly, strengthen governance and partnership with stakeholders and assess performance and impact of educational interventions. One of the strategies advocated was fostering outcome-based education.[15]

Many training programmes are moving towards competency based specialist training. It involves identifying the abilities required of anaesthesiologists and then designing curriculum to support the achievement of these predefined abilities.[16] There is emphasis on the central theme of a trainee progressing through training with ever increasing levels of knowledge and skills[16] (transition to discipline, foundations of discipline, transition to practice, continuing professional development and transition out of discipline),[14] and will include competencies other than just clinical anaesthesiology expertise.[17]

An important and valid concern among educators is whether this approach to training will lead to a reductionist approach where skills will be broken down into checklists, and that the trainees' ability to integrate components of complex skills in clinical situations may be undervalued or overvalued.[14,16] These concerns must be addressed in the curriculum planning phase and must be communicated to both trainers and trainees.

Another considerable concern is added workload, especially on performance assessment. A robust assessment system is required both to assist trainees to improve and develop (formative) and for decisions to be made regarding their competency (summative), especially in the clinical workplace i.e. workplace-based assessment (WPBA).[14,16, 18]

The limitations of WPBA are that it requires direct observations, the limitation of standardisation (clinical context, patient condition, and supervisor availability), assessor bias (rater leniency, halo effect, restrictions of range of practice, poor discrimination of learners' deficiencies and poor inter-rater consistency). It also requires the clinician supervisor to acquire a different mindset when approaching WPBA while performing clinical tasks i.e. patient care.[19]

In 2005, the term Entrustable Professional Activities (EPA) was introduced.[20] It is defined as "a unit of professional practice, defined as a task or responsibility to be entrusted to a trainee once sufficient specific competence is reached to allow for unsupervised practice".[21] It aims to connect the competency framework to the clinical workplace. It describes the tasks to be done by learners to earn trust in the clinical workplace, bridging the gap between competence-based education and clinical tasks and context.[21,22] It ensures safety in patient care, fulfilling the social contract between the medical profession and society.[19] This promise has led its adoption across specialties in the Western world.[19]

Entrustable Professional Activities allow the curriculum to be truly competence based, as opposed to time based.[22] It allows each trainee the flexibility to progress at their own pace, capabilities, and other legitimate commitments (clinician - researcher tracks, family duties). A curriculum based on EPAs not only helps trainers and trainees manage their expectations, it facilitates constructive alignment between learning outcomes, learning environment and process (in the workplace) and assessment.

For the clinician supervisor, it serves to align assessment and clinical practice. It supports the trainers' and supervisors' accountability for the outcomes of training, ensuring safety for future patients.

The benefits for learners include increased levels of participation and responsibility until they are prepared for independent practice.[23] It promises learners' appropriate and progressive levels of responsibilities to match their capabilities.[23] It serves to be truly competency base, as a trainee/learner is allowed to progress when an entrustment level is reached.[22]

In summary, EPA can be used as both training and assessment tools in our training programme.

What is being Done?

Since 2014, a group of anaesthesiologists from all the universities offering the programme and the MOH Malaysia has been working on improving the current curriculum into a competency based one. Understanding our countries' needs and resource limitations, we have decided to begin the change with a balance of the need for competence-based training and time based training by training more trainers, harmonise existing training and strengthening assessment strategies.

The aims and objectives of this curriculum is to match the 7 of the Malaysian Qualification Framework domains (knowledge; practical skills; social skills and responsibilities; values, attitudes and professionalism; communication, leadership and team skills; problem solving and scientific skills; information management and lifelong learning skills) while also answering to the needs of the nation: competent general anaesthesiologists who would be able to provide anaesthesiology and periprocedural care, critical care and pain management.

To ensure these outcomes are planned, taught, learnt and assessed holistically, the writing group agreed to adopt the concept based on EPAs, focusing on the tasks our graduates would be able to perform independently. We have rebranded it as Essential Learning Activities (ELAs) to shift the focus to training and learning, rather than just assessment.

We will soon validate our entry and exit ELAs and include trainees input in the development.

CONCLUSION

The future of anaesthesiology training promises to continue the culture of accountability, safety and excellence in anaesthesiology. It will require buy in from all stakeholders, major resource investments and like any change process will be difficult. Like everything else in anaesthesiology, we will continue to be adaptable and improve.

References

1. Delikan AE, Sachithanandan T, Lim SW. Postgraduate training in anaesthesiology in Malaysia - The past, the present and the future. *Med J Malaysia* 1977;**31**(4):347-8
2. Gurubatham AI, Damodaran A. History of Anaesthesia in Malaysia. Malaysian Society of Anaesthesiologists and College of Anaesthesiologists, Academy of Medicine Malaysia, 2013, pp 34
3. University of Malaya Anaesthesiology Training Manual, 10th Ed
4. http://www2.mqa.gov.my
5. http://www.nsr.org.my
6. http://coanaes.com
7. ten Cate O, Gruppen L, Kogan J, Lingard L, Teunissen P. Time-variable training in medicine: theoretical considerations. *Academic Medicine* 2018;**93**:S6-S11
8. Castanelli D, Wickramaarachchi S, Wallis S.Burnout and the learning environment of anaesthetic trainees. *Anaesthesia and intensive care* 2017;**45**(6):pp744-751
9. Waechter J. Competency by design: when opportunity stops knocking. *Canadian journal of Anaesthesia* 2016;**64**: 325-6
10. Ministry of Health Anaesthesiology Census Report 2015
11. Smith N, Castenelli D. Measuring the clinical learning environment in anaesthesia. *Anaesthesia and intensive care* 2015;**43**(2):199-203
12. Larsson, J., Holmstrom, I., Lindberg, E., Rosenqvist, U., (2004). Trainee anaesthetists understand their work in different ways: implications for specialist education. *British Journal of Anaesthesia* 92(3): 381-387
13. Wakatsuki, S., Tanaka, P., Vinagre, R., Marty, A., Thomsen, J., Macario, A.,(2018) What makes for good anesthesia teaching by faculty in the operating room? The perspective of anesthesiology residents. *Cureus* 10(5): e2563. DOI10.7759/cureus.2563
14. Levine F, Shorten G. Competency-based medical education: Its time has arrived. *Canadian Journal of Anesthesia* 2016;**63**:802-6
15. Global consensus for social accountability of medical schools 2010
16. Ebert T, Fox C, Competency-based education in anaesthesiology: History and challenges. *Anesthesiology* 2014;**120**:24-31
17. Bould M, Naik V, Hamstra S. Review article: New directions in medical education related to anaesthesiology and perioperative medicine. *Canadian Journal of Anaesthesiology* 2102;**59**:136-60
18. Fraser A, Stodel E, Jee R, Dubois D, Chaput A. Preparing anaesthesiology faculty for competency-based medical education. *Canadian Journal of Anesthesia* 2016;**63**:1364-73
19. ten Cate O, Hart D, Ankel F, Busari J, Englander R, Glasgow N, et al. Entrustment Decision Making in Clinical Training. *Academic Medicine* 2016;**91**:191-198

20. ten Cate O. Entrustability of professional activities and competency-based training. *Medical Education* 2005;**39**:1176-1177

21. ten Cate O. Competency-Based Postgraduate Medical Education: Past, Present and Future. *GMS Journal for Medical Education* 2017;**34**:Doc69-Doc69

22. ten Cate O. A primer on entrustable professional activities. *Korean Journal of Medical Education* 2018;**30**:1-10

23. Hauer K, Iobst W, ten Cate O. & O'Sullivan P. Understanding trust as an essential element of trainee supervision and learning in the workplace. Adv in Health Sci Educ [Online]. 203.1

Pharmacology In Intensive Care Patients: The Role Of Renal Clearance In Antibiotic Dosing

Mohd Basri Mat Nor[1], **Shahir Asraf Abdul Rahim**[2]
[1] Professor, Department of Anaesthesiology and Intensive Care, Kulliyyah of Medicine, International Islamic University Malaysia, Kuantan, Pahang, Malaysia
[2] Department of Anaesthesiology and Intensive Care, IIUM Medical Centre, Kuantan, Pahang, Malaysia

INTRODUCTION

Sepsis, a dysregulated host response to infection, is common in the intensive care unit (ICU) worldwide. It remains a major challenge for critical care physicians because of the associated high mortality and morbidity. According to the Malaysian Registry of Intensive Care (MRIC) Report in 2017, sepsis was the first leading cause of admission to the Ministry of Health ICUs with mortality rate of 52.8%.[1] In management of critically ill patients with sepsis and septic shock, there is compelling evidence that source control of the pathogen, early and appropriate administration of antimicrobial therapy remain the most important intervention. Correct, adequate and timely dosing of antibiotics is the cornerstone of success of therapy, and this depends on drug absorption, distribution and excretion. Inappropriate dosing may contribute to increase mortality and development of antibiotic resistance, therefore optimising antibiotic therapy should be a priority in treating septic patients.[2] To achieve favourable clinical outcomes, the goal of antimicrobial prescription is to reach effective active drug concentrations at the site of infection and achievement of pharmacodynamics targets whilst avoiding toxicity (Figure one).[3]

In critically ill septic patients, pathophysiological changes are associated with disease-driven variation in pharmacokinetics and pharmacodynamics. The development of organ failures may further complicate metabolism, elimination and clearance of drugs that may result in under or overdosing of antimicrobial agents (Figure two). In a review article by Ulldemolins *et al*, the two parameters that vary with greatest significance in patients with multiple organ dysfunction syndromes (MODS) are apparent volume of distribution (Vd) and drug clearance (CL).[4] These changes potentially affect the achievement of targeted concentrations in blood and tissues which may adversely affect the efficacy of antimicrobial therapy. Disease and clinician driven changes lead to an increased in Vd and

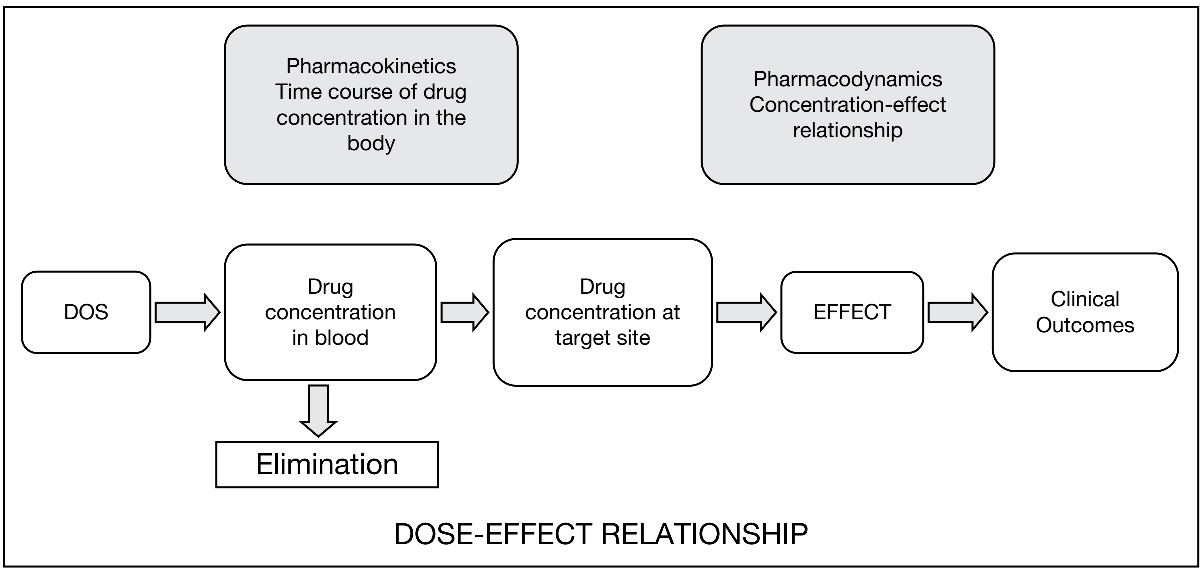


Figure 1: Interrelationship among pharmacokinetics, pharmacodynamics and pharmacokinetics/ pharmacodynamics

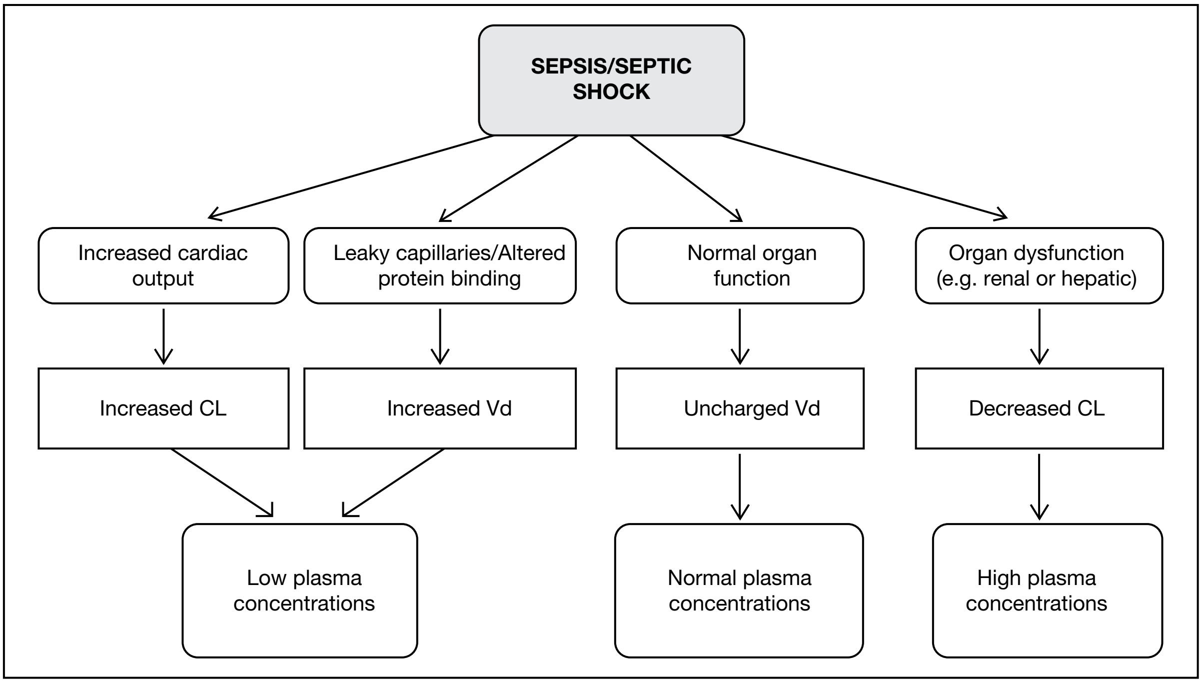


Figure 2: The effects of sepsis/septic shock on drug clearance (CL) and volume of distribution (Vd)

lower than expected plasma concentrations during the first day of therapy. When patients develop organ dysfunction, decreased antibiotic clearance is common and can lead to toxicity. The main method of excretion of drugs from the body is via renal clearance; hence in the presence of acute kidney injury (AKI), clearance of hydrophilic antibiotics is significantly diminished. In our recent study using KDIGO criteria, the incidence of AKI was close to 65% (based on either urine output or creatinine criteria) and almost half of AKI cases were related to sepsis or septic shock.[5] In the presence of AKI, dose adjustments in patients with reduced renal clearance are commonly applied. However, dose adjustments in patients with enhanced renal clearance are still not commonly applied due to difficulty in ascertaining such condition.

Hydrophilic drugs predominantly distribute into intravascular and interstitial water but unable to passively cross the lipid cellular membrane, therefore their Vd is equivalent to the extracellular water i.e. in between 0.1 L/kg and 0.3 L/kg. Therefore, hydrophilic antibiotics are mostly renally cleared by glomerular filtration and tubular secretion. During the initial phase of sepsis, there is an increased Vd especially in patient with MODS. Recent studies suggested that initial antibiotic dosing needs to account for this phase. The concept of "front-loaded" doses is recommended during the first 24 hours of therapy of hydrophilic drugs whose Vd dramatically increase during the early phase of sepsis.[4] Decreased clearance in renal dysfunction requires dose reductions or extended dosing intervals to prevent drug accumulation and toxicity. On the other hand, augmented renal clearance (ARC) which is a manifestation of enhanced renal function is becoming an important phenomenon in critically ill patients. The use of regular unadjusted doses of hydrophilic antibiotics in this condition may lead to suboptimal serum concentration and worse patient outcome. Reduction in renal CL or enhanced renal CL may potentially affect the PK/PD of hydrophilic antibiotics especially beta-lactams, aminoglycosides and vancomycin (Figure three).[6] In the following sections, this article is focusing on the ARC and associated pharmacokinetics changes of hydrophilic antibiotics in critically ill patients.

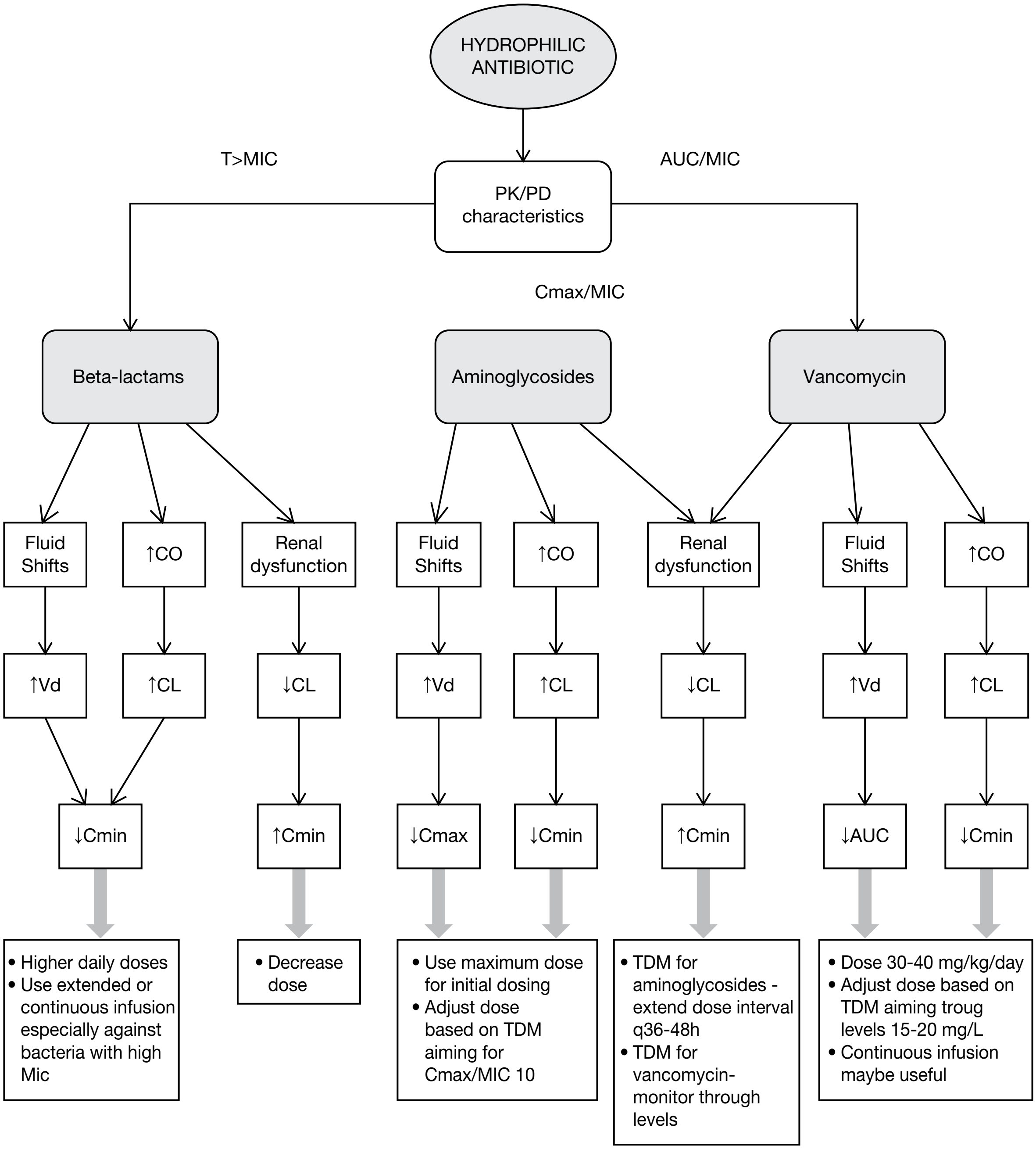


Figure 3: The effects of pathophysiologic changes in PK/PD parameters of hydrophilic antibiotics. AUC=area under the curve; Cmax=maximum drug concentration; Cmin=minimum drug concentration; CL=clearance; CO=cardiac
output; MIC=minimum inhibitory concentration; Vd=volume of distribution

RENAL DYSFUNCTION AND ESTIMATION OF GFR

Early diagnosis of AKI is essential to guide and optimise dosing of antimicrobial agents. Regular monitoring of urine output to detect oliguria (< 0.5 ml/kg/hr) and biochemical parameters such as creatinine level to estimate glomerular filtration rate (GFR) is commonly used. However, this is best to detect deteriorating renal function but not occurrence of ARC. The estimation of creatinine clearance (CrCL) as a surrogate for estimated glomerular filtration rate (eGFR) formulas i.e. Cockcroft-Gault (CG), Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI), Modification of Diet in Renal Disease (MDRD) must be interpreted carefully in critically ill patients and may not accurately identify patients with ARC. Serum creatinine level may be affected by age, gender, sex, race, metabolic state, diet and degree of hydration, thus leading to inaccurate results.[7] The estimated CrCL by CG, MDRD and CKD-EPI are only validated for patients with stable renal function or chronic renal impairment, therefore, there is limited use in variable renal function in critically ill.[8] Studies has demonstrated a significant amount of critically ill patient with normal serum creatinine level, eGFR CG, MDRD and CKD-EPI but demonstrated ARC.[9] These formulas may lead to inaccurate estimations of GFR and lead to inappropriate antibiotic dose adjustments. Therefore, at the moment, the best practical method available to assess renal clearance is by measured CrCL. Where possible, it is preferable to use 4-, 8-, 12-, or 24-hour urinary CrCL to estimate GFR in critically ill patients. The question is what best duration of collection for an accurate measured CrCL was explored by Cherry *et al* that compared 2-, 6-, 8-, 16- and 24-hour CrCL. They recommended that 8-hour urine collection is best to accurately measure CrCL.[10] Pickering *et al* evaluated serial 4-hour CrCL in 484 critically ill patients in two-centre randomised controlled trial and they concluded that repeated 4-hour CrCL measurements was accurate to monitor timely changes in renal function compared to plasma creatinine.[11]

Definition of Augmented Renal Clearance

Augmented renal clearance is an important phenomenon where there is an elevated renal clearance seen in critically ill patients. It is currently defined as an increase of measured CrCL >130 ml/min/1.73m^2. This cut off point is used by most literature because subtherapeutic concentrations of vancomycin were observed when the measured CrCL exceeded 130 ml/min/1.73m^2.[12] Augmented renal clearance has been described in multiple literatures regarding its common occurrence but variable prevalence in developed countries, depending on the method of diagnosis and the case-mix studied.

Mechanism of Augmented Renal Clearance

The definite mechanism of ARC is difficult to be determined but the development of a systemic inflammatory response syndrome (SIRS) appears closely associated with ARC.[13] Systemic inflammatory response syndrome is common in critically ill patients with severe infections, trauma, burn injury, pancreatitis, major surgery, ischemia and haematological malignancy. Inflammatory mediators released with SIRS can markedly increase cardiac output and decrease systemic vascular resistance via activation of the sympathetic response. Therefore, this response results in increased renal blood flow and GFR in normal kidneys. This can further be aggravated using vasoactive drugs and high-volume fluid resuscitation, which are common measures in the critically ill. A recent study demonstrated an increase in GFR in a small cohort of SIRS patients supporting this key mechanism.[14] This study also showed increased tubular secretion of anions, which could possibly contribute to increased clearance of anionic antibiotics like some beta-lactams.

Risk Factors of Augmented Renal Clearance

There are multiple risk factors that lead to ARC as shown in Figure four. Even though the pathophysiology of ARC is not well understood, it is possible to identify the patients who have high risk of developing ARC from previous pharmacokinetic studies of hydrophilic antibiotics. Recognising patients at risk may guide the clinician to adjust dosing since numerous studies reported therapy failures when using standard dosing regimens. Various studies have shown that patients exhibiting ARC include younger age (< 50 years old), male gender, recent history of surgery, trauma, traumatic brain injury (TBI), sepsis and have lower critical illness severity. Trauma and surgery are associated with stress induced SIRS and are significant risk factors for ARC.[15] Brown *et al* has illustrated the elevated CrCL reaching peak of 190 ml/min/1.73m^2 in trauma patients on the fourth postoperative day.[16] He also showed that there was modest correlation between cardiac output and measured CrCL, even after excluding septic patients and those who are on vasoactive medications. Cherry *et al* also found similar findings of elevated CrCL in their study to determine the accuracy of shorter duration of creatinine clearance collection.[10]

Traumatic brain injury is another sub-population where ARC commonly seen due to its association

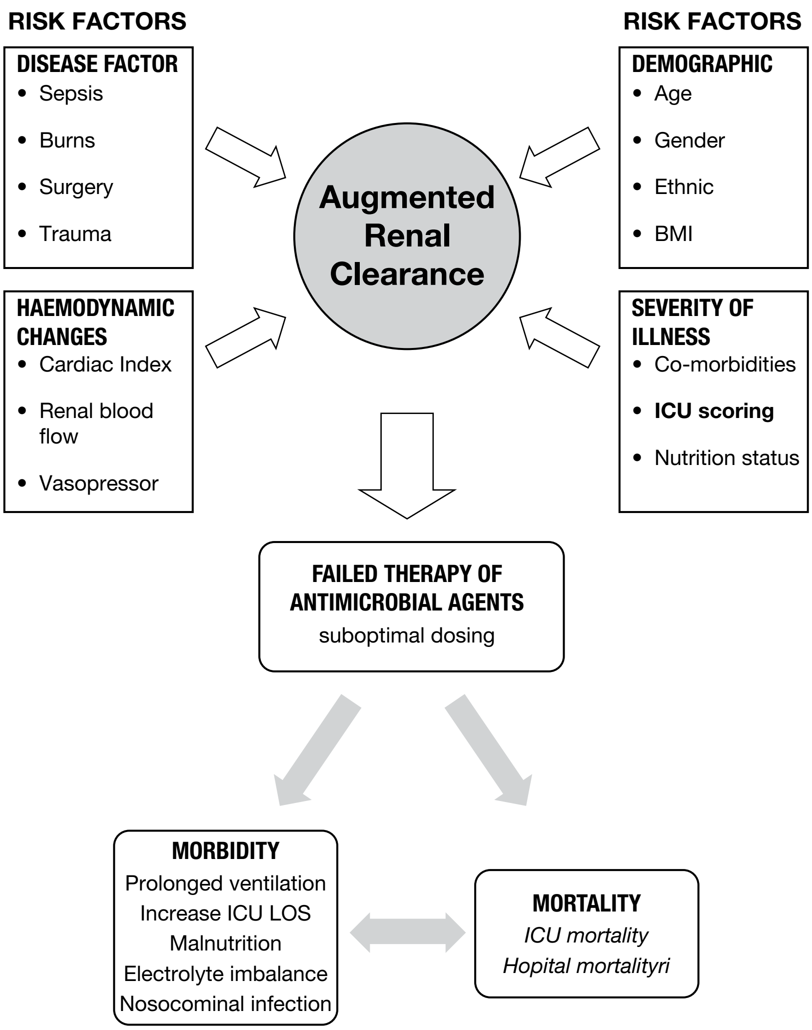


Figure 4: Risk factors of augmented renal clearance and consequences of suboptimal antimicrobial therap

with polytrauma. The patient demographic usually involves younger age group with relatively limited comorbidities.[17] The ICU management in TBI commonly involves fluid resuscitation and vasoactive medications to maintain adequate cerebral perfusion pressure (CPP), and hypertonic saline infusion to induce osmotic diuresis in order to reduce cerebral oedema. Augmented renal clearance has also been demonstrated in patients who are treated with or without vasopressor therapy[18] and with the infusion of hypertonic saline.[19]

Burn injury is another sub-group of trauma patients that is characterised by two phases of clinical course. The initial phase that persists up to 72 hours is characterised by SIRS and extensive protein capillary leak. The initial management involves large volume of fluid resuscitation, early debridement and management of other related complications e.g. inhalational injury and carbon monoxide poisoning. The second phase is characterised by hypermetabolic response due to increased metabolic demand for wound healing that often lasts for several weeks. This results in increased cardiac output that leads to an increase in renal blood flow and GFR.[20] Conil *et al* found that 42% of burns patient demonstrated enhanced CrCL > 120 ml/min/1.73m^2. As expected, the clearance of renally excreted antibiotics is enhanced in this condition.[21] This has been confirmed in various studies of hydrophilic antibiotics which include cefepime, ceftazidime, piperacillin, imipenem, vancomycin, tobramycin, amikacin, daptomycin and ciprofloxacin.

Hypoalbuminemia is commonly seen in the critically ill patients and it may be contributed by multiple factors such as impaired liver synthetic functions, dilutional effect fluid resuscitation, premorbid malnutrition and inadequate protein intake. The presence of SIRS combined with catabolic response of critical illness may result in significant protein degradation. For drugs that are excreted mainly by the kidney and have high protein binding, there will be an increased elimination of the free fraction of the drugs. This increased drug clearance in hypoalbuminaemic patients has been proven in pharmacokinetic studies using ceftriaxone, teicoplanin and ertapenem.

Udy *et al* developed a scoring system to predict the occurrence of ARC. This predictive tool was validated by Akers *et al*, demonstrating a sensitivity of 100% and a specificity of 71% based on data from altered piperacillin/tazobactam pharmacokinetics (Table I).[9,22] Barletta *et al* developed another scoring system called ARC in trauma intensive care (ARCTIC) which excluded SOFA score. If the score is > 6, the patient has a high risk for ARC with a sensitivity of 84% and a specificity of 68%.[23] Augmented renal clearance or ARCTIC predictive tools allow early recognition of high risk patients and allow early intervention if necessary.

Table I: The ARC and ARCTIC scoring systems for screening augmented renal clearance ICU patients

Scoring system	**ARC**		**ARCTIC**	
		Points		Points
Criteria	Age ≤ 50 years Trauma pts SOFA score ≤ 4	6 3 1	Sr creatinine < 62 µmol/L Male sex Age < 56 years Age 56 - 75 years	3 2 4 3
Augmented renal clearance risk	Low High	<6 >6	Low High	<6 >6
Sensitivity %	100		84	
Specificity %	71		68	

PREVALENCE OF AUGMENTED RENAL CLEARANCE

The prevalence of ARC in critically ill patients is between 30% and 65%, even in patients with normal serum creatinine.[24] A prospective study on 89 critically ill patients in Spain showed 17.9% presented with ARC on admission, and the prevalence increased up to 30% during the first week of ICU stay.[25] Another multicentre observational study of four tertiary ICUs in Australia, Singapore, Hong Kong and Portugal demonstrated prevalence of ARC as high as 65.1% (183 out of 281 patients) in on at least one occasion during the first seven study days.[26]

The prevalence is between 30% and 85% in ICU population with sepsis,[27] trauma,[28] traumatic brain injury (TBI),[9] subarachnoid haemorrhage (SAH)[25] and central nervous system (CNS) infection.[24,29] This may be explained by differences in case mix, patient characteristics and also by the cut off value used to diagnose ARC. Fuster-Lluch *et al* defined ARC as measured creatinine clearance > 120 ml/min/1.73m^2 and found that the prevalence was 30% in severe sepsis or septic shock cohort.[25] Baptista *et al* conducted a single centre study in adult ICU patients with sepsis who received Vancomycin.[30] Using definition of ARC as measured creatinine clearance > 130 ml/min/1.73m^2, they found that 40% of the study population had ARC. In a small cohort of 20 TBI patients who underwent neuroprotection measures, using cut-off value > 160 ml/min/1.73m^2 for men and > 150 ml/min/1.73m^2 for women, Udy *et al* diagnosed 85% of them had ARC.[19] Using a cut off creatinine clearance > 120 ml/min/1.73m^2 in patients with burns, Conil *et al* found that prevalence of ARC was 54%.[21]

A small sample size Malaysian data from 49 patients in a single centre study in one of the main trauma centres in Malaysia showed ARC prevalence of 39% in the initial 24 hours of ICU stay.[31] In this study, Adnan *et al* used measured 24-hour CrCL > 130 ml/min/1.73m^2 as definition of ARC. Most patients were young male (median age 34 years) who suffered from trauma, traumatic brain injury and had emergency surgery prior to ICU admission. Recently, we conducted a study in two tertiary-level ICUs in Kuantan, Pahang. Among 102 patients recruited, 55.9% had ARC. Patients in the younger age group (median age 39 years) and lower SOFA score were at more risk to develop ARC. In this study, Abdul-Rahim *et al* measured 4-hour CrCL and defined ARC when CrCl > 130 ml/min/1.73m^2.[32]

Impact of Augmented Renal Clearance

Augmented renal clearance causes increased clearance of therapeutic drugs from the body. Several studies showed that ARC results in significant subtherapeutic dosing of critical drugs such as antibiotics (e.g. vancomycin and beta lactam antibiotics) and anti-epileptic (e.g. levetiracetam).[33-35] In patients with sepsis treated with vancomycin, Baptista *et al* found strong association between ARC and subtherapeutic vancomycin concentration (< 9.5 ug/ml) during the first three days of treatment.[30] Another study on 363 surgical ICU patients in Argentina who received vancomycin showed that all patients with ARC did not achieve the desired target trough therapeutic concentration.

In an observational study of 100 critically ill patients who received imipenem-cilastatin, meropenem, piperacillin-tazobactam or cefepime demonstrated that 64% of them had ARC. The presence of ARC strongly predicted low trough serum concentration.[36] Another observational study conducted by Claus *et al* on 128 critically ill patients, showed incidence of ARC was 51.6% and more treatment failure was seen in ARC compared to the non-ARC group.[27] In this study, patients with ARC had longer ICU stay compared to those without ARC. Although study directly correlating ARC with adverse patient outcome is limited, ARC is certainly associated with subtherapeutic antibiotic concentration. These studies emphasise the need of dose optimisation measures by clinicians when prescribing antibiotics in patients diagnosed with ARC. The use of regular unadjusted doses may lead to therapy failure and worse patient outcome.

Implications and Recommendations

Augmented renal clearance is common in critically ill patients and limited study in Malaysia showed prevalence in the range of 39 to 56%. The estimated CrCL is not a good tool to detect ARC as compared to measured CrCL by 4- to 24-hour urine collection. Early recognition of ARC is important and this allows further intervention to prevent antibiotic therapy failure. The patients at risk can be identified by using predictive tool such as ARC or ARCTIC scoring systems. In patients who have score > 6, measured creatinine clearance using 4-, 8-, 12- or 24-hour urine collection is recommended. In patients with ARC, higher doses of renally eliminated antibiotics are recommended or administration of non-renally eliminated drugs as alternatives should be considered. Therapeutic drug monitoring (TDM) and dose adjustment should be performed, when available. For those drugs where TDM is not routinely available and there is not sufficient evidence to guide dosage modification, the use of the highest approved dose or most frequent administration regimen could be considered with close monitoring. The patients with ARC should be monitored for delayed or insufficient clinical response. The occurrence for risk or presence of ARC should be assessed daily. The dosing adjustments of commonly used antibiotics is summarised in Table II.[6]

Table II: Suggested dosing recommendations of the studied drugs in adult ARC population

	Antibiotic	Suggested dosage
1.	Levofloxacin	Dose: IV 1000 mg q8h
2.	Meropenem	Dose: IV 2000 mg q8h
3.	Piperacillin/Tazobactam	• Dose: IV 45000 mg q6h • Extended infusion of the dose over 4h might be required
4.	Vancomycin	• Initial loading dose: 25 - 30 mg/kg followed by a maintenance dose of 45 mg/kg/day in divided doses q8h or continuous infusion • Therapeutic drug monitoring is recommended (target 10 - 20 μg/ml or 15-20 μg/ml depending on the indication)

CONCLUSION

Early and appropriate administration of antimicrobial therapy remains the most important intervention in managing sepsis. To achieve favourable outcomes, the goal is to achieve effective drug concentrations at the site of infection. In critically ill patients, development of organ failure may complicate antibiotic dosing. Two pharmacokinetic parameters that vary with greatest significance in patients with MODS are Vd and drug CL. In presence of AKI, antibiotic dose adjustments in patients with reduced clearance are commonly applied to avoid adverse effects. Augmented renal clearance is another important phenomenon which is a manifestation of enhanced renal function. Early recognition of patients at risk of ARC allows further intervention to prevent antibiotic failure. In patients with ARC, higher doses of renal eliminated antibiotics are recommended or administration of non-renally eliminated drugs should be considered.

References

1. Tai LL, Lim CH, Ismail NI, Mohd Nor MR, Wan Ismail WN. Malaysian Registry of Intensive Care Report for 2017 report 2017:1-57

2. Santos Filho L, Kuti JL, Nicolau DP. Employing pharmacokinetic and pharmacodynamic principles to optimize antimicrobial treatment in the face of emerging resistance. *Brazilian J Microbiol* 2007;**38**(2):183-193

3. Varghese JM, Roberts JA, Lipman J. Antimicrobial Pharmacokinetic and Pharmacodynamic Issues in the Critically Ill with Severe Sepsis and Septic Shock. *Crit Care Clin* 2011;**27**(1):19-34

4. Ulldemolins M, Roberts JA, Lipman J, Rello J. Antibiotic dosing in multiple organ dysfunction syndrome. *Chest* 2011;**139**(5):1210-1220

5. Md Ralib A, Mat Nor M-B. Acute kidney injury in a Malaysian intensive care unit: Assessment of incidence, risk factors, and outcome. *J Crit Care* 2015;**30**(3):636-642

6. Mahmoud SH, Shen C. Augmented renal clearance in critical illness: An important consideration in drug dosing. *Pharmaceutics* 2017;**9**(3):2-27

7. Cartin-Ceba R, Afessa B, Gajic O. Low baseline serum creatinine concentration predicts mortality in critically ill patients independent of body mass index. *Crit Care Med* 2007;**35**(10):2420-2423

8. Hosein S., Udy AA. b, Lipman J. b. Physiological changes in the critically Ill patient with sepsis. *Curr Pharm Biotechnol* 2011;**12**(12):1991-1995

9. Udy AA, Roberts JA, Shorr AF, Boots RJ, Lipman J. Augmented renal clearance in septic and traumatized patients with normal plasma creatinine concentrations: identifying at-risk patients. *Crit Care* 2013;**17**(1):R35

10. Cherry RA, Eachempati SR, Hydo L, Barie PS. Accuracy of short-duration creatinine clearance determinations in predicting 24-hour creatinine clearance in critically ill and injured patients. *J Trauma* 2002;**53**(2):267-271

11. Pickering JW, Frampton CM, Walker RJ, Shaw GM, Endre ZH. Four hour creatinine clearance is better than plasma creatinine for monitoring renal function in critically ill patients. *Crit Care* 2012;**16**(3):R107

12. Udy AA, Roberts JA, Lipman J. Implications of augmented renal clearance in critically ill patients. *Nat Rev Nephrol* 2011;**7**(9):539-543

13. Shimamoto Y, Fukuda T, Tanaka K, Komori K, Sadamitsu D. Systemic inflammatory response syndrome criteria and vancomycin dose requirement in patients with sepsis. *Intensive Care Med* 2013;**39**(7):1247-1252

14. Udy AA, Jarrett P, Stuart J, et al. Determining the mechanisms underlying augmented renal drug clearance in the critically ill: use of exogenous marker compounds. *Crit Care* 2014;**18**(6):1-9

15. Kohl BA, Deutschman CS. The inflammatory response to surgery and trauma. *Curr Opin Crit Care* 2006;**12**(4):325-332

16. Brown R, Babcock R, Talbert J, Gruenberg J, Czurak C, Campbell M. Renal function in critically ill postoperative patients: sequential assessment of creatinine osmolar and free water clearance. *Crit Care Med* 1980;**8**(2):68-72

17. Ott L, Mcclain CJ, Gillespie M, Young B. Cytokines and Metabolic Dysfunction After Severe Head Injury. *J Neurotrauma* 1994;**11**(5):447-472

18. Benmalek F, Behforouz N, Benoist JF, et al. Renal effects of low-dose dopamine during vasopressor therapy for posttraumatic intracranial hypertension. *Intensive Care Med* 1999;**25**(4):399-405

19. Udy A, Boots R, Senthuran S, et al. Augmented creatinine clearance in traumatic brain injury. *Anesth Analg* 2010;**111**(6):1505-1510

20. Loirat P, Rohan J, Baillet A, Beaufils F, David R, Chapman A. Increased glomerular filtration rate in patients with major burns and its effect on the pharmacokinetics of tobramycin. *N Eng J Med* 1978;**299**(17):915-919

21. Conil JM, Georges B, Lavit M, et al. Pharmacokinetics of ceftazidime and cefepime in burn patients: The importance of age and creatinine clearance. *Int J Clin Pharmacol Ther* 2007;**45**(10):529-538

22. Akers KS, Niece KL, Chung KK, Cannon JW, Cota JM, Murray CK. Modified Augmented Renal Clearance score predicts rapid piperacillin and tazobactam clearance in critically ill surgery and trauma patients. *J Trauma Acute Care Surg* 2014;**77**(3 Suppl 2):S163-70

23. Barletta JF, Mangram AJ, Byrne M, et al. Identifying augmented renal clearance in trauma patients: Validation of the Augmented Renal Clearance in Trauma Intensive Care scoring system. *J Trauma Acute Care Surg* 2017;**82**(4):665-671

24. Hobbs ALV, Shea KM, Roberts KM, Daley MJ. Implications of augmented renal clearance on drug dosing in critically ill patients: A focus on antibiotics. *Pharmacotherapy* 2015;**35**(11):1063-1075

25. Fuster-Lluch O, Gerónimo-Pardo M, Peyró-García R, Lizán-García M. Glomerular hyperfiltration and albuminuria in critically ill patients. *Anaesth Intensive Care* 2008;**36**(5):674-680

26. Udy AA, Baptista JP, Lim NL, et al. Augmented renal clearance in the ICU: Results of a Multicenter observational study of renal function in critically ill patients with normal plasma Creatinine concentrations. *Crit Care Med* 2014;**42**(3):520-527

27. Claus BO, Hoste EA, Colpaert K, Robays H, Decruyenaere J, De Waele JJ. Augmented renal clearance is a common finding with worse clinical outcome in critically ill patients receiving antimicrobial therapy. *J Crit Care* 2013;**28**(5):695-700

28. Udy AA, Roberts JA, Boots RJ, Paterson DL, Lipmanl J. Augmented renal clearance: Implications for antibacterial dosing in the critically Ill. *Clin Pharmacokinet* 2010;**49**(1):1-16

29. Lautrette A, Phan TN, Ouchchane L, et al. High creatinine clearance in critically ill patients with community-acquired acute infectious meningitis. *BMC Nephrol* 2012;13(124)

30. Baptista JP, Sousa E, Martins PJ, Pimentel JM. Augmented renal clearance in septic patients and implications for vancomycin optimisation. *Int J Antimicrob Agents* 2012;**39**(5):420-423

31. Adnan S, Ratnam S, Kumar S, et al. Select critically ill patients at risk of augmented renal clearance: experience in a Malaysian intensive care unit. *Anaesth Intensive Care* 2014;**42**(6):715-722

32. Abdul Rahim SA, Mat Nor MB, Md Ralib A. Augmented Renal Clearance in East Coast Malaysia Intensive Care Setting: Assessment of Prevalence, Risk Factors and Outcomes. *MMed Anaesth Thesis* 2019

33. Carlier M, Carrette S, Roberts J a, et al. Meropenem and piperacillin/tazobactam prescribing in critically ill patients: does augmented renal clearance affect pharmacokinetic/pharmacodynamic target attainment when extended infusions are used? *Crit Care* 2013;**17**(3):R84

34. Udy AA, Varghese JM, Altukroni M, et al. Subtherapeutic initial ??-lactam concentrations in select critically Ill patients: Association between augmented renal clearance and low trough drug concentrations. *Chest* 2012;**142**(1):30-39

35. Cook AM, Arora S, Davis J, Pittman T. Augmented renal clearance of vancomycin and levetiracetam in a traumatic brain injury patient. *Neurocrit Care* 2013;**19**(2):210-214

36. Huttner A, Von Dach E, Renzoni A, et al. Augmented renal clearance, low ß-lactam concentrations and clinical outcomes in the critically ill: An observational prospective cohort study. *Int J Antimicrob Agents* 2015;**45**(4):385-392

ABCDE Of Childhood Obesity: An Overgrowing Concern In Anaesthesia

Nur Hafiizhoh Abd Hamid
Paediatric Anaesthesiologist, Department of Anaesthesiology and Intensive Care, Hospital Sultanah Bahiyah, Alor Setar, Kedah, Malaysia

INTRODUCTION

Malaysia has been declared the fattest nation in Asia and has the second highest child obesity rate at 12.7% among ASEAN children aged 5 to 19 years, with 7.1% of children under the age of 5 being overweight.[1,2] The epidemic of childhood obesity has become a pandemic. Nowadays, obese children coming for non-bariatric surgery are increasingly common that further challenges anaesthesiologists' capability in ensuring anaesthesia safety. In contrast to adults, obese children rarely present with common morbid effect of obesity such as ischaemic heart disease, cerebral vascular accident, diabetes mellitus, hypertension and its organopathies. Nevertheless, obesity would significantly influence anaesthesia management and outcome in every obese child due to higher incidence of perioperative complications. The aim of this article is to evaluate and summarise the latest concerns, practices and evidence pertaining to anaesthesia in obese children.

ABCDE OF CHILDHOOD OBESITY

Acknowledgement of Obese Definition in Children

Defining obesity in children is never easy. Growth rates are not identical between infant, toddler and adolescent stages of boys and girls because of different fat, muscle and bone density distribution occurring at puberty. Therefore the calculated value of body mass index [BMI = weight (kg)/height^2 (m^2)] $\geq$ 30 kgm^{-2} cannot be used directly to depict obesity in paediatric populations. For most children, the cutoff points should be based upon percentiles from BMI-for-age and gender specific curves at which overweight and obesity is considered when BMI $\geq$ 85th and $\geq$ 95th percentile respectively. Table I summarises commonly used gender specific BMI-for-age curves to classify the overweight and obese children of different age ranges. [3-5]

Breathing Disorder

Sleep-Disordered Breathing (SDB) is commonly related to obese children. The spectrum of SDB is wide; from habitual snoring to obstructive sleep apnoea (OSA). Obese children with OSA may go unrecognized prior to anaesthesia and administration of postoperative opioid analgesics would make them at risk of developing perioperative opioid related adverse event (ORAE) and perioperative opioid related adverse event (PRAE). Polysomnography (PSG) is the gold-standard diagnostic tool to diagnose OSA in both paediatric and adult populations.[6] Blanket PSG screening is however, time consuming, logistically complex and not cost-effective. A simpler oximetry study is sometime conducted as surrogate to PSG.[6] Table II shows severity of OSA based on PSG in children in comparison to adult and oximetry study.[6,7] The McGill score has 4-level severity (McGill 1-4), based on the numbers and depth of desaturations in an overnight pulse oximeter recording. Frequently, neither PSG nor oximetry study is readily available to obese children prior to emergency surgery. Tait *et al* 2013 had proposed a STBUR questionnaire, a quicker way to identify kids with potential OSA in comparison with the classically lengthy Paediatric Sleep Questionnaire (PSQ).[8,9] This STBUR questionnaire consists of 5 questions pertaining to the nature of Snoring, incident of Troubled Breathing while sleeping and Un-Refreshed feeling upon waking up from sleep. A score of $\geq$ 3 out of 5 is considered high risk of SDB.[8] The likelihood of PRAE was increased three-fold in the presence of any 3 STBUR symptoms and ten-fold when all 5 symptoms were present.[10] STBUR questionnaire is a simple screening tool with high specificity, easy to use for SDB risk-stratification in a busy preoperative anesthesia setting,[8,10-12] thus would likely be an excellent clinical utility in identifying obese children with potential OSA.

Co-Morbidities

Obesity is classified as ASA physical status II. Obese children in association with other comorbidities would further increase the anaesthetic risk and ASA physical status.[13] Table III summarises potential comorbidities and complications commonly correlated with longstanding childhood obesity and its anaesthetic implications.[14-20]

Drug Dosing and Calculation

Drug dose calculation per weight basis is mandatory in paediatric anaesthesia practice. In comparison to normal children or obese adult, several important factors need to be considered during drug calculation in obese children; such as variations in body mass composition, dissimilar blood volumes and constituents and differences in renal and liver maturity rate. These physiological alterations will affect distribution, metabolism and clearance as well as determination of the onset and offset of the drug. It is also important to remember that total blood volume, cardiac output, plasma protein binding and regional blood flow would also affect the volume of distribution. Table IV summarises the physiological changes in obese children and its impact on pharmacokinetics of commonly used anaesthetic drugs.[14-22] Different drugs would require a different dosing scale depending on its hydrophilicity or lipophilicity. However, there is lack of clear guidance on whether to use TBW, ideal body weight (IBW) or lean body mass (LBM) for calculation of anaesthetic drugs in obese children. Most available data were extrapolated from obese adult populations, which are helpful but need to be carefully considered prior to its application on obese paediatric patients. Table V displays list of recommended weight scales to be used for calculation of intravenous anaesthetic drug in overweight and obese children.[14-22] The maximal dose of local anaesthetic agent for regional anaesthesia is usually determined by the regional technique, child's age, physical status and weight according to LBM.[24]

Another important factor in calculating anaesthetic drug dosage in obese children is their associated co-morbidity. Non-alcoholic fatty liver disease (NAFLD) and OSA would alter the pharmacokinetics and pharmacodynamics response causing narrowing of therapeutic index of anaesthetic drugs. Considering NAFLD, anaesthetic drugs which are metabolised predominantly by the liver should be titrated to effect in obese children in view of potential overdose or risk of drug induced liver toxicity.[14,15,19,22]

Basically, hypnotic agents with rapid recovery profile, short and ultra-short acting opioids and multimodal analgesia are advocated in obese paediatric patients. Depth of anaesthesia and intraoperative neuromuscular monitoring should be mandatory in all obese and paralysed children. This additional monitoring would facilitate titration of anaesthetic drugs, improve safety of drug delivery and reduce potential side effects.

Obese children have the lowest total blood volume of 65 ml/kg compared to their normal peers of 70 ml/kg.[25] Total body water and blood volume calculation of obese children has to be readjusted based on IBW to avoid excessive fluid infusion and blood product transfusion.[25-27]

Events and Complications

i. Perioperative respiratory-related adverse event (PRAE)

Obesity is an independent risk factor for PRAE even for minor surgery or procedural sedation.[28-31] Desaturation in obese children is rather rapid because their basal oxygen consumption is higher than the normal children of comparable height and age.[16,32-34] Obese children have higher risk of developing PRAE due to a combination of pathophysiological changes of the airway and respiratory system and their common association with respiratory morbidities such as OSA, bronchial asthma, hyperactive airway and recurrent respiratory tract infection.[14-19,21,35,36] Table VI displays an overview of relevant studies on PRAE in obese children.[28-31] PRAE incidence is significantly higher in obese children coming for airway surgery.[29,31,35] A secondary analysis on 21,524 children from Anaesthesia Practice In Children Observational Trial (APRICOT)

Table I: Overview of commonly used publications on gender specific BMI-for-age curves.[3-5]

	Cole *et al* (2000)[3]	**Kuczmarski *et al* (2002)[4]**	**WHO (2006)[5]**
Chart	International Obesity Task Force BMI cutoff values - The curve passing through BMI of 25 and 30 kgm^{-2} at age 18	2000 CDC BMI-for-age percentile curve	WHO BMI-for-age curve - Z-scores and percentiles used for under 5 and above 5 years of age respectively
Details	Age range: 2 - 18 years United State, Britain, the Netherlands, Brazil, Singapore, Hong Kong	Age range: 2 - 18 years United State	Age range: - 0 - 2 years - 2 - 5 years - 5 - 19 years United State, Brazil, India, Ghana, Oman, Norway
Interpretation	*overweight* - ≥ 25 kgm^{-2} curve cutoff point *at risk of obesity* - ≥ 30 kgm^{-2} curve cutoff point	*at risk for overweight* - Percentile ≥ 85^{th} *at risk for obesity* - Percentile ≥ 95^{th}	*overweight* - Z-score ≥ 2 - Percentile ≥ 85^{th} *obesity* - Z-score ≥ 3 - Percentile ≥ 95^{th}

CDC - Centers for Disease Control
WHO - World Health Organization
BMI - Body Mass Index

Table II: Severity of OSA in children based on polysomnography and oximetry study

OSA Severity	**AHI in Adult**	**AHI in Children**	**McGill Oximetry Score**
None	0 - 5	0	1
Mild	6 - 20	1 - 5	2
Moderate	21 - 40	6 - 10	3
Severe	> 40	> 10	4

OSA - Obstructive Sleep Apnoea
AHI - Apnoea Hypopnoea Index

Table III: List of comorbidity and complication associated with longstanding childhood obesity and anaesthetic implication.[14-20]

AFFECTED ORGAN/SYSTEM	ANAESTHETIC IMPLICATION
Respiratory	
Obstructive sleep apnoea	- Increased risk of PRAE and ORAE causing unanticipated paediatric ICU admission, postoperative oxygen support and prolonged hospitalization
Bronchial asthma & hyperreactivity	- Increased risk of PRAE
Recurrent respiratory tract infection	
Pulmonary Hypertension	- Evaluation for right heart disease would be required
Gastrointestinal	
Gastroesophageal reflux disease	- Adequate fasting time is mandatory especially in emergency cases. Allowing clear fluid up to 2 hours prior to surgery does not increase the pulmonary aspiration risk.
Non-alcoholic Fatty liver diease - Asymptomatic steatohepatitis - Cirrhosis	
Cholelithiasis & Cholecystitis	
Endocrine	
Metabolic syndrome - insulin resistance and glucose intolerance - hypercholestrolaemia - elevated trigliseride	- Preoperative fasting blood glucose should be obtained to rule out undiagnosed type II diabetes mellitus; facilitate perioperative glucose control and reduce postoperative complication related to hyperglycaemia.
Pseudohypothyroidism	
Polycystic ovarian syndrome	
Cardiovascular	
Higher resting heart rate and cardiac output	
Hypertension	
Left ventricular hyperthrophy	- Increase risk of left ventricular dysfunction, preoperative cardiac assessment would be necessary if cardiac disease is suspected.
Artherosclerotic disease	
Musculoskeletal	
Slipped femoral epiphysis	- Careful of posture and positioning
Excessive subcutaneous & visceral fat deposit	
- upper airway & anterior neck region	- Difficult mask ventilation and laryngoscopy
- chest wall - abdominal	- Reduced chest wall compliance, requiring higher ventilator setting; Reduced ERV, FRC resulting in higher closing volume; causing atelectasis and V/Q mismatch.
- limbs	- Difficult intravenous access

PRAE - Perioperative Respiratory-related Adverse Event
ORAE - Perioperative Opioid-Related Adverse Event

Table IV: Physiological changes in obese children and its impact on pharmacokinetic of anaesthetic drugs.[14-22]

Physiological changes in obese children	Pharmacokinetic impact on anaesthetic drugs
Body Composition i. Increase subcutaneous adipose tissue ii. Increase lean body mass	- Increased volume of distribution of lipophilic drugs; requiring higher initial dose
Blood and Constituents i. Increase total blood volume ii. Increase cardiac output	- Increased volume of distribution; requiring higher initial dose
Liver system i. Increase liver mass to blood volume ratio ii. Increase liver blood flow	- Increased volume of distribution, peak concentration and clearance.
iii. Increase in alpha-1-glycoprotein	- Reduced free form drugs that are highly protein bound. But no consistent pattern of protein binding in obese children
iv. Increase activity of CYP 2E1, 2D6, 2C9, 1A2 v. Decrease activity of CYP3A4	- Affect clearance of drugs metabolized by the specific enzymatic pathways.
Renal system i. Increase kidney size ii. Increase renal blood flow	- Increased clearance of drugs

Table V: Recommendation of weight scales for calculation of intravenous anaesthetic drugs in overweight and obese children.[14-22]

DRUGS	INDUCTION /1st DOSE	MAINTENANCE DOSE	COMMENTS
Induction Agents			
Sodium Thiopentone	TBW	-	
Propofol	LBM	TBW	Titrated to effect
Etomidate	LBM	-	Titrated to effect
Benzodiazepine	IBW	IBW	
Neuromuscular Blocking Agents			
Suxamethonium	TBW	-	
Atracurium	IBW	IBW	
Cisatracurium	IBW	IBW	
Rocuronium	IBW	IBW	
Vecuronium	IBW	IBW	
Opioid Analgesia			
Fentanyl	TBW	LBM	
Sulfentanyl	TBW	LBM	
Alfentanyl	TBW	LBM	
Remifentanyl	LBM	LBM	
Morphine	IBW	IBW	
Naloxone		-	Titrated to effect
Non-Opioid Analgesia			
Paracetamol	IBW		
Clonidine	LBW	IBW	
Dexmeditomidine	LBW	IBW	
Reversal Agents			
Neostigmine	TBW		Maximum dose 5 mg
Sugammadex	TBW		

TBW - Total Body Weight
IBW - Ideal Body Weight
LBM - Lean Body Mass

Table VI: Overview of studies on perioperative respiratory adverse event in obese children.[28-31]

	Nafiu *et al* (2007)[28] n = 6094	**Tait *et al* (2008)[29] n = 2025**	**El-Metainy *et al* (2011)[30] n = 1465**	**Gleich *et al* (2012)[31] n = 300**
Procedure	all surgery	non-cardiac surgery	general surgery	tonsillectomy ± adenoidectomy
Prevalence	Normal - 68.4% Overweight - 14.4% Obese - 17.2%	Normal - 68.2% Overweight - 14.5% Obese - 17.3%	Normal - 74.3% Overweight - 15.2% Obese - 10.5%	Normal - 66.7% Severe Obese - 13.3%
Adverse Event	Difficult BMV Difficult laryngoscopy Airway obstruction Prolonged PACU	Difficult BMV Bronchospasm Continuous coughing Airway obstruction Oxygen desaturation	Difficult BMV Oxygen desaturation Airway obstruction Bronchospasm	Airway obstruction Bronchospasm Severe hypoxemia Laryngospasm

BMV - Bag Mask Ventilation

demonstrated an increased risk of occurrence of perioperative laryngospasm, bronchospasm and postoperative stridor in children coming for ENT surgery when compared to non-ENT surgery. Laryngospasm primarily occurred at awakening than during induction. Bronchospasm occurred throughout the stages of anaesthesia at induction, maintenance and awakening. However, BMI has no statistically significant effect on the incidence of PRAE amongst obese children coming for airway surgery.[36]

Airway challenge in obese children is due to fatty deposits of the upper airway structures and subcutaneous fat deposits in the anterior neck region causing significant difficulty during bag mask ventilation, laryngoscopy and intubation. Prolonged ineffective mask ventilation can result in gaseous distension of the stomach. In addition, excessive adipose tissue deposits in the chest wall and abdomen together with cephalad displacement of the diaphragm would decrease chest wall compliance, along with functional residual capacity, vital capacity and inspiratory capacity causing ineffective ventilation.[17-19] Therefore, inhalational induction with sevoflurane could be a challenge in obese children who have a higher potential of airway obstruction causing inadequacy of anaesthetic depth prior to intravenous cannulation and securement of the airway due to ventilation - perfusion mismatch, intermittent airway obstruction and difficult mask fitting. Laryngeal mask airway (LMA) selection should not be done based on total body weight (TBW). Patient age, upper airway anatomy and sizes need to be considered.

Being aware of the associated risks and potential complications, it is advised that two or more trained anaesthesiologists should be present during induction and extubation to help smoothen the process and prevent airway complications.

ii. Perioperative Pulmonary Aspiration Event (PPAE)

Perioperative pulmonary aspiration event (PPAE) is uncommon in paediatric patients. Emergency surgery, a complicated airway management at induction, unprotected airway and failure to maintain adequate anaesthetic depth had been identified as a critical time for PPAE of gastric content or blood to occur in children.[37-40] Table VII displays an overview of relevant studies on PPAE in obese children.[38-41] It is stipulated that the incidence is higher in

Table VII: Overview of perioperative vomiting and pulmonary aspiration related to obese children.[38-40,46]

	Warner *et al* (1999)[38] retrospective single center n = 63 180	**Cook-Santher *et al* (2009)[40] prospective single center n = 1000**	**Walker (2013)[41] prospective multicenter n = 118 371**	**Tan & Lee (2016)[42] retrospective single center n = 102 425**
Age Incidence	< 18 year 24 cases Aspiration: 3.8 per 10 000 - EL : 2.0 per 10 000 - EM: 25 per 10 000	2 – 12 year (day surgery) Emesis: 8 per 1000 - OSA: 6 out of 8 - Obese: 4 out of 8 - ASA II & III: 6 vs 2	< 18 year 24 cases Aspiration: 2 per 10 000 - EL: 2.0 per 10 000 - EM: 2.2 per 10 000	< 18 year 24 cases Aspiration: 2.1 per 10 000
Mortality	nil	nil	nil	nil
Risk Factors	Emergency surgery Induction process Gastrointestinal pathology Age < 3 years	ASA II & III physical status Obesity OSA	Difficult airway Gastrointestinal pathology Obesity Preoperative opioid Anxiety Light Anaesthesia	Emergency surgery Induction process

EL - elective case
EM - emergency case

obese children because of a significantly positive association between obese children with GERD due to high gastric acid output, increase abdominal mass and intra-abdominal pressure.[42-45] Sonographic assessment by Chiloiro *et al* 1999 found a positive correlation between fasting antral area and BMI in non-hospitalised children. Both fasting and post-prandial antral area were significantly different between severely obese in comparison with obese and normal weight children, indicating a progressive effect of obesity severity toward gastric emptying.[46] Cook-Santher *et al* 2009 demonstrated an increasing BMI percentile associated with increasing gastric fluid volume and decreased gastric fluid acidity.[40] There is a different rate of gastric emptying between solid food and fluid. Emptying solid food from the stomach is energy density related, depending on the digestion process required. Although childhood obesity is a recognized potential risk but the correlation of obesity with PPAE is not significant[37-40] because obese children have an accelerated gastric emptying time.[45-47] Therefore, in the absence of GERD or gastrointestinal disease; fasting time of solid food and clear fluid in obese children should be 6 and 2 hours respectively, following our national paediatric fasting guideline.[48]

iii. Perioperative Opioid-related Adverse Event (ORAE)

Obese children with or without OSA have higher incidence of perioperative ORAE.[9,10,49,50] Children with OSA are more sensitive to the effects of opioid-related respiratory depression because of diminished response to hypercarbia and have difficulties arousing from normal sleep or from opioid-related over-sedation.[9,49,50]

United States Food and Drug Administration has recently announced that administration of codeine and tramadol in children younger than 12 years is contraindicated. A new warning was also issued against prescribing codeine and tramadol to adolescent age 12 to 18 years who are obese, have OSA or severe lung disease.[51] Regardless of being catagorised as a weak opioid, codeine and tramadol is a prodrug required to be bioactivated through cytochrome P450 micro-enzyme CYP2D6 pathway to morphine and M1 metabolite respectively. Its opioid activity results mainly from binding of the metabolites to μ-opioid receptors, which have significantly higher affinity than the parent drugs. Ultra-rapid metabolizers and extensive metabolizers of CYP2D6 relatively produce more active opioid metabolites resulting in life-threatening ORAE especially in young children. In the absence of pharmacogenetic testing, prescribing opioids metabolized by CYP2D6 such as codeine, tramadol, hydrocodone and oxycodone to paediatric patients is not safe.[52,53]

Beside the pharmacogenetic factor, ORAE could occur in obese children due to failure in recognising obesity in the children itself or incorrect weight scale selection causing wrong dose calculation and administration. Obese and OSA children requiring postoperative opioid analgesia should be monitored closely in special care unit, or alternative multimodal analgesia could be offered.

iv. Difficult intravenous access

Nafiu *et al* (2010) demonstrated that peripheral venous cannulation in anaesthetised obese children is time-consuming, highly frustrating and more likely to require two or more cannulation attempts than lean children, even for the experienced anaesthesia professionals. A thicker subcutaneous adipose tissue layer had rendered the superficial veins significantly less visible and less palpable. Hence the most likely site for successful placement in obese children after a failed attempt over dorsum of the hand is the volar surface of the wrist.[54] This information is useful to give parents an estimate of how many attempts will likely be needed for success, and helpful to determine which children would benefit from further interventions like trans-illumination and ultrasound-guided cannulation.

v. Venous thromboembolism (VTE)

Venous thromboembolism is not uncommon in children. Kim and Sabharwal (2014) approximated the incidence to be 1 in 10,000 per year and estimated its prevalence among hospitalized children to be 9.7 per 10,000 admissions.[54] The highest incidence occurs during neonatal until infancy period and the second peak is post pubertal or greater than or equal to 12 years old. Table VIII classifies and summarises the risk factors of VTE in children.[55-59] The majority of anaesthesiologists are not aware regarding these multifactorial risks in paediatric population. Hence, identification of children at risk is often neglected. The Association of Paediatric Anaesthetists of Great Britain and Ireland (APAGBI) Working Group on Thromboprophylaxis in Children has recently published a risk assessment and decision-making algorithm as well as recommendation on mechanical and pharmacological prophylaxis to prevent perioperative VTE in paediatric patients coming for surgery.[59] Thromboprophylaxis should be considered for obese children coming for major surgery with prolonged postoperative immobilization period.

vi. Postoperative Paediatric Intensive Care Unit Admission

There is no specific guideline on postoperative Paediatric Intensive Care Unit (PICU) requirement for obese children. A child with OSA per se does not require a blanket referral for routine postoperative PICU admission. The American Academy of Paediatric and American Academy of Otolaryngology-Head and Neck Surgery Foundation had identified risk factors for PRAE in children with OSA undergoing adenotonsillectomy. Children younger than 3 years, severe OSA, cardiac complications of OSA, nadir saturation < 80%, craniofacial anomalies, neuromuscular disorders,

Table VIII: Identified risk of VTE in children.[54-59]

CONGENITAL	ACQUIRED
Congenital Severe Thombophilia - Antithrombin III deficiency - Homozygous Factor V Leiden mutation - Homozygos Prothrombin mutation - Protein C deficiency - Protein S deficiency Complex congenital heart disease	Age (bimodal age risk distribution) - Neonate to infancy (1 day - 12 months of age) - ≥ 12 years old or post puberty Central venous catheter Venous thromboembolism - previous history of VTE - 1st degree family history of VTE or severe thrombophilia Co-morbidity - Malignancy, not in remission - Nephrotic syndrome - Inflammatory disease (reactive) - Blood Stream Infection (severe and active) - Hyperosmolar state (serum osmolarity >320mOsm/kg) Obesity Medications - Estrogen therapy (within 12 months) - Asparaginase Trauma - spinal cord injury, pelvic and > 1 long bone fractures - requiring ICU admission Surgery or Procedure - orthopedic hip and pelvic - abdominal and thoracic - > 90minutes within the last 14 days Decrease mobility > 48 hours Burn > 50% Body Surface Area Pregnancy (until 6 weeks postpartum)

obesity, prematurity, recent respiratory infection and failure to thrive are considered high-risk patients, which require referral to a specialist center and should be monitored as inpatient postoperatively.[6,60]

Walker *et al* 2003 had identified criteria for elective PICU admission following adenotonsillectomy surgery such as PSG proven OSA patient with respiratory disturbance index (RDI) > 40, or RDI > 20 associated with desaturation < 70%, age < 3 years, weight < 3rd centile, central apnoea, neuromuscular disease and specific syndrome liable for postoperative airway obstruction, or patient with significant risk of primary haemorrhage and blood dyscrasias, or patient with cyanotic and complex congenital heart disease.[61] Shine *et al* 2006 was in agreement with some of the criteria. Nevertheless, admission to PICU, paediatric high dependency or step-down units varies from hospital to hospital. The most appropriate setting to monitor these patients postoperatively must be decided by each unit, given individual hospital resources and expertises.[62]

CONCLUSION

Childhood obesity, with or without OSA, is a major risk for perioperative adverse event. A tailor-made anaesthesia regime should be offered to every obese child coming for surgery. It is imperative that we prepare ourselves with the knowledge to handle this challenging patient. This should start with preoperative screening and optimization, followed by suitable intraoperative technique and ending with postoperative monitoring, analgesia and rehabilitation. A multidisciplinary team of paediatricians, paediatric surgeons, paediatric anaesthetists should work together with the patients and parents themselves in an attempt to achieve optimal perioperative condition in ensuring patient safety and parental satisfaction.

References

1. Clark-Hattingh M. and Lo YR. Sugary drinks tax important first step, but obesity in Malaysia demand further action. [https://www.unicef.org/malaysia/press-releases/sugary-drinks-tax-important-first-step-obesity-malaysia-demands-further-action] Accessed July 20,2019
2. Clark-Hattingh M. and Lo YR. Tax on sugary drinks will make children and the budget healthier. [https://www.unicef.org/malaysia/press-releases/tax-sugary-drinks-will-make-children-and-budget-healthier] Accessed July 20,2019
3. Cole TJ, Bellizzi MC, Flegal Katherine M and Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ* 2000;**320**:1240-3
4. Kuczmarski RJ, Ogden CL, Guo SS, Grummer-Strawn LM, Flegal KM, Johnson CL et al. 2000 CDC growth charts for the United States: methods and development. *Vital Health Stat* 2002;**11**(246):1-190
5. WHO Multicentre Growth Reference Study Group. WHO Child Growth Standards: length/height-for-age, weight-for-age, weight-for- length, weight-for-height and body mass index-for-age: methods and development. *Geneva: the World Health Organization* 2006. 1-312
6. Marcus CL, Brooks LJ, Draper KA, Gozal D, Halbower AN, Shiffmann RN et al. Clinical Practice Guideline: Diagnosis and management of childhood obstructive sleep apnea syndrome. *Pediatrics* 2012;**130**:576-84
7. Patino M, Sadhasivam S and Mahmoud M. Obstructive sleep apnoea in children: perioperative considerations. *British Journal of Anaesthesia* 2013;**11**(S1):i83-i95
8. Tait AR, Voepel-Lewis T, Christensen R, O'Brien LM. The STBUR questionnaire for predicting perioperative respiratory adverse events in children at risk for sleep-disordered breathing. *Pediatric Anesthesia* 2013;**23**(6):510-16
9. Chervin RD, Hedger K, Dillon JE and Pituch KJ. Pediatric Sleep Questionnaire (PSQ): validity and reliability of scales for sleep-disordered breathing, snoring, sleepiness, and behavioral problems. *Sleep Medicine* 2000;**1**:21-32
10. Tait AR, Bickham R, O'Brien LM, Quinlan M, Voepel-Lewis T. The STBUR questionnaire for identifying children at risk for sleep-disordered breathing and postoperative opioid-related adverse events. *Pediatric Anesthesia* 2016;**26**(7):759-66
11. Galvez JA, Yaport M, Maeder-Chieffo S, Simpao AF, Tan J, Wasey JO et al. STBUR: Sleep Trouble Breathing and Unrefreshed questionnaire: Evaluation of screening tool for post-anesthesia care and disposition. Pediatric Anesthesia 2019; Version of Record online:10 July 2019. doi: 10.1111/pan.13660
12. Terry KL, Disabato J, Krajicek M. Snoring, Trouble Breathing, Un-Refreshed (STBUR) Screening Questionnaire to Reduce Perioperative Respiratory Adverse Events in Pediatric Surgical Patients: A Quality Improvement Project. *AANA journal* 2015;**83**(4):256-62
13. ASA House of Delegates/Executive Committee. ASA Physical Status Classification System. (Last amendment October 2014). [https://www.asahq.org/standards-and-guidelines/asa-physical-status-classification-system]. Accessed July 20,2019
14. Chidambaran V, Tewari A and Mahmoud M. Anesthetic and Pharmacologic Considerations in Perioperative Care of Obese Children. *Journal of Clinical Anesthesia* 2018;**45**:39-50
15. Ingrande J. and Lemmens HJM. Anesthetic Pharmacology and the Morbidly Obese Patient. *British Journal of Anaesthesia* 2010;**105**(suppl 1):i16-23
16. Mortensen A, Lenz K, Abildstrøm H and Lauritsen TLB. Anesthetizing the Obese Child. *Pediatric Anesthesia* 2011;**21**:623-9
17. Brenn BR. Anesthesia for Pediatric Obesity. *Anesthesiol Clinica of North America* 2005;**23**:745-64
18. Ross PA, Scott GM. Childhood obesity: a growing problem for the pediatric anesthesiologist. *Semin Anesth Perioper Med Pain* 2006;**25**:142-8
19. Veyckemans F. Childhood Obesity and Anaesthetic Morbidity. *Current Opinion in Anaesthesiology* 2008;**21**:308-12

20. Owen J and John R. Childhood obesity and the anaesthetist. *Continuing Education in Anaesthesia, Critical Care and Pain* 2012;**12**(4):169-75

21. Philippi-Höhne C. Anaesthesia in the obese child. *Best Practice & Research Clinical Anaesthesiology* 2011;**25**:53-60

22. Lejus C, Orliaguet G, Servin F, Dadure C, Michel F, Dahmani S et al. Peri-operative management of overweight and obese children and adolescents. *Lancet Child Adolesc Health* 2017;**1**(4):311-322

23. Smith HL, Meldrum DJ, Brennan LJ. Childhood obesity: A Challenge for The Anesthetist? *Pediatric Anesthesia* 2002;**12**:750-6

24. Suresh S, Polaner DM and Cote CJ. Regional Anesthesia, A Practice of Anesthesia for Infant and Children. 5th edition Elsevier Health Sciences 2013, pp835-79

25. Barcelona SL, Thomson AA and Cote CJ. Intraoperative pediatric blood transfusion therapy: a review of common issues. Part II: transfusion therapy, special considerations, and reduction of allogenic blood transfusions. *Pediatric Anesthesia* 2005;**15**:814-30

26. Lemmens HJM, Bernstein DP and Brodsky JB. Estimating Blood Volume in Obese and Morbidly Obese Patients. *Obesity Surgery* 2006;**16**:773-76

27. Muraki R, Hiraoka A, Nagata K, Nakajima K, Oshita T, Sakaguchi T et al. Novel method for estimating the total blood volume: the importance of adjustment using the ideal body weight and age for the accurate prediction of haemodilution during cardiopulmonary bypass. *Interactive CardioVascular and Thoracic Surgery* 2018;**27**:802-7

28. Nafiu OO, Reynolds P, Bambgade O, Tremper K, Welch K, Kasa-Vubu J. Childhood body mass index and perioperative complications. *Pediatric Anesthesia* 2007;**17**:426-30

29. Tait AR, Voepel-Lewis T, Burke C, Kostrzewa A, Lewis I. Incidence and risk factors for perioperative adverse respiratory events in children who are obese. *Anesthesiology* 2008;**108**:375-80

30. El-Metainy S, Ghoneim T, Aridae E and Wahab MA. Incidence of perioperative adverse events in obese children undergoing elective general surgery. *British Journal of Anaesthesia* 2011;**106**(3):359-63

31. Gleich SJ, Olson MD, Sprung J, Weingarten TN, Schroeder DR, Flick RP et al. Perioperative outcomes of severely obese children undergoing tonsillectomy. *Pediatric Anesthesia* 2012;**22**(12):1171-8. Setzer N and Saade E. Childhood obesity and anesthetic morbidity. *Pediatric Anesthesia* 2006;**17**:321-6

32. Patel R, Lenczyk M, Hannallah RS and McGill WA. Age and the onset of desaturation in apnoeic children. *Can J Anaesth* 1994;**41**:771-4

33. Heald FP. Basal oxygen consumption in obese adolescent. *The Journal of Pediatrics* 1962;327-30

34. Bhammar DM, Stickford JL, Bernhardt V and Babb TG. Verification of Maximal Oxygen Uptake in Obese and Nonobese Children. *Medicine and Science in Sport and Exercise* 2017;**49**(4):702-10

35. Whippey A, Kostandoff G, Ma HK, Cheng J, Thabane L and Paul J. Predictors of unanticipated admission following ambulatory surgery in the pediatric population: a retrospective case-control study. *Pediatric Anesthesia* 2016;**26**(8):831-37

36. Virag K, Sabourdin N, Thomas M, Veyckemans F and Walid Habre for the APRICOT Group of the European Society of Anaesthesiology Clinical Trial Network. Epidemiology and incidence of severe respiratory critical events in ear, nose and throat surgery in children in Europe. A prospective multicentre observational study. *Eur J Anaesthesiol* 2019;**36**:185-93

37. Borland LM, Sereika SM, Woelfel SK, Saitz EW, Carrillo PA, Motoyama EK. et al. Pulmonary Aspiration in Pediatric Patients During General Anesthesia: Incidence and Outcome. *Journal of Clinical Anesthesia* 1998;**10**:95-102

38. Warner MA, Warner ME, Warner DO, Warner LO and Warner EJ. Perioperative Pulmonary Aspiration in Infants and Children. *Anesthesiology* 1999;**90**:66-71

39. Cook-Sather SD, Gallagher PR, Kruge LE, Beus JM, Ciampa BP, Schreiner MS. Overweight / Obesity and Gastric Fluid Characteristics in Pediatric Day Surgery: Implications for Fasting Guidelines and Pulmonary Aspiration Risk Anesth Analg 2009;**109**:727-36

40. Walker R.W.M. On behalf of the Association of Paediatric Anaesthetists of Great Britain & Ireland Pulmonary Aspiration Project. Pulmonary aspiration in pediatric anesthetic practice in the UK: a prospective survey of specialist pediatric centers over a one-year period. *Pediatric Anesthesia* 2013;**23**:702-11

41. Tan, Z. and Lee, S. Y. Pulmonary aspiration under GA: A 13-year audit in a tertiary pediatric unit. *Pediatric Anesthesia* 2016;**26**(5):547-552

42. Stordal K, Johannesdottir GB, Bentsen BS, Carlsen KC, Sandvik L. Asthma and overweight are associated with symptoms of gastro-oesophageal reflux. *Acta Paediatr* 2006;**95**:1197-201

43. Malaty HM, Fraley JK, Abudayyeh S, Fairly KW, Javed US, Aboul- Fotouh H et al. Obesity and gastroesophageal reflux disease and gastroesophageal reflux symptoms in children. *Clinical and Experimental Gastroenterology* 2009;**2**:31-6

44. Quitadamo P, Buonavolontà R, Miele E, Masi P, Coccorullo P, Staiano A. Total and abdominal obesity are risk factors for gastroesophageal reflux symptoms in children. *J Pediatr Gastroenterol Nutr* 2012;**55**:72-5

45. Quitadamo P, Zenzeri L, Mozzillo E, Cuccurullo I, Rocco A, Staiano A. et al. Gastric Emptying Time, Esophageal pH-Impedance Parameters, Quality of Life, and Gastrointestinal Comorbidity in Obese Children and Adolescents. *The Journal of Pediatrics* 2018;**194**:94-9

46. Chiloiro M, Caroli M, Guerra V, Piepoli AL and Riezzo L. Gastric emptying in normal weight and obese children - an ultrasound study. *International Journal of Obesity* 1999;**23**:1303-6

47. Xing JH and Chen JDZ. Alterations of gastrointestinal motility in obesity. *Obesity Research* 2004;**12**(11):1723-32

48. College of Anaesthesiologists, Academy of Medicine of Malaysia. Guideline on Preoperative Fasting. Revised 2008

49. Brown K, Laferriere A, Moss I. Recurrent hypoxemia in young children with obstructive sleep apnea is associated with reduced opioid requirement for analgesia. *Anesthesiology* 2004;**100**:806-810

50. Brown KA, Laferrière A, Lakheeram I, Moss IR. Recurrent hypoxemia in children is associated with increased analgesic sensitivity to opiates. *Anesthesiology* 2006;**105**(4):665-9

51. FDA restricts use of prescription codeine pain and cough medicines and tramadol pain medicines in children; recommends against use in breastfeeding women. [https://www.fda.gov/drugs/drug-safety-and-availability/fda-drug-safety-communication-fda-restricts-use-prescription-codeine-pain-and-cough-medicines-and-tramadol-pain-medicines-in-children-recommends-against-use-in-breastfeeding-women.] Accessed July 21,2019

52. Sadhasivam S and Myer CM. Preventing Opioid-Related Deaths in Children Undergoing Surgery Pain Medicine 2012;13:982–3.

53. Cote' CJ. Anesthesiological considerations for children with obstructive sleep apnea. *Curr Opin Anesthesiol* 2015;**28**:327-32

54. Nafiu OO, Burke C, Cowan A, Tuuo N, Maclean S and Tremper KK. Comparing peripheral venous access between obese and normal weight children. *Pediatric Anesthesia* 2010;**20**(7):172-6

55. Kim SJ and Sabharwal S. Risk factors for venous thromboembolism in hospitalized children and adolescents: A systemic review and pooled analysis. *Journal of Pediatric Orthopaedics B* 2014;**23**:389-93

56. Gillespie MA, Lyle CA and Goldenberg NA. Updates in pediatric venous thromboembolism. *Current Opinion Hematology* 2015;**22**:413-9

57. Jackson PC and Morgan JM. Perioperative thromboprophylaxis in children: development of a guideline for management. *Pediatric Anesthesia* 2008;**18**:478-87

58. Mahajerin A, Branchford BR, Amankwah EK, Raffini L, Chalmers E, Goldenberg NA et al. Hospital-associated venous thromboembolism in pediatrics: a systematic review and meta-analysis of risk factors and risk-assessment models. *Hematologica* 2015;**100**(8):1045-50

59. Morgan J, Checketts M, Arana A, Chalmers E, Maclean J, Powis M, and Morton N et al. for the Working Group on Thromboprophylaxis in Children of APAGBI. Prevention of perioperative venous thromboembolism in pediatric patients: Guidelines from the Association of Paediatric Anaesthetists of Great Britain and Ireland (APAGBI). *Pediatric Anesthesia* 2018;**28**:382-91

60. Roland PS, Rosenfeld RM, Brooks LJ, Friedman NR, Jones J and Rabortson P et al. Clinical Practice guideline: Polysomnography for sleep-disordered breathing prior to tonsillectomy in children. *Otolaryngol Head Neck Surg* 2011;**145**(supl 1):S1-15

61. Walker P, Whitehead B and Rowley M. Criteria for Elective Admission to the Paediatric Intensive Care Unit Following Adenotonsillectomy for Severe Obstructive Sleep Apnoea. *Anaesth Intensive Care* 2004;**32**:43-46

62. Shine NP, Coates HL, Lannigan FJand Duncan AW. Adenotonsillar Surgery in Morbidly Obese Children: Routine Elective Admission of all Patients to the Intensive Care Unit is Unnecessary. *Anaesth Intensive Care* 2006;**34**:724-30

End-Of-Life Care In The Intensive Care Unit

Noor Airini Ibrahim
Senior Consultant Intensivist, Anaesthesiology Unit, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, Selangor, Malaysia

The primary goal of intensive care is to treat acute reversible life-threatening conditions so that patients survive with acceptable functional status and quality of life. While providing therapeutic interventions, clinicians should also attend to patients' discomfort and control any distressing symptoms. However, when death appears inevitable or the possibility of restoring a meaningful life becomes remote, the patient should be accorded a dignified death.

Death in Malaysian Intensive Care Unit (ICU)

Data from the Malaysian Registry of Intensive Care 2017[1] showed a crude in-ICU mortality of 18.3% and crude in-hospital mortality of 26.4% which has remained the same over the years. These figures were comparable to a multicentre European cohort which reported incidences of 19.1% and 23.9% respectively.[2] There was variable in-hospital all-cause mortality depending on patient cohort with severe sepsis alone at 41.6%, increasing to 51.5% with concomitant adult respiratory distress syndrome (ARDS) and 57.7% in the presence of acute kidney injury (AKI) and while the presence of both AKI and ARDS with sepsis increased the mortality to 72.5%.

Approximately 5 - 10% of intensive care admissions will become chronic[3] as increasing number of patients survive their acute life-threatening illnesses. This chronic critically ill period will be interspersed with periods of recurrent sepsis, difficult weaning off mechanical ventilation and various other neurocognitive and physical impairments. Life expectancy does not return to that of normal population even if discharged home and this will be worse in the elderly.

Despite continuing medical advances, mortality following a critical care admission remains approximately 20%, with 60% of these deaths occurring after the decision to withdraw active treatment.[4] Withholding or withdrawal of therapy refers to the discontinuation or not initiating vasoactive drugs, renal replacement therapy, mechanical ventilation, surgery, cardiopulmonary resuscitation or any other life-sustaining measures.[5] There has been a wide variability in the practice of withholding and withdrawing therapy in Malaysian ICUs from 0% to 80% in 2013 and 0% to 91% in 2017,[1] with level 3 ICUs managed by registered intensivists recording higher percentage of withdrawal. There is a gradual increase in the average number of deaths across all ICUs that die following withholding or withdrawal of therapy in 2013 and 2017 at 35% and 40.3% respectively,[6] as reflected in the registry. This is possibly due to better awareness among intensive care physicians as efforts have been made since the last decade to increase understanding in this regard.

Ethical Principles and Decision-Making Capacity

The main principles that underpin end-of-life (EOL) medical decisions are the same as the principles we abide by for any other patient. Respect for autonomy is acting in accordance to what the patient wants, though many critically ill patients are no longer able to exercise such autonomy. Beneficence is acting to benefit the patient needs to be weighed against non-maleficence which is ensuring that minimal harm is caused. At the EOL specifically, the burdens of intervention are often high, while the benefits are marginal and quality of life of ICU survivors is markedly diminished. Amidst all these, distributive justice needs to be ensured, paying due attention to fairness and equity while allocating intensive care beds and other limited resources.

These principles need to be applied either individually or collectively to frame the discussion on EOL care and one principle does not supersede the other. They may at times be conflicting, for example:

- between respect for autonomy and beneficence: a terminal cancer patient who insists all life-sustaining therapies (LST) to be provided although they will not benefit him.

- between beneficence and justice: providing invasive mechanical ventilation in a patient with decompensated heart failure who has had multiple hospital admissions in the last 6 months and is dyspnoeic at rest versus allocation of ICU bed for a polytrauma patient.

A patient's decision-making capacity should be assessed before having a discussion with him on EOL care. This includes the patient's ability to comprehend, appreciate, rationalise and express choice of treatment. Most ICU patients do not have decision-making capacity and hence families become the surrogate decision-makers. The standards that may be used by surrogates in decision-making are:[7]

- substituted judgement standard where decision of the patient is considered, if known, or

- the best interest standard where decisions are made based on the potential benefits and burdens of treatment vs patient's values and beliefs.

The accuracy of surrogates' predictions of patients' preferences remain in question. In a systematic review, the accuracy of surrogates predicting patients' treatment preferences correctly was only 68%.[8] Ultimately, EOL decisions are shared medical decisions made by clinicians and concurred by family members. Once decision-making capacity is established, patient's autonomy must be respected even though survival may be implicated. In cases of non-beneficial medical treatment, clinicians are not obliged to initiate or continue LST. The MMA Code of Ethics 2001[11] states "where death is deemed to be imminent and where curative or life-prolonging treatment appears to be futile, ensure that death occurs with dignity and comfort. Such futile therapy could be withheld, withdrawn or one may allow irreversible pathology to continue without active resuscitation. One should always take into consideration any advance directives and the wishes of the family in this regard. In any circumstances, if therapy is considered to be lifesaving, it should never be withheld."

Respect for the dying should be maintained at all times. All dying patients should be afforded the same standard of care as other patients and be treated with dignity, respect and compassion. Their privacy and confidentiality should be respected at all times.

Who Will Not Benefit From Intensive Care[7]

The clinician is obligated to provide the best possible service within the confines of limited resources. Following this, the priority of admission into the ICU shall be for the critically ill patients who are most likely to survive and resume a functional life. Patients who are highly unlikely to benefit from life support therapy include those with:

- Severe, irreversible brain condition impairing cognition and consciousness

- End stage cardiac, respiratory or liver disease with no options for transplant

- Metastatic cancer unresponsive to treatment

- Advanced age with poor functional status due to multiple chronic organ dysfunctions

- Severe disability with poor quality of life

- Advanced disease of progressive life-limiting condition

- Those who have explicitly stated their wish not to receive life support therapy

The goals of care for such patients should have ideally been discussed earlier with them or their families before they become critically ill.

Prognostication of Intensive Care Outcomes

Prognostication of critically ill patients being treated in the intensive care unit is neither easy nor precise. Severity scoring systems are of limited value in predicting outcome in individual patients. The clinician needs to draw from his own expertise and experience in identifying patients who are unlikely to benefit from further aggressive life support therapy. Besides reviewing the patient's course of disease, the clinician must weigh the benefits against the burden of continuing life support therapy. EOL discussion with the family (or patient, whenever possible) should be initiated early, sometimes even upon admission to the ICU and not necessarily wait until the burden of treatment outweighs the benefit. The patient can continue to receive life support therapy following initiation of EOL discussion until a final decision is made. EOL decisions should be integrated with the patient's or family's values and hence strict evidence-based decision cannot be applied. These decisions need to be individualised.[7]

The determinants of poor intensive care outcome are multifactorial. They are not to be considered in isolation, but in the context of the entire story and clinical status of the patient. Some of the determinants listed below can help the clinician recognise when to initiate discussion on EOL decisions.

- Severity of illness
- Multi-organ failure
- No period of clinical improvement despite optimal therapy
- Pre-existing advanced chronic condition e.g. congestive cardiac failure, chronic lung disease, chronic liver disease
- History of cardiac arrest
- Recurrent ICU admission during a single hospital admission
- Recurrent unplanned hospital admission within the last 6 months
- Poor and deteriorating performance status prior to admission e.g. NYHA Class III or IV, limited self-care, with more than 50% of the day spent in bed
- Underlying diagnosis remains unknown despite extensive investigations

When faced with prognostic uncertainty, treatment should be continued to allow clearer assessment to be made with additional time and consultation with other clinicians. As the patient's critical illness progresses and when the burden of treatment options outweighs its benefit, the clinician should initiate discussion on withdrawal or withholding of life support therapy. Patient should be allowed a natural and dignified death by not prolonging the dying process.

Although there is no ethical difference between withdrawal or withholding of LST, the former usually generates more concern because the possible short interval from withdrawal to death may be mistaken for terminating the patient's life. In actual fact, the intention in withdrawing a treatment no longer of any benefit is equivalent to stop the postponement of death, and allowing the disease process to take its due course.

Practical Considerations of Withholding and Withdrawal of Life-Sustaining Treatment

There is no single way to withdraw or withhold life support therapy in the critically ill. The actual practice needs to be individualised to address physical, psychological, social and spiritual needs of the patient and family. When the direction of care has changed from curative intent to comfort the principles of palliative care should be enforced, including maintaining comfort and dignity, controlling symptoms, attending to psychological and spiritual needs, and supporting the family.[9]

Firstly, medical team consensus needs to be established. The intensive care team and the primary team should agree on EOL care decisions prior to discussion with the family. Communication with patients and relatives is best done by the same clinician (specialist/consultant) who is involved in the active care of the patient, has frequently communicated with the family and has established trust and rapport with them. A witness (nurse or doctor) should be present during these discussions. Clinicians need to respect the fact that each patient and family will differ in how much input they wish to have in the decision-making process.

In the event of a disagreement, allow time for repeated discussions and negotiations. Failing this, consider either:

- time limited trial (TLT) which is a goal-directed trial of any intervention limited by predetermined outcomes that are evaluated at planned intervals

- second medical opinion from another clinician from a similar specialty

- facilitation by a third party e.g. spiritual advisor

Patients and families must be given sufficient time to reach decisions on EOL and come to terms with the impending loss of their loved ones.

A clear management plan is essential to ensure that the withdrawal process occurs smoothly. It should be conveyed to the family, with an emphasis on maintenance of comfort for the patient. Whatever form of support should be continued until the patient and family have had adequate time together. Other healthcare professionals e.g. primary team, physiotherapist, dietitian and others need to be aware of withdrawal plan and all investigations e.g. blood taking and X-rays are ceased.

Pain and other symptoms e.g. dyspnoea need to be well controlled. Morphine is the most commonly used opioid for analgesia and comfort. There is no maximum dose and large doses of opioids may be required for comfort and may unintentionally hasten death. This "double effect" of opioids is acceptable. Neuromuscular blockade makes assessment of comfort impossible and should not be used in intubated patients. Terminal sedation with benzodiazepines may be considered only when high doses of opioids are inadequate for comfort.

Airway secretion is managed by using glycopyrrolate, positioning in lateral position and frequent suctioning. All treatment that do not contribute towards comfort e.g. antibiotics, blood transfusions are discontinued. Feeding and intravenous fluids may also be discontinued unless specifically requested by family. Patient's personal hygiene and dignity must be maintained at all times. e.g. diaper soiling is to be dealt with immediately.[9]

Families should be made aware that withdrawal of vasopressors may result in immediate death and, therefore, they should be nearby. Withdrawal of mechanical ventilation may be carried out either as terminal weaning where ventilator settings are reduced while leaving the endotracheal tube in-situ or terminal extubation. Terminal weaning for better titration of sedatives may be less traumatic to families, though it may prolong the dying process. It may be the preferred option in patients with excessive respiratory secretions. Terminal extubation, on the other hand, removes the discomfort from the endotracheal tube and restores the "natural" EOL process. However, the family may interpret the ensuing noisy breathing or agonal breaths as discomfort and may misinterpret this as abandonment of care. Non-invasive ventilation may be used as a palliative care technique to minimise dyspnoea in conscious patients. Patients should be demedicalised and all monitors and ventilator alarms disabled. Families should be given unrestricted access to the patient. Patients are reassessed frequently to ensure patient comfort and needs are met.[10]

Documentation of all EOL decisions is imperative including the basis of the decision and amongst whom it was reached and specific treatments to be withheld or withdrawn. Death should be notified in direct language gently as soon as it occurs. Bereavement support to the family and healthcare providers should be made available if necessary.

References

1. Tai Li Ling, Lim Chew Har, Mohd Ridhwan Mohd Nor, Nahla Irtiza Ismail, Wan Nasrudin Wan Ismail Malaysian Registry of Intensive Care 2017 report

2. Capuzzo M. et al. Hospital mortality of adults admitted to Intensive Care Units in hospitals with and without Intermediate Care Units: a multicentre European cohort study. *Crit Care* 2014:**18**(5);551

3. Kahn JM, Le T, Angus DC, Cox CE, Hough CL, White DB et al. The epidemiology of chronic critical illness in the United States. *Crit Care Med* 2015;**43**:282-287

4. Manara AR, Pittman JA, Braddon FEM. Reasons for withdrawing treatment in patients receiving intensive care. *Anaesthesia* 1998;**53**:523-8

5. General Medical Council (2010). Treatment and care towards the end of life: good practice in decision making. GMC:UK. ISBN: 978-0-901458-46

6. Jenny Tong May Geok, Tai Li Ling, Tan Cheng Cheng, Ahmad Shaltut Othman, As-Niza Abdul Shukor, Lim Chew Har Malaysian Registry of Intensive Care 2013 report

7. Tai LL, Chan L. Ibrahim NA. Othman AS. EOL Care in ICU. Handbook of Palliative Care Medicine in Malaysia. Lim R.B. Katiman D.(ed) pg. 71-75

8. Shalowitz DI, Garrett-Mayer E, Wendler D. The Accuracy of Surrogate Decision Makers A Systematic Review. *Arch Intern Med* 2006;**166**:493-497

9. Connolly C, O. Miskolci, D. Phelan, D. J. Buggy. End-of-life in the ICU: moving from 'withdrawal of care' to a palliative care, patient-centred approach. *Br J Anaesth* 2016;**117**(2):143-145

10. Shanawani H Wenrich MD, Tonelli MR, Curtis JR. Meeting physicians' responsibilities in providing EOL care. *Chest* 2008;**133**(3):776-786 *Chest* 2008 Mar;**133**(3):775-86

11. Malaysian Medical Association Code of Medical Ethics 2001. Clause 5. The dying patient. pg. 12

Challenges As A Cardiothoracic Anaesthesiologist In Government Hospital

Azmiza Maharani
Cardiothoracic Anaesthesiologist, Hospital Sultanah Aminah, Johor Bahru, Johor, Malaysia

INTRODUCTION

The Cardiothoracic Anaesthesia and Perfusion Unit under the Ministry of Health (MOH), Malaysia started its services in Kuala Lumpur General Hospital in 1994 before they moved the cardiac centre to Hospital Pulau Pinang (HPP) back in 1995. Later, the Sultanah Aminah Hospital in Johor Bahru, Johor, commenced its service in 1996. This was followed by Sarawak General Hospital, Serdang Hospital, Queen Elizabeth Hospital II, Raja Perempuan Zainab II Hospital and lastly Tengku Ampuan Afzan Hospital. Joining this fraternity makes me realize the challenges in managing one of the leading causes of death in Malaysia, ischaemic heart disease among males, estimated to cause 12,656 (15.4%) of all male death. To date, we have about 20 Cardiothoracic Anaesthesiologists giving our service in the government hospitals across our country.

Cardiac anaesthesia has long been recognised as a subspecialized area. Anaesthesiologists in the Ministry of Health Malaysia (MOH) are required to undergo a three-year training programme to be able to independently provide anaesthesia for patients going for cardiothoracic surgery. Because of the extended training period, it can be a challenge to the interested anaesthesiologists to further their career in this field. Entry requirement is the same as other subspeciality which is two years post-gazettement as a specialist with reports from two supervisors pertaining suitability of the candidate. The three-year programme includes two years supervised training in the local centres and one year abroad. In a nutshell, this programme objectives are to provide in-depth and comprehensive training in the field of cardiothoracic anaesthesia and perfusion - including principles, technique and physiology of cardiopulmonary bypass (CPB), techniques of myocardial preservation and cardiothoracic surgical technique, competency in the anaesthetic management of patients in cardiothoracic related surgeries (e.g. carotid artery, aortic, pericardial, lung and mediastinal surgeries), competency using Transoesophageal Echocardiography (TOE), managing patients in Cardiothoracic Intensive Care Unit (CICU) and to accrue knowledge in recent advances and technological developments in cardiothoracic anaesthesia and perfusion. However, the TOE training is informal and it is optional to the trainee to take his/her own examination to get certified in TOE. The total duration of training is 36 months with the first 24 months fully supervised, and the final 12 months may be under distant supervision. The 24 months of supervised training includes at least nine months of overseas training. Details of the programme can be found in the www.moh.gov website.

Teamwork between the anaesthesiologists, surgeons, perfusionists and nurses, both in operation theatre and intensive care unit, play an important role in ensuring successful outcome of the surgery, hence reducing morbidity and mortality. Case discussion, especially the high risk patients, need to be addressed thoroughly during preoperative assessment with the involvement of the cardiologists. It necessitates the responsibility of giving balanced anaesthesia in high risk cardiac patients while monitoring the perfusionist operating the heart lung machine (HLM) during cardiopulmonary bypass. In HSAJB, etomidate, midazolam and fentanyl are given for induction followed by rocuronium with inhalational agent, Sevoflurane as maintenance of anaesthesia with target-control-infusion (TCI) Remifentanil. The BiSpectral index monitor is used while titrating the maintenance of anaesthetic given throughout the surgery.

As mentioned above, a cardiac anaesthesiologist needs to be equipped with the knowledge of using the TOE perioperatively to provide care to the patients as well as managing the Advance Cardiac Monitoring device to facilitate the management of the patient efficiently. Pulmonary Artery Catheter

(Swan Ganz) monitoring is still the gold standard in monitoring the cardiac output either intermittently or continuous monitoring of the cardiac output. Other advanced cardiac monitoring device used is EV 1000 monitor (FloTrac device). Intra-Aortic Balloon Pump (IABP) may be inserted in high risk cases to increase myocardial oxygen perfusion and indirectly increases cardiac output through afterload reduction. The anaesthesiologist, perfusionist and surgeon should be able to manage the IABP. However, Extracorporeal Membrane Oxygenation (ECMO) service is only available in certain MOH centres. Currently, we are in the middle of making a comprehensive protocol on ECMO for MOH cardiac centres. Attending courses locally or internationally does help to further improve the knowledge in managing complex cases.

Technological innovation and surgical expertise have led to widespread of popularity of minimally invasive cardiac surgery (MISC). Anaesthetic practices are continually evolving with advancement and innovation of MISC. The involvement of the anaesthesiologist from the beginning of patient evaluation is important to avoid unnecessary change in plan later on. The requirement of one-lung ventilation mandates an evaluation of pulmonary function. MISC with femoral arterial and venous cannulation may not have adequate venous drainage in which the full flow of cardiopulmonary bypass cannot be achieved. In this situation, the surgeon might need to cannulate the superior vena cava via the internal jugular vein. One-lung ventilation in "almost" supine position worsened the ventilation-perfusion mismatch. These two situations need to be addressed perioperatively. Our surgeons are still in their learning curve in performing the surgery and so do us in managing such cases. The communication between the anaesthesiologist and surgeon in managing such cases is utmost important in ensuring a successful outcome. Video-Assisted Thoracoscopy is widely used for lung and pleural diseases. Anaesthesia with one-lung ventilation will be required during surgery. Evaluation of pulmonary function is important to predict the ventilation perioperatively.

Managing remote anaesthesia in Invasive Cardiac Laboratory (ICL) may have their own challenges in view of hostile environment with a sparse and crowded workspace requiring vigilance and organisation to maintain access to the patient in cases such as Patent Ductus Arteriosus occlusion, atrial septal defect/ventricular septal defect occlusion. Indication for Transcatheter Aortic Valve Implantation (TAVI) is strictly perform in high-risk patients or those with contraindications to surgery in severe aortic stenosis. It is vital to communicate a plan in management for unexpected events and any limitation in resuscitation must be well discussed in advance. There should be provision for urgent femoral cardiopulmonary bypass, defibrillation and pacing with surgical intervention as required.

The rise in the number of cardiac cases (myocardial infarction) and high risk cardiac patients is mostly due to unhealthy lifestyles and poor management by the patients themselves. These issues can also be a challenge as most of them are elderly with multiple co-morbidities. It needs to be addressed in view of high morbidity and mortality rate. This will translate to a longer duration of stay in the hospital hence the increase in hospital cost. The government covered most of the total cost for cardiothoracic surgeries. Younger patients will present themselves for valve or thoracic surgery. However, now, we are getting younger patients with smoking as the only risk factor for coronary artery bypass graft surgery (CABG). With ever changing and advances in the medical field, we were able to manage the patients better in more complex cases. Managing the patient after the surgery poses a different kind of challenge as we do not have intensivist managing our Cardiothoracic Intensive Care Unit (CICU). The same anaesthesiologist/surgeon will manage the patient postoperatively.

Paediatric cardiac cases are more complex and challenging as compared to adults. Only a few MOH cardiac centres are performing surgery on the paediatric population, which mandate the anaesthesiologists to be involved in the management of this group of patients with paediatric cardiac surgeons, paediatric cardiologists as well as paediatric intensivists. There are only two paediatric cardiac surgeons in the government hospital. A cardiothoracic anaesthesiologist will improve the skill in paediatric cardiac anaesthesia when there is available and dedicated paediatric cardiac surgeon in each MOH centre.

One of the important challenges that we are facing is the lack of manpower. Due to a lack of the number of trained cardiothoracic anaesthesiologists, some centres are manned by only one cardiothoracic anaesthesiologist. These anaesthesiologists will be on call everyday throughout the year which may lead to exhaustion e.g. in Raja Perempuan Zainab II Hospital and Tengku Ampuan Afzan Hospital. The same goes for the cardiothoracic surgeons. A covering anaesthesiologist from other centre will help out when the need arises. It is quite a challenge in itself for the covering anaesthesiologist in adapting to a new environment and medical personnel in a short period of time while managing high risk cases. Different centres may have different type of equipment, e.g. the Echocardiogram machine, heart lung machine (HLM), ventilators as well as Advanced Haemodynamic Cardiac Monitoring available in that centre. However, it did give the covering anaesthesiologist a new exposure and valuable experience away from his/her comfort zone.

A special team is required to provide care in this unit which includes perfusionists, scrub nurses, anaesthetic nurses with intensive unit nurses. They too are required to undergo training to be able to work in the cardiothoracic centre. The perfusionists has their Advanced Diploma In Cardiovascular Perfusion programme by the Ministry of Health Malaysia in order for them to be privileged and having credentialled to handle the HLM under the supervision of the cardiothoracic anaesthesiologist. These perfusionists will be under the Cardiothoracic Anaesthesia and Perfusion Unit. Continuous hands-on teaching is done to improve the skill and learn how to handle a crisis situation.

Last but not least, this job can be time-consuming. It is long hours working time mostly due to long hours of surgery especially with complicated and difficult cases. The anaesthesiologist need to be vigilant at all times which can be affected with tiredness. The shortage of cardiac anaesthesiologists equates to frequent on-call duty, especially in centres with only one cardiac anaesthesiologist. These anaesthesiologist have to be available at all times and only be relieved when another colleague from another centre is available. Long working hours can take a toll on our social life with less time to spend with the family. The family needs to understand and empathize with the cardiac anaesthesiologist line of work. Managing time between our career and family is important for a better quality of life.

Despite all the challenges, the passion to make a difference in giving patients a new breath of life makes me pursue in this speciality and the feeling is priceless!

References

1. Omar A, Ganapathy SS. Cause-specific mortality estimates for Malaysia in 2013: results from a national sample verification study using medical record review and verbal autopsy. *BMC Public Health* 2019;**19**:110

2. Malik V, Jha AK, Kapoor PM. Anaesthetic challenges in minimally invasive cardiac surgery: Are we moving in a right direction? *Ann Card Anaesth* 2016;**19**:487-97

3. Anaesthesia for Transthoracic Aortic Valve Implantation (TAVI) in aortic stenosis - Cardiothoracic Anaesthesia Tutorial 348