MALAYSIAN SOCIETY OF ANAESTHESIOLOGISTS YEAR BOOK 2020/2021

MALAYSIAN SOCIETY OF ANAESTHESIOLOGISTS

Year Book 2020/2021

Evolution and Revolution

ISSN 2462-1307

MALAYSIAN SOCIETY OF ANAESTHESIOLOGISTS

Year Book 2020/2021

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

Foreword

As the President of Malaysian Society of Anaesthesiologists (MSA), it is with great pride that I write the foreword for the MSA Year Book 2020/2021. With the rise of the COVID-19 pandemic, the profile of our profession has now risen higher in the eyes of the public, and as such it is imperative that we as anaesthesiologists keep abreast with the latest advances for patient safety. Hence, this 11th issue of the MSA Year Book serves to update our members on the current best practices in the field of anaesthesia, critical care and pain medicine.

The theme chosen for this year is *"Evolution and Revolution"*, which is apt as we learn to move forward with living and working in the new norm. The book's content is a mixture of clinical practicality, human factors, and cutting-edge technology in anaesthesia. I believe this book will energise our members and serve as an up-to-date guide in enhancing our knowledge in anaesthesiology, critical care, and pain medicine. Congratulations to both editors, Associate Professor Dr Azrina Md Ralib and Assistant Professor Dr Nur Fariza Ramly from International Islamic University Malaysia for their excellent leadership and commitment in ensuring the Year Book's high quality.

I would like to thank all the authors for taking the time and effort to pen down their ideas and producing such informative articles. Last but not least, sincere gratitude to all the reviewers for sharing their experience in making this book a success.

To all members, I hope all of you will enjoy reading this book.

Stay safe, stay healthy.

Professor Dr Ina Ismiarti Shariffuddin
President
Malaysian Society of Anaesthesiologists

Preface

We would like to thank the Malaysian Society of Anaesthesiologists (MSA) for entrusting us to be the editors of the MSA Year Book 2020/2021. Our utmost appreciation to all authors and reviewers who have contributed their precious time in ensuring the successful publication of this Year Book.

Our theme for this year is *'Evolution and Revolution'*. We look upon the past and how it has evolved or revolved to the current practice and the future prospect. We cover specific domains in our specialty which include Clinical Anaesthesiology, Critical Care, and Pain Medicine. In the era of rapid progress of technology in our life, its contribution to our daily clinical practice and to the teaching and learning in our specialty are discussed. Last but not least, ethics, safety and social issues that impact our daily clinical life are dealt with in the final three articles.

It is our hope that these articles could enrich our esteemed colleagues on the specific topics covered that could help our clinical practice. Finally, our thanks go to the MSA secretariat who has provided excellent logistics that make this publication possible.

Happy reading!

Associate Professor Dr Azrina Md Ralib
Assistant Professor Dr Nur Fariza Ramly
Editors
MSA Year Book 2020/2021

Acknowledgements - Reviewers

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

Dr Aliza Mohammad Yusof
Department of Anaesthesiology and Intensive Care
Universiti Kebangsaan Malaysia
Kuala Lumpur
Malaysia

Associate Professor Dr Azarinah Izaham
Department of Anaesthesiology and Intensive Care
Universiti Kebangsaan Malaysia
Kuala Lumpur
Malaysia

Dr Azhar Mohamed
Department of Anaesthesiology and Intensive Care
Hospital Raja Perempuan Zainab II
Kota Bahru, Kelantan
Malaysia

Dr Azrin Azidin
Department of Anaesthesiology and Intensive Care
Hospital Kuala Lumpur
Kuala Lumpur
Malaysia

Dr Devanandhini Krisnan
Pain Management Clinic
Department of Anaesthesiology and Intensive Care
Hospital Raja Permaisuri Bainun
Ipoh, Perak
Malaysia

Dr Kamaruddin Ibrahim
Department of Anaesthesiology and Intensive Care
School of Medical Sciences
Universiti Sains Malaysia
Kubang Kerian, Kelantan
Malaysia

Associate Professor Dr Mohd Fahmi Lukman
Department of Anaesthesiology
Faculty of Medicine and Defence Health
Universiti Pertahanan Nasional Berhad
Kuala Lumpur
Malaysia

Dr Nazuha Mohd Najid
Department of Anaesthesiology and Intensive Care
Hospital Sultanah Bahiyah
Alor Setar, Kedah
Malaysia

Associate Professor Dr Noorjahan Haneem Md Hashim
Department of Anaesthesiology and Intensive Care
University of Malaya
Kuala Lumpur
Malaysia

Dr Sabri Dewa
Rawang Specialist Hospital Sdn Bhd
Selangor
Malaysia

Dr Wan Fadzlina Wan Mohd Shukeri
Department of Anaesthesiology and Intensive Care
School of Medical Sciences
Universiti Sains Malaysia
Kubang Kerian, Kelantan
Malaysia

Dato' Dr Wan Rahiza Wan Mat
Department of Anaesthesiology and Intensive Care
Universiti Kebangsaan Malaysia
Kuala Lumpur
Malaysia

Difficult Airway Management: Review of Evidence and Application to Daily Clinical Practice

Mohd Nizamuddin Ismail
Department of Anaesthesiology and Intensive Care, Kulliyyah of Medicine, International Islamic University Malaysia, Pahang, Malaysia

Airway management is the practice of evaluating, planning, and using a wide range of techniques and airway devices in order to maintain and restore a safe, effective pathway for oxygenation and ventilation. Difficult airway management is one of the most challenging tasks for an anaesthesiologist, and failure in securing the airway could lead to fatal consequences. We must always be prepared to deal with either anticipated or more importantly unanticipated difficult airway at any time. There are many guidelines with valid evidence from different airway societies published in recent years. Practice guidelines are systematically developed recommendations that help an anaesthesiologist in the management of difficult airway. Some of these guidelines and evidence are briefly reviewed, and suggestions are outlined on its application in our daily clinical practice.

INTRODUCTION

Airway management is one of the main aspects of anaesthetic practice. Good skills and knowledge in this area are imperative for any anaesthesiologist especially when it comes to dealing with difficult airway. Difficult airway is defined as the clinical situation when a conventionally trained anaesthesiologist experiences difficulty with facemask ventilation and/or difficulty with tracheal intubation. A more complete definition would include difficulty with airway instrumentation (e.g., with supraglottic airway devices and video laryngoscopy), direct tracheal access, and also consideration of the airway at extubation. Two characteristics must be met to allow controlled ventilation, firstly the airway must be open, and it must also be sealed to prevent air leak and pulmonary aspiration. Failure to meet these two conditions will eventually lead to a difficult airway. Poor planning and suboptimal management in dealing with these conditions will lead to a significant morbidity and mortality. The fourth National Audit Project of the Royal College of Anaesthetists and Difficult Airway Society (NAP4) that was published in 2011 reported an incidence of 1 major airway complication in every 22,000 and a mortality rate due to airway complications of 1 per 180,000 general anaesthesia.[1] There are many practice guidelines published by anaesthetic societies which were derived based on the available evidence and these guidelines should be applied in our daily clinical practice. The aim of this review is to briefly highlight some of the important updates and recent evidence pertaining to difficult airway management and its application in daily clinical practice.

EVIDENCE, GUIDELINES AND ALGORITHMS

Safe practice in the management of difficult airway relies on the appropriate plan and techniques. Identifying patients at risk and optimal prevention strategies are equally important in the pre-operative period. Some of the guidelines published, especially those pertaining to predicting difficult airway and prevention strategies were based on good quality evidence. There were 29 guidelines and expert consensus for the management of difficult airway in various patients' groups found in the literature, and of these, 19 were published after the year 2004.[2]

The American Society of Anaesthesiologist (ASA) task force had come up with the practice guidelines in 2013 with regards to the management of the difficult airway. These guidelines were produced based on the levels of evidence available. In addition to that, several anaesthetic societies have attempted to compile all the evidence available and published them as management guidelines. Some of these were expressed graphically as algorithms.[3-10]

There have been updated recommendations for the management of adult difficult airway by other national airway task forces. These recommendations supported the use of an algorithm-based strategy

when dealing with a difficult airway. This has been widely used and emphasised in many of the recent guidelines and the main goals of the algorithm are to improve the quality of airway management by promoting rapid decision-making and reducing errors. Besides the use of airway tools and devices, the main emphasis has been on good planning, preparation, and communication. The new 2015 Difficult Airway Society (DAS) guidelines differ from the original 2004 DAS guidelines in that they are more concise and more pragmatic, with considerable emphasis placed on preparedness and accountability of the practitioner by optimising conditions and minimising patient morbidity in a difficult airway situation.

SAFE APNOEA TIME

It is recognised that effective pre-oxygenation is crucial before the induction of general anaesthesia to ensure that the onset of hypoxia is delayed. Adequate pre-oxygenation will certainly provide optimum safe apnoea time especially in those who have predicted difficult airway. The new DAS guidelines have included several techniques to increase safe apnoea time which include Nasal Oxygenation During Efforts of Securing a Tube (NODESAT)[11] and Trans-nasal Humidified Rapid-Insufflation Ventilatory Exchange (THRIVE).[12]

NODESAT technique uses a simple nasal cannula with the flow of 5 to 15 L/min. It was first described by Levitan in 2010 and this technique has been shown to increase the apnoea time by 2 to 5 minutes. THRIVE technique was introduced in 2015 using high flow humidified oxygen at a rate of up to 70 L/min. It combines the benefits of apnoeic oxygenation with continuous positive airway pressure and gaseous exchange through flow-dependent dead space flushing. Patel *et al.* has demonstrated that the mean apnoea time was increased up to 14 minutes after the induction of anaesthesia and paralysis in patients with difficult airway with the use of THRIVE.[12]

Another technique that was suggested is pharyngeal oxygen insufflation. This technique involves insufflation of oxygen (3 to 10 L/min) via a nasal catheter or oral tube directly into the oropharynx. A study by Teller *et al.* demonstrated that apnoeic elective surgical patients had a sustained oxygen saturation of more than 97% for 10 minutes when given a pharyngeal oxygen insufflation at 3 L/min.[13] It was concluded that this technique provided 10 minutes of safe apnoea time in ASA 1 or 2 patients without airway obstruction.

PREDICTORS OF DIFFICULT AIRWAY

Managing a difficult airway will be much easier and effective if it is planned earlier in the pre-operative period. Therefore, it is of paramount importance that we identify those patients who are at risk of having a difficult airway and to plan appropriate modalities for airway management (Table I). Some of the scoring systems developed showed improved precision in predicting difficult airway. Those predictors for difficult tracheal intubation were developed by Arne *et al.*, Wilson *et al.* and Naquib *et al.*[14,15] and for difficult face mask ventilation by Langeron *et al.*, Kheterpal *et al.* and Yilzid *et al.*[16] A systematic review by Michael E. Detsky *et al.* in 2019 found that the best predictors of difficult endotracheal intubation were an upper lip bite test (ULBT), a short hyomental distance, retrognathia, or a combination of findings based on the Wilson score.[17] Langeron *et al.* in 2006 concluded that limited or severely limited mandibular protrusion, abnormal neck anatomy, snoring, sleep apnoea, and a body mass index (BMI) of 30 kg/m^2 or greater were independent predictors of grade 3 (inadequate, unstable, or requiring two providers) or 4 mask ventilation (impossible to ventilate) and difficult intubation.[18]

Table I: Predictors of difficult laryngoscopy and difficult face mask ventilation (FMV)

Predictors of difficult direct laryngoscopy[19-22]	Predictors of difficult FMV[23,24]
Limited mouth opening	Higher body mass index or weight
Limited mandibular protrusion	Older age
Narrow dental arch	Male sex
Modified Mallampati class 3 or 4	Limited mandibular protrusion
Decreased submandibular compliance	Decreased thyromental distance
Decreased sternomental distance	Modified Mallampati class 3 or 4
Limited head and upper neck extension	Beard
Increased neck circumference	Lack of teeth
Decreased submandibular compliance	History of snoring or obstructive sleep apnea

FMV: Face mask ventilation

It is important from the clinical studies to determine the sensitivity, specificity and positive predictive values for each of the tests used in an airway assessment. Positive predictive value refers to the chance that a positive test result will be correct.[25] There is currently no single test that fits the criteria, but a combination of the tests has proven to be reliable. Study by Patel *et al.* in 2014 found that a combination of modified mallampati, thyromental distance and sternomental distance has a sensitivity of 100% and a specificity of 92.7%.[26] Most of the commonly used tests were summarised in an airway assessment protocols by the Australian and New Zealand College of Anaesthetists (ANZCA) as in Table II.

Table II: Summary of sensitivity, specificity and PPV for different airway assessment tests

Test	Sensitivity %	Sensitivity %	PPV %
Mallampati	42-60	81-89	4-21
Modified Mallampati	65-81	66-82	8-9
Thyromental distance	65-91	81-82	8-15
Sternomental distance	82	89	27
Wilson	42-55	86-92	6-9
Arne	80-98	91-94	25-42
Mouth opening	26-47	94-95	7-25
Jaw protrusion	17-26	95-96	5-21

PPV: Positive predictive value. Source: *anzca.edu.au*

ANTICIPATED DIFFICULT AIRWAY

When a surgical patient is predicted to have a difficult airway, it is advisable to proceed with the surgery under a local or regional anaesthesia if it is deemed feasible. However, if general anaesthesia with tracheal intubation is indicated, a careful assessment prior to the procedure must be undertaken and appropriate plan of action is formulated. It is crucial that careful consideration be made in deciding whether to perform awake or post-induction tracheal intubation. The safest recommended approach is by awake intubation which will maintain patient's airway patency, gas exchange as well as protecting

the airway from aspiration during intubation.[27] Some factors that need to be considered in the planning of the strategies to deal with anticipated difficult tracheal intubation include patient, clinician and equipment factors (Figure 1).

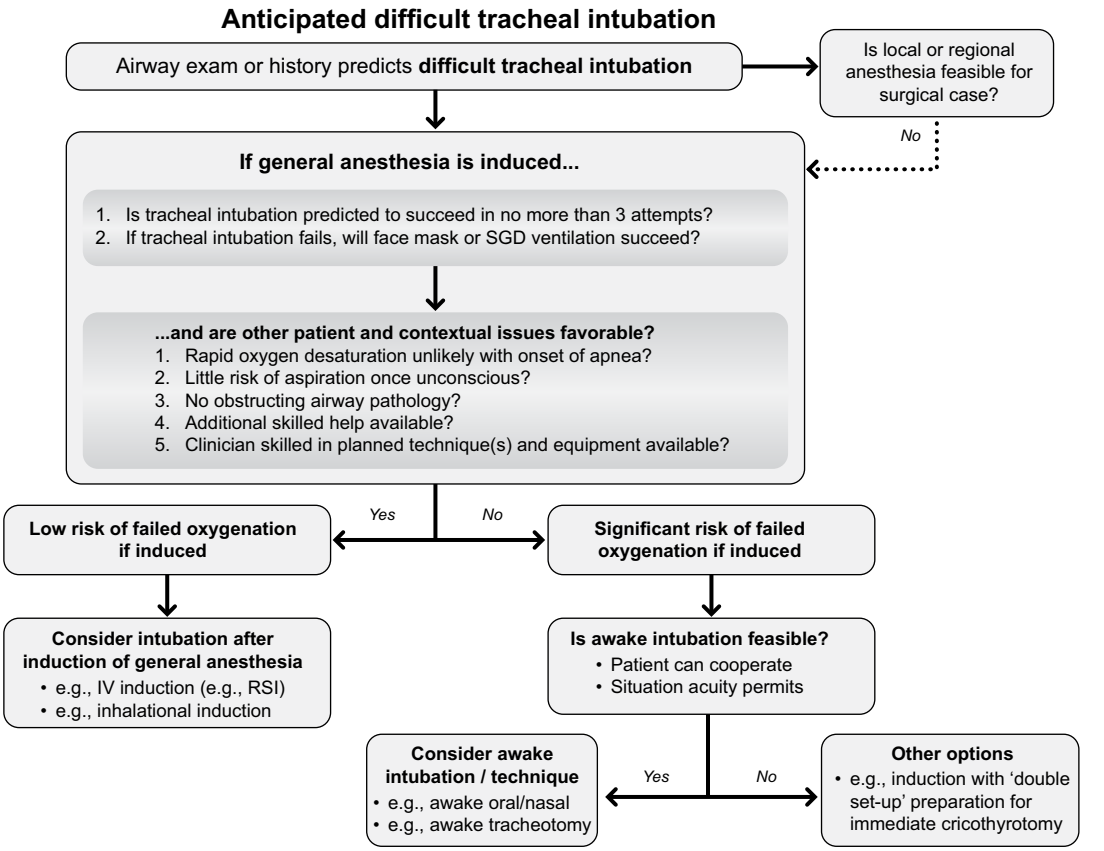

Figure 1: Anticipated difficult tracheal intubation flowchart. Adapted from "The difficult airway with recommendations for management - Part 2 - The anticipated difficult airway".[7]

The Canadian Airway Focus Group (CAFG) had published updated recommendations for the management of the difficult airway in 2021. Part of the recommendations was the use of questions (Figure 2) that can help the airway physician to decide whether awake tracheal intubation (ATI) is indicated or if the management might safely occur after induction in predicted difficult airway patients.[28] In the event that the case must proceed but patient is not cooperative with ATI, "double set-up" preparations for emergency front of neck access (eFONA) are recommended before the induction of general anaesthesia.

Components of the "double set-up" include: (1) Marking of the location of the cricothyroid membrane with the patient's head and neck extended. Use ultrasound guidance if skilled, (2) Deciding on who will undertake eFONA. This should be someone other than the primary airway manager if possible, (3) Ensuring that the equipment for the chosen eFONA technique is present in the room, opened and ready to be used, and (4) Briefing the team before induction, including the potential need for eFONA and triggers for proceeding with it.

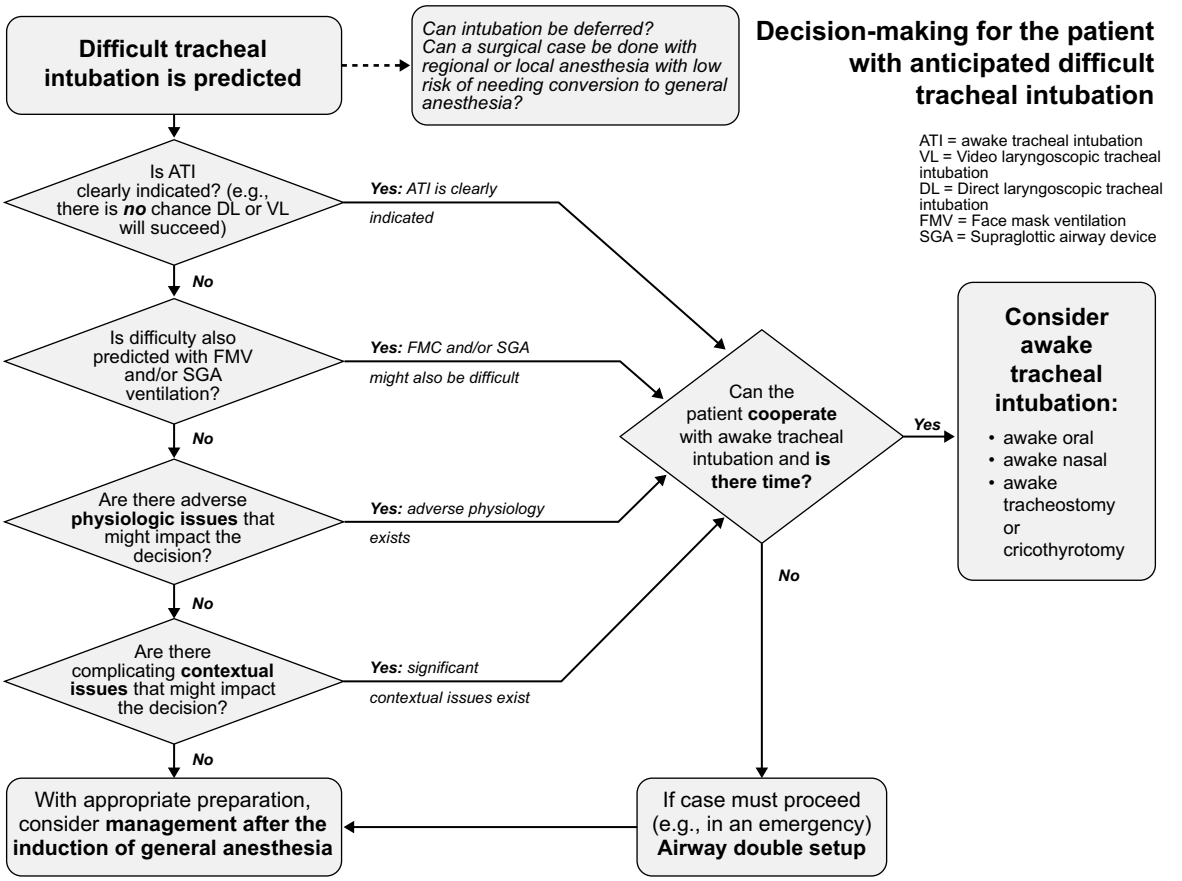

Figure 2: Decision making for the patient with anticipated difficult tracheal intubation. Adopted from the Canadian Airway Focus Group guidelines.[28]

MORBIDLY OBESE PATIENT

Obese patient is at an increased risk during airway management. It was reported that patients with a BMI of more than 30kg/m^2 were twice as likely to suffer a severe airway complication, and those with BMI of more than 40kg/m^2 were four times as likely.[1] A higher BMI, co-existing thick neck (e.g., circumference > 40-50cm), obstructive sleep apnoea (OSA), and/or a history of snoring are associated with difficult face mask ventilation (FMV),[29-31] whereas a thick neck and OSA are associated with difficult direct laryngoscopy (DL) or intubation.[32] This group of patients pose significant physiological challenges especially with regards to respiratory reserve with reduced functional residual capacity (FRC) which could lead to poor tolerance to apnoea during airway manipulation. It is important to anticipate rapid oxygen desaturation and appropriate preparation must be done prior to induction of anaesthesia.

The followings are the recommendations for the airway management of the obese and morbidly obese patient by the Canadian Airway Focus Group (2021):

- The anaesthesiologist should carefully consider whether ATI might confer a safety benefit in obese patients due to the potential

for technical difficulty with both tracheal intubation and other modes of ventilation and the likely occurrence of apnoea intolerance.

- Close attention to patient positioning, with ramping position to make sure that the patient's tragus is aligned with the sternum. Reverse Trendelenburg position will help in delaying oxygen desaturation[33] and if general anaesthesia is chosen, careful pre-oxygenation with a goal of achieving $FeO_2 \geq 0.9$ must be done.

- Apnoeic oxygenation technique to be used during laryngoscopy and intubation when managed after the induction of general anaesthesia.

- Primary use of video laryngoscopy (with appropriately selected blade type) for tracheal intubation to maximise first-pass success.

- Careful planning and documentation are recommended. The team should be briefed on the appropriate strategy including the triggers for moving to the next step in the plan if the difficulty is encountered. The anaesthesiologist should also consider having a second experienced airway manager or anaesthesiologist stand by for assistance, if needed.

UNANTICIPATED DIFFICULT AIRWAY

We may encounter patients who have an unpredictable difficult airway, more so during laryngoscopy when tracheal intubation is difficult. It is important to maintain patients' oxygenation either by mask ventilation or by using supraglottic airway devices (SGD) if possible. Laryngoscopic view can be optimised by a proper application of sniffing position, external laryngeal manoeuvre and the use of different laryngoscopic blades. It is recommended to use a video-assisted laryngoscopy (VAL) if available whenever a difficult tracheal intubation is encountered. This is to minimise the attempt and more importantly to avoid traumatising the airway which can further complicate the procedure. A systematic review by Sharon *et al.* in 2016 on VAL versus DL for adult patients requiring tracheal intubation involving 64 studies concluded that videolaryngoscopes may reduce the number of failed intubations, particularly among patients presenting with a difficult airway. They improve the glottic view and may reduce the incidence of laryngeal/airway trauma.[34] Another trial published in 2016 evaluated six different videolaryngoscopes in 720 patients with a simulated difficult airway found that highest success and lowest tissue trauma rates were achieved by the McGrath™ and C-MAC™ D-blade.[35]

After an unsuccessful initial intubation attempt, restoration of ventilation is the priority, by either a non-invasive (i.e., supraglottic airway (SGA)) or an invasive intervention, or by awakening the patient. Repeated attempts at intubation should not delay non-invasive airway ventilation (i.e., SGA) or emergency invasive airway access. The new DAS guidelines favour the use of second-generation SGAs in this situation, because they have specifically designed features to reduce the risk of aspiration and provide a better airway seal. Figure 3 shows the DAS guidelines for the management of unanticipated difficult tracheal intubation in adults.

CAN'T INTUBATE, CAN'T VENTILATE (CICO)

In the event of failed intubation and failed oxygenation using all non-invasive methods, life-threatening situation may arise leading to a rapid decline in oxygenation or even death within minutes. It is recommended to ask for all available help, declare the CICO crisis and proceed with an emergency invasive airway technique. The method of choice in adults and children over 8 years old would be open cricothyrotomy. Needle cricothyrotomy method using a large bore IV cannulas (14-16G) is not effective due to kinking tendency, high resistance and the risk of tissue insufflation and barotrauma.[3,36] Nevertheless there were some arguments to the DAS recommendations of using only scalpel technique as this will greatly reduce the success of subsequent cannula attempts if it

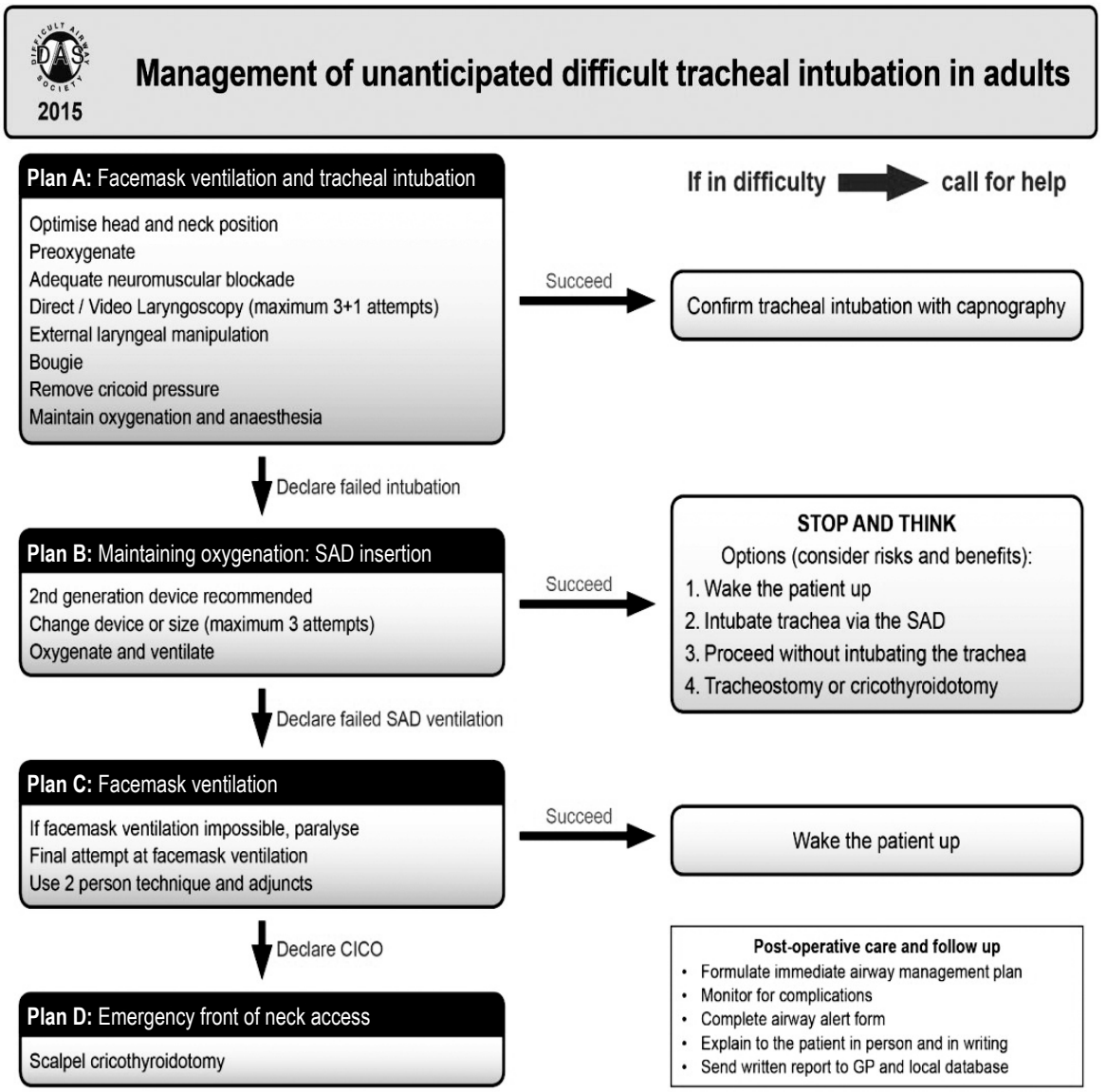

Figure 3: Difficult Airway Society guideline for the management of unanticipated difficult tracheal intubation in adults.[3]

fails by soiling of the trachea with blood. However, when conducted with the correct technique and equipment, a failed cannula insertion technique does not limit the success of subsequent scalpel attempts. Furthermore the surgical airway access was usually undertaken by surgeons and in the majority of cases they were head and neck surgeons.[17]

The CAFG in 2021 recommended that adult cricothyrotomy should proceed with either a percutaneous needle-guided wide-bore cannula or an open surgical technique, governed by operator preference and equipment availability. The anaesthesiologist must also bear in mind the significant reported failure rates of the percutaneous

techniques and must be prepared for immediate conversion to an open surgical technique should the percutaneous needle-guided technique fail. Figure 4 shows the DAS algorithm in the CICO crisis.

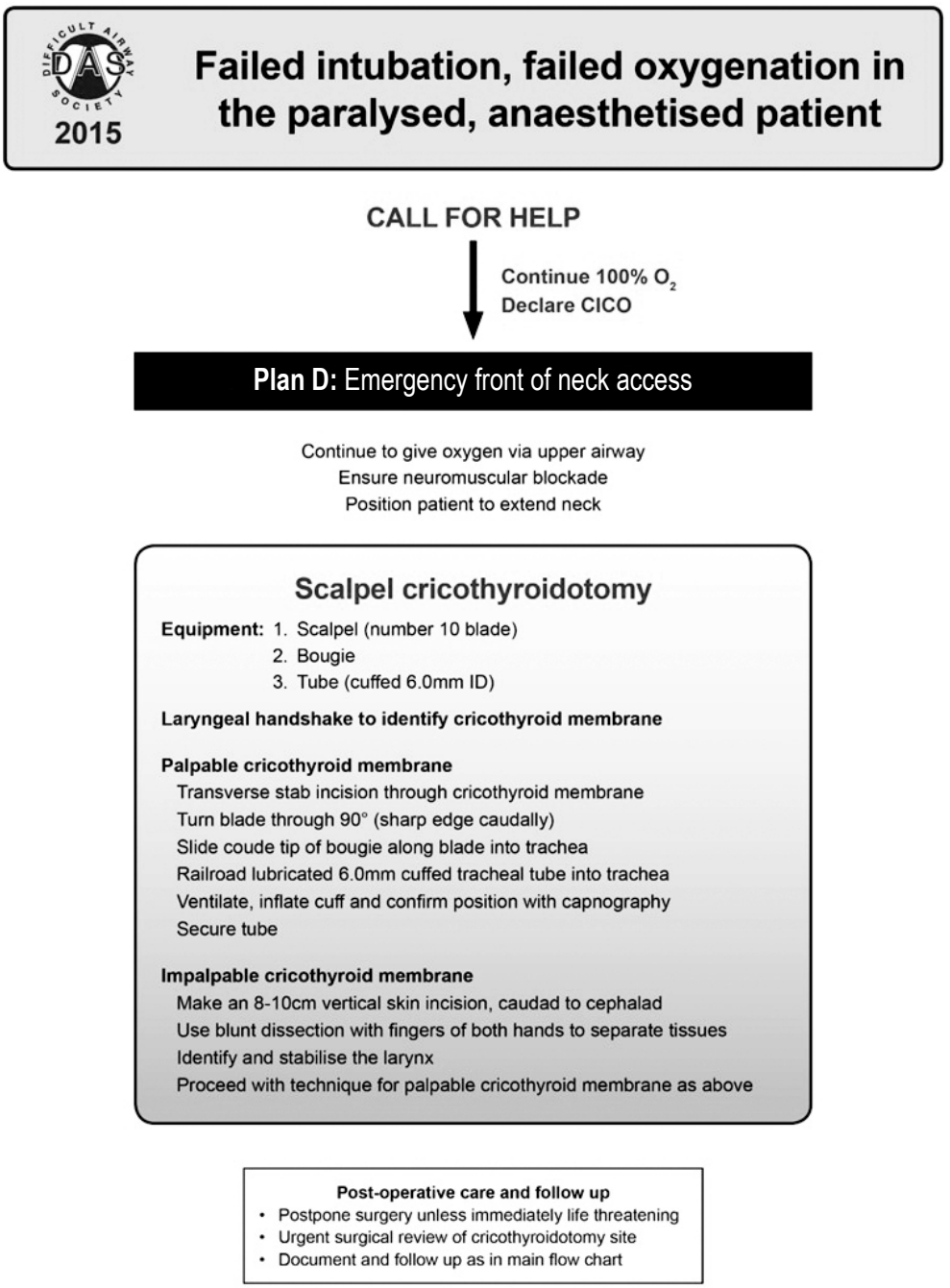

Figure 4: Difficult Airway Society guideline for the management of failed intubation and oxygenation in paralysed, anaesthetised patients.[3]

ULTRASONOGRAPHY GUIDED USAGE

All major guidelines recommended an access via the anterior neck, preferably via the cricothyroid membrane in CICO situations. Despite its importance as a part of airway management strategy, it has been reported that the success rate for the anaesthesiologists in identifying the cricothyroid membrane with usual modalities of inspection and palpation is extremely low, especially in obese patients, in whom the reported success rates vary between 0 and 39%.[37,38] The use of ultrasound to identify the cricothyroid membrane has been among a topic of discussion in recent years. This modality has been shown to be useful particularly in obese or morbidly obese patients.

A narrative review by Kristensen *et al.* in 2016 on clinical studies which compared the use of ultrasonography with palpation technique in a larger heterogeneous group of clinicians found a significant improvement with the use of ultrasonography. Successful identification of the cricothyroid membrane with palpation alone was reportedly 67% in lean subjects, 46% in a mixed BMI cohort, and 37% in the morbidly obese, and these improved to 69%, 100% and 83% respectively with ultrasonography.[39] The skill in using this technique could be acquired in a short but structured training, and its use is recommended in patients who are obese to facilitate the identification of cricothyroid membrane.

TRACHEAL EXTUBATION

Closed legal claims and published audits continue to document the risks associated with tracheal extubation. The incidence is much higher in those at higher risk of failed extubation. Patients may be deemed at risk at the time of tracheal extubation are those who may not be able to tolerate tracheal extubation or if the re-intubation might be difficult. There have been excellent guidelines[40] and narrative reviews[41] published on tracheal extubation. The most important aspect is the planning as recommended by CAFG (Figure 5) and also identification of patients at risk. Figure 6 shows DAS guidelines on extubation strategies in 'at risk' patients.

R EVERSAL	• Ensure recovery from neuromuscular blockade • Optimize patient factors
E XTUBATION PLAN	• Assess risk of extubation difficulty • Devise plan and response to difficulty
V ERIFY	• Verify that equipment, personnel, environmental factors are optimized • Brief team
E XTUBATE	• Consider "sterile cockpit" procedure • Optimize patient positioning • Consider airway exchange catheter
R ECOVERY	• Plan for location, monitoring, observation, and resources required after extubation
S AFE	• Perform safe transfer and handover
E XTUBATION FAILURE PLAN	• Predetermine extubation failure criteria • Equipment and personnel for re-intubation plan must be available

Figure 5: Planning of safe tracheal extubation by Canadian Airway Focus Group 2021.[28]

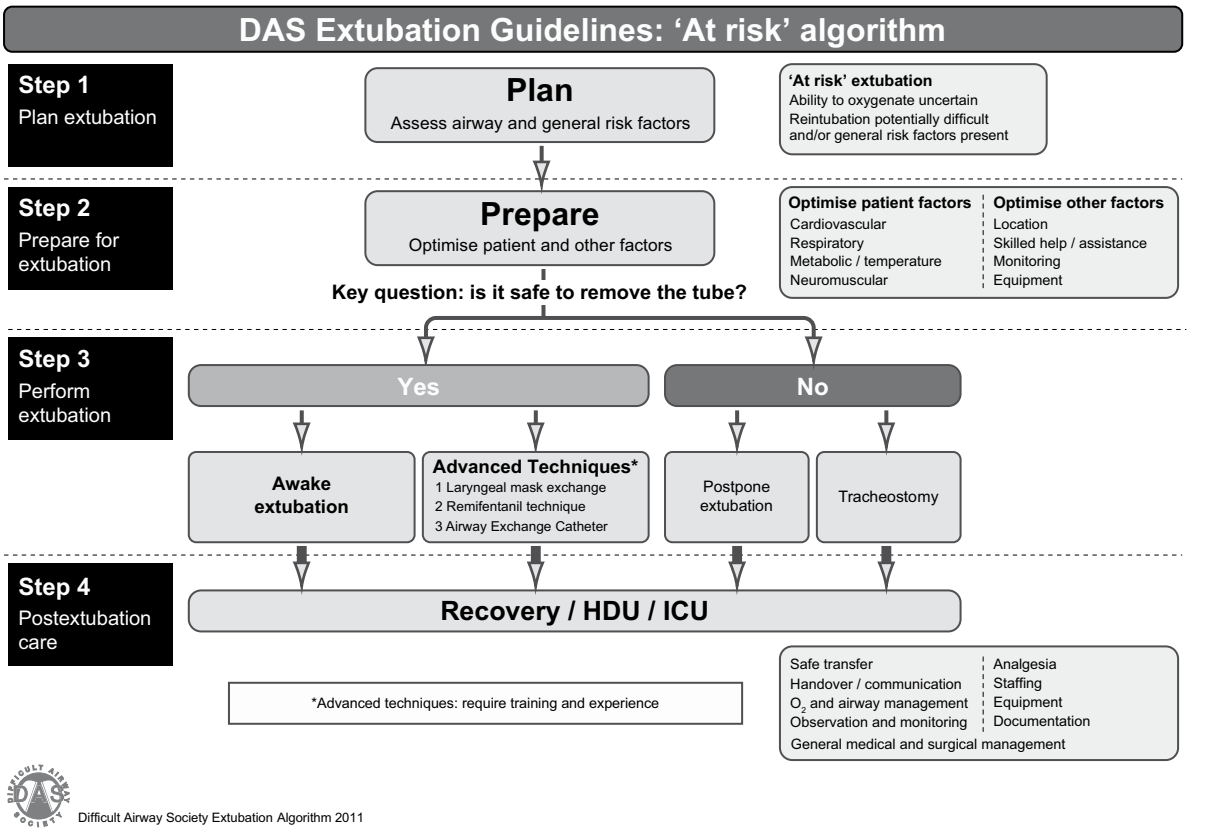

Figure 6: Difficult Airway Society guideline for 'at risk' extubation.[3]

CONCLUSION

Dealing with difficult airway situations can sometimes be nerve-wracking. It is crucial to remain calm and composed while planning for the next feasible and safe steps. Identifying patients at risk of a difficult airway by using reliable predictors and good planning will definitely improve the patient's outcome. We are still in the quest to search and develop the perfect and simplified difficult airway algorithm. Several professional anaesthetic societies have therefore proposed a series of algorithms for the airway management. These include numerous options that can be chosen depending upon specific circumstances. It should be remembered that while an ever-increasing number of techniques and devices are introduced, none of them are perfect in every situation. At any point in the algorithm, the anaesthesiologist must always choose the technique with which he is most comfortable and has the most experience with. After all, maintaining patients' oxygenation is of utmost importance.

References

1. Cook TM, Woodall N. Major complications of airway management in the UK: Results of the 4th National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society. Part 1 Anaesthesia. *Br J Anaesth* 2011;**106**:617-31
2. Iván Mauricio Alvarado Arteaga. Update on difficult airway management with a proposal of a simplified algorithm, unified and applied to our daily clinical practice. *Rev Colomb Anestesiol* 2018;**46**:55-64

3. Frerk C, Mitchell VS, McNarry AF, et al. Difficult Airway Society 2015 guidelines for management of unanticipated difficult intubation in adults. *Br J Anaesth* 2015;**115**:827-48

4. Mushambi MC, Kinsella SM, Popat M, et al. Obstetric Anaesthetists' Association and Difficult Airway Society guidelines for the management of difficult and failed tracheal intubation in obstetrics. *Anaesthesia* 2015;**70**:1286-306

5. Black AE, Flynn PE, Smith HL, et al. Association of Pediatric Anaesthetists of Great Britain and Ireland. Development of a guideline for the management of the unanticipated difficult airway in pediatric practice. *Paediatr Anaesth* 2015;**25**:346-62

6. Henderson JJ, Popat MT, Latto IP, et al. Difficult Airway Society. Difficult Airway Society guidelines for management of the unanticipated difficult intubation. *Anaesthesia* 2004;**59**:675-94

7. Apfelbaum JL, Hagberg CA, Caplan RA, et al. Practice guidelines for management of the difficult airway: an updated report by the American Society of Anesthesiologists Task Force on management of the difficult airway. *Anesthesiology* 2013;**118**:251-70

8. Law JA, Broemling N, Cooper RM, et al. The difficult airway with recommendations for management: part 2: the anticipated difficult airway. *Can J Anaesth* 2013;**60**:1119-38

9. Combes X, Le Roux B, Suen P, et al. Unanticipated difficult airway in anesthetized patients: prospective validation of a management algorithm. *Anesthesiology* 2004;**100**:1146-50

10. Petrini F, Accorsi A, Adrario E, et al. Recommendations for airway control and difficult airway management. *Minerva Anestesiol* 2005;**71**:617-57

11. Weingart SD, Levitan RM. Preoxygenation and prevention of desaturation during emergency airway management. *Ann Emerg Med* 2012;**59**:165-75.e1

12. Patel A, Nouraei SA. Transnasal Humidified Rapid-Insufflation Ventilatory Exchange (THRIVE): a physiological method of increasing apnoea time in patients with difficult airways. *Anaesthesia* 2015;**70**:323-9

13. Teller LE, Alexander CM. Pharyngeal insufflation of oxygen prevents arterial desaturation during apnea. *Anaesthesiology* 1988;**69**:980-2

14. Baker P. Assessment before airway management. *Anesthesiol Clin* 2015;**33**:257-278

15. Naguib M, Scamman FL, O'Sullivan C, et al. Predictive performance of three multivariate difficult tracheal intubation models: a double-blind, case-controlled study. *Anesth Analg* 2006;**103**:1579-81

16. Kheterpal S, Han R, Tremper KK, et al. Incidence and predictors of difficult and impossible mask ventilation. *Anesthesiology* 2006;**105**:885-91

17. Heard A, Dinsmore J, Douglas S, Lacquiere D. Plan D: cannula first, or scalpel only? Br J Anaesth 2016;533-34

18. Langeron O, Amour J, Vivien B, Aubrun F. Clinical review: Management of difficult airways. *Critical Care* 2006;**10**:243

19. Rocke DA, Murray WB, Rout CC, Gouws E. Relative risk analysis of factors associated with difficult intubation in obstetric anesthesia. *Anesthesiology* 1992;**77**:67-73

20. Frerk CM. Predicting difficult intubation. *Anaesthesia* 1991;**46**:1005-8

21. Hung O, Murphy M. Context-sensitive airway management. *Anesth Analg* 2010;**110**:982-3

22. Khan ZH, Kashfi A, Ebrahimkhani E. A comparison of the upper lip bite test (a simple new technique) with modified Mallampati classification in predicting difficulty in endotracheal intubation: a prospective blinded study. *Anesth Analg* 2003;**96**:595-9

23. Kheterpal S, Han R, Tremper KK, et al. Incidence and predictors of difficult and impossible mask ventilation. *Anesthesiology* 2006;**105**:885-91

24. Kheterpal S, Martin L, Shanks AM, Tremper KK. Prediction and outcomes of impossible mask ventilation: a review of 50,000 anesthetics. *Anesthesiology* 2009;**110**:891-7

25. Loong TW. Understanding sensitivity and specificity with the right side of the brain. *BMJ* 2003;**327**:716-9

26. Patel B, Khandekar R, Diwan R, Shah A. Validation of modified Mallampati test with addition of thyromental distance and sternomental distance to predict difficult endotracheal intubation in adults. *Indian J Anaesth* 2014;**58**:171-5

27. Law JA, Broemling N, Cooper RM, et al. The difficult airway with recommendations for management: part 2: the anticipated difficult airway. *Can J Anaesth* 2013;**60**:1119-38

28. Law JA, Duggan LV, Asselin M et al. Canadian Airway Focus Group updated consensus-based recommendations for management of the difficult airway: part 2. Planning and implementing safe management of the patient with an anticipated difficult airway. Can J Anesth/J Can Anesth 2021;1-32

29. Cattano D, Killoran PV, Cai C, Katsiampoura AD, Corso RM, Hagberg CA. Difficult mask ventilation in general surgical population: observation of risk factors and predictors. *F1000Res* 2014;**3**:204

30. Leoni A, Arlati S, Ghisi D, et al. Difficult mask ventilation in obese patients: analysis of predictive factors. *Minerva Anestesiol* 2014;**80**:149-57

31. Cattano D, Katsiampoura A, Corso RM, Killoran PV, Cai C, Hagberg CA. Predictive factors for difficult mask ventilation in the obese surgical population. *F1000Res* 2014;**3**:239

32. Toshniwal G, McKelvey GM, Wang H. STOP-Bang and prediction of difficult airway in obese patients. *J Clin Anesth* 2014;**26**:360-7

33. Couture EJ, Provencher S, Somma J, Lellouche F, Marceau S, Bussieres JS. Effect of position and positive pressure ventilation on functional residual capacity in morbidly obese patients: a randomized trial. *Can J Anesth* 2018;**65**:522-8

34. Lewis SR, Buter AR, Parker J, Cook TM, Smith AF. Videolaryngoscopy versus direct laryngoscopy for adult patients requiring tracheal intubation. *Cochrane Database Rev* 2016;**11**:CD011136

35. Kleine-Breuggeney M, Greif R, Schoettker P, Savoldelli GL, Nabecker S, Theiler LG. Evaluation of six videolaryngoscopes in 720 patients with simulated difficult airway: a multicenter randomized controlled trial. *Br J Anaesth* 2016;**116**:670-9

36. Vanner R. Emergency cricothyrotomy. *Curr Anaesth Crit Care* 2001;**12**:238-43

37. Kristensen MS, Teoh WH, Rudolph SS, et al. Structured approach to ultrasound-guided identification of the cricothyroid membrane: a randomized comparison with the palpation method in the morbidly obese. *Br J Anaesth* 2015;**114**:1003-412

38. Lamb A, et al. Accuracy of identifying the cricothyroid membrane by anesthesia trainees and staff in a Canadian institution. *Can J Anaesth* 2015;**62**:495-503

39. Kristensen MS, Teoh WH, Rudolph SS. Ultrasonographic identification of the cricothyroid membrane: best evidence, techniques, and clinical impact. *British Journal of Anaesthesia* 2016;**117**(S1):i39-i48

40. Difficult Airway Society Extubation Guidelines Group; Popat M, Mitchell V, et al. Difficult Airway Society Guidelines for the management of tracheal extubation. *Anaesthesia* 2012;**67**:318-40

41. Cavallone LF, Vannucci A. Review article: Extubation of the difficult airway and extubation failure. *Anesth Analg* 2013;**116**:368-83

D'anaesthésie Et D'analgésie Loco-Régionale: Coup D'oeil Through the Past, the Present and the Future

Mohamed Asri Mohamed Zaini[1], Muhammad Salman Borhan[1], Mohd Fauzi Ibrahim[2], Muhamad Rasydan Abd Ghani[1,2]

[1]Department of Anaesthesiology and Intensive Care, Sultan Ahmad Shah Medical Centre (SASMEC@ IIUM), Pahang, Malaysia

[2]Department of Anaesthesiology and Intensive Care, Kulliyyah of Medicine, International Islamic University Malaysia, Pahang, Malaysia

Since K. Koller introduced the first regional anaesthesia with cocaine in 1846, it has evolved rapidly. Regional anaesthesia has become the contemporary anaesthesia approach to facilitate surgical procedures and promote patient safety, thanks to break throughs in pharmacology, knowledge in medicine and innovative technology. In recent years, regional anaesthesia techniques have been used as part of multimodal analgesia for patients rather than as the primary anaesthetic strategy during surgery. It is used in conjunction with general anaesthesia, which effectively reduces the use of systemic analgesics such as morphine and non-steroidal anti-inflammatory agents. This article revisits its past, highlights current practices and its potential future as it evolves.

THE PAST HISTORY OF REGIONAL ANAESTHESIA

Fundamental to neural block and regional anaesthesia is the concept of sensory block that is achieved pharmacologically by the interruption of electrical conduction along specific nerve fibres or its pathway. Nodes of Ranvier, also known as the myelin-sheath gaps, were first discovered in 1878 by French histopathologist, Louis-Antoine Ranvier, who described the nodes as constrictions. These nodes interrupt the insulation at intervals, and this discontinuity enables impulses to propagate between the nodes in a process known as saltatory conduction.

Cocaine is an active drug originally isolated from the leaves of Erythroxylum Coca in 1860 by German chemist, Albert Niemann. During the process, Nieman noted that cocaine made his lips go numb, but he could not make the mental leap to realise the potential medicinal use of cocaine.[1] Only in 1884, the anaesthetic effect of cocaine was discovered by ophthalmologist, Carl Koller who initially observed the tongue-numbing properties of the drug, which subsequently led to his self-experimental corneal application (Figure 1).[2,3] Koller published his first paper on the anaesthetic use of cocaine in the Viennese Weekly Medical Journal in October 1884, a month after he had successfully performed a corneal surgery under topical anaesthesia. Koller's discovery spread throughout the western world like wildfire, which opened the door to modern local and regional anaesthesia.[4]

During this time, the medical world started to learn and became interested in using cocaine for local anaesthesia, leading to the discovery and emergence of new techniques. American surgeons, William Stewart Halsted and Richard John Hall, performed the first actual nerve block in 1884 by injecting 4% solutions of cocaine into the brachial plexus and the posterior tibial nerve.[5] In 1885, a neurologist in New York City, James Leonard Corning, came up with the idea of using cocaine in the subarachnoid space after frequently observing Halsted and Hall performing cocaine injections. He injected cocaine into what he thought was the subarachnoid space at T11-T12 interspace. Corning did not notice any effect in his experiment after 8 minutes of local administration and repeated his injection. After 10 minutes, the patient complained of 'sleepiness' in his legs but could stand and walk. Corning did not mention cerebrospinal fluid efflux during the procedure, which most likely meant that he inadvertently gave an epidural rather than a spinal injection to the patient.[6]

German surgeon, Karl August Gustav Bier, performed the first and formal description of the subarachnoid block in 1899. Bier and his assistant,

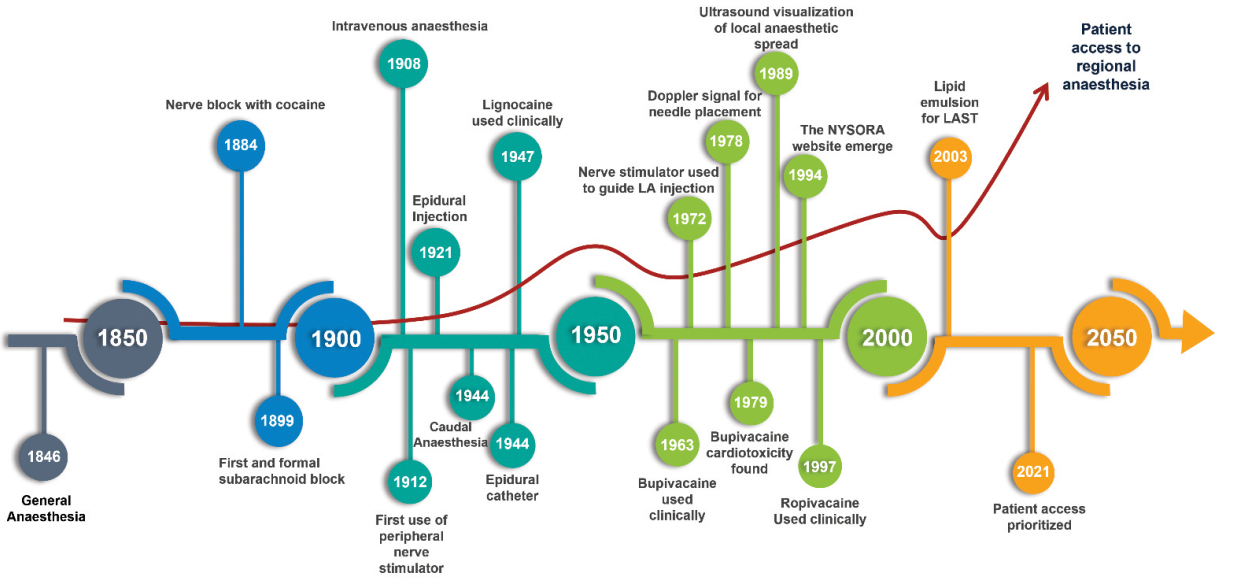

Figure 1: Chronicle of critical historical events in the evolution of regional anaesthesia. Adapted from Chin.[3]

August Hildebrandt, performed subarachnoid injections of 5mL cocaine 1% on each other. Injection into his assistant resulted in a lack of sensation over the lower extremities in response to a knock on the shin using a hammer. Unfortunately, Hildebrandt's attempt to inject cocaine into Bier failed because the syringe outlet did not fit the needle's hub. A large volume of Bier's cerebrospinal fluid leaked out, and he started to suffer headaches the next day, which more likely were post-dural puncture headaches.[7] However, it was undoubtedly a great moment for the future of regional anaesthesia.

Another August Bier's contribution to the regional anaesthesia world is his introduction of Intravenous Regional Anaesthesia (IVRA) technique in 1908, which is also known as Bier's Block. The technique essentially consists of injecting a local anaesthetic solution into the venous system between two tourniquets.[2] Even though the technique is termed as Bier's Block, it did not gain popularity until reintroduced again by New Zealand anaesthesiologist, Charles McKinnon Holmes, in 1963 with the novel use of lidocaine.[2] The significant advantages of this technique were its cost-effectiveness, sufficient muscle relaxation and a fast on-offset.

In 1901, the epidural technique for locoregional anaesthesia was invented by two French physicians, Fernand Cathelin and Jean Athanase Sicard. They anaesthetised the lowest sacral and coccygeal nerves through the epidural space by injecting cocaine into the caudal peridural space through the sacral hiatus.[6] Despite the early discovery of epidural anaesthesia, only nineteen years later, the lumbar epidural injection was introduced by Spanish surgeon Fidel Pages-Mirage in 1921. He identified the epidural space through a technique which sensed subtle tactile distinctions as the needle was introduced through the ligaments.[5] In 1931, Italian surgeon, Achille Dogliotti popularised the technique by describing a new method to identify the epidural space via a loss of resistance technique. In the same year, Argentine surgeon, Alberto Gutiérrez, expounded the "drop test method" to identify the space. Both techniques had been used since then to identify the epidural space. Later in 1949, Cuban anaesthesiologist, Manuel Curbelo, used the Tuohy needle to introduce a ureteral catheter into the epidural space enabling the first continuous epidural anaesthesia.[8]

In the middle of the twentieth century, regional anaesthesia was at its nadir, which was reflected

by the introduction of safer anaesthetic agents and improved techniques for general anaesthesia. The turning point for the advancement of regional anaesthesia was seen only after the ultrasound revolution in the early 1980s. The ultrasound machine has become an essential piece of equipment together with the nerve stimulator, to ensure patient's safety and help increase success rates during administration of peripheral nerve blocks.

Georg Clemens Perthes was the first person to describe the technique of peripheral nerve stimulation in 1912, by passing electrical current via a needle inserted through an intact skin. Unfortunately, Perthes technique was not adopted until 1960 when Greenblatt and Denson introduced a portable solid-state nerve stimulator with variable current output, which became the gold standard for the performance of peripheral nerve blocks in the 1980s.[9] The authors would like to acknowledge Dr Philippe Macaire, Dubai Health Authority, Medinfusion and University Montpellier (France) for their efforts in propagating the knowledge and practices of regional anaesthesia worldwide.

THE PRESENT EVOLUTION OF REGIONAL ANAESTHESIA

Since the beginning of the 21st century, there has been a resurgence of regional anaesthesia practices, influenced by advances in the medical field, better access of ultrasound to patients and the widespread interest in regional anaesthesia among the new generation of anaesthesiologists. The introduction of ultrasound in the anaesthetic practice about 15 to 20 years ago paved the way for the revolution of regional anaesthesia in Malaysia. New technologies, that made the ultrasound machine previously only available in the radiology department, now are considered an essential tool to safely perform regional anaesthesia. A smaller machine with improved image resolution makes identification of nerves, bones, muscles and fascial planes easier than before. With a more reasonable cost of decent ultrasound machines and appropriate training, our emergency physician colleagues can also provide analgesia by performing regional anaesthesia at an earlier point of contact.

Improved needle guidance such as beam steering incorporated in the ultrasound machine is one of the technologies available for needle enhancements. Production of various types of echogenic (enhanced visibility under ultrasound) needles provides much improved needle visibility. Among others, the latest currently available needle tip tracking technology, from B Braun and Philips, Onvision®, utilises Onvision® ultrasound and Stimuplex® Onvision® single shot needles.

The evolution of regional anaesthesia from an initial landmark-based to nerve stimulator guided, and now with the use of dual or triple monitoring are in accordance with current society guidelines and recommendations. Dual guidance, using ultrasound and nerve stimulator and additional use of injection pressure monitor in triple guidance, has theoretical advantages in terms of enhancing precision and safety but have shown no clear benefits based on current evidence. However, there are some suggestions that dual guidance is best used for blocks of deep structures, such as psoas compartment block, adductor canal block, and to be used in training of novice doctors. The role of nerve stimulation has also changed over the last 15 years from an essential tool to locate nerves, to a safety adjunct to US in avoiding intraneural injection. Nerve stimulation is also useful in teaching novice officers ultrasound-guided regional anaesthesia techniques, especially when the nerve's position and/or appearance may be variable.[10] In-line pressure measurement (connecting monitoring device along the block needle) with a diagnostic value of 15 psi (103kPa) exhibits high sensitivity for recognition of needle nerve contact while avoiding nerve damage, but questions remain over the validity of this technique.[11]

In the era of the COVID-19 pandemic, regional anaesthesia may be the key in reducing the need for general anaesthesia and reducing risk associated with aerosol-generating procedures. Thus, regional anaesthesia in the capable hands can be a tool to protect healthcare providers while safeguarding patient's safety.[12]

The introduction of adjuvants such as perineural dexmedetomidine (50 to 60 mcg) and systemic

dexamethasone (0.1 to 0.2 mg/kg) has increased the mean duration of analgesia for up to 6-8 hours.[12] To improve and enhance postoperative analgesia, catheter techniques are becoming more favourable. It offers extended duration of analgesia compared with adjuvant drugs which can only provide a maximum duration of 14 hours. Various local anaesthetic regimes can now be administered to patients, tailored to each patient's needs from the immediate post-op until the next few days of recovery.

The knowledge about regional anaesthesia is expanding tremendously. To block the upper limb, there are about six techniques to learn, and each technique has its indications and its idiosyncrasies. There are now many ways of performing regional anaesthesia, especially in the most ergonomic way possible. Sitting down on an ergonomic chair, planning on the needling technique, placing the ultrasound monitor in front of the operator's view, placing the regional anaesthesia tray on the hand's dominant side and positioning the patient closer to the operator are some of the magic ergonomic practices that are incorporated in day-to-day work.

With multiple need-to-know blocks, different new techniques with new skills to acquire, it is time to have a list of essential blocks to learn as part of perioperative skills like what is done for our central neuraxial techniques. To determine which block should be performed, five questions (Figure 2) should be answered for all available block options, and appropriately allocated scoring marks.[13] By doing this, each practitioner can answer which block approach gives the best outcome to patients. It is best to adopt a pragmatic approach in encouraging ongoing utilisation of a less complex nerve block to perform compared with no regional anaesthesia conduct.[14]

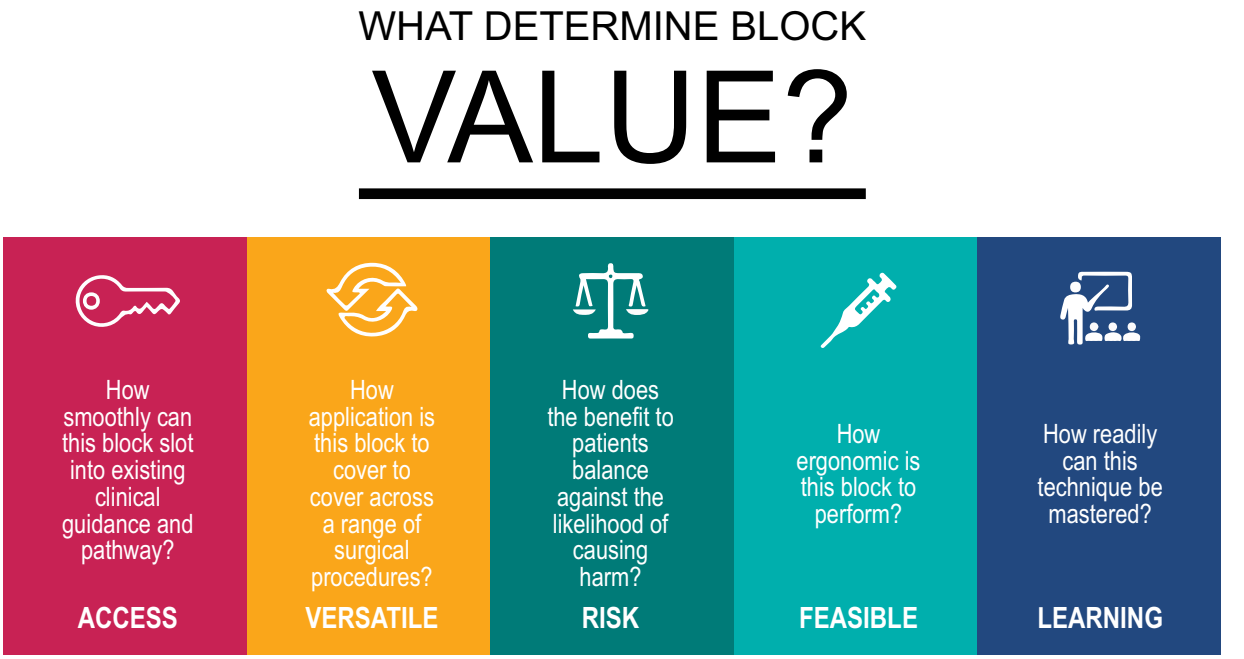

Figure 2: Importance of value in performing regional anaesthesia, all questions pertinent to practising doctors. Adapted from Johnston.[14]

When patients have access to information on regional anaesthesia and attain more knowledge, informed consent is key and must be obtained. Understanding of basic anatomy of the nerves, involving fascial planes and the surrounding vascular structures, having spatial and temporal awareness, identifying anatomical variations, recognising local and systemic complications are some of regional anaesthesia practitioners' most essential knowledge and skills. In attaining competency and as experience grows, higher patient's expectations in terms of favourable outcome may be anticipated and hence higher litigation risks when complication occurs. How much information should an anaesthesiologist inform? Such is the importance that a thorough explanation about regional anaesthesia to a standard expectation of a reasonable patient should be explored. LAST and Postoperative Neurological Symptoms are two catastrophic but rare potential occurrences following a peripheral nerve block, quoted as around 0.03% and 0.2 to 2.2% respectively. Fortunately, among patients experiencing neurological symptoms, a large majority will resolve within three to six months. With increasing regional anaesthesia performed, the importance of informed consent and managing complications are deemed necessary to all practitioners.[15]

THE FUTURE OF REGIONAL ANAESTHESIA

Regional anaesthesia is now being considered in place of opioid dependence, a significant tool in the Enhanced Recovery After Surgery (ERAS) initiative but side-lined due to unfamiliarity performing the nerve blocks as one of the perioperative managements, due to a lack of exposure in knowledge, training and block performance. Changes had to be made in the training modules to be more comprehensive to prepare future anaesthesiologists to perform an extensive array of regional anaesthesia blocks in Residency or Postgraduate Training.

In Malaysia, there appears to be a large disproportion in regional anaesthesia exposure within the curriculum of postgraduate anaesthesiology training highlighting the lack of focus towards core regional anaesthesia competencies required, in the education of trainee anaesthesiologists as far as regional anaesthesia is concerned. Current practice in regional anaesthesia is driven by trainers who are enthusiasts with common special interest in regional anaesthesia and they are also the ones involved in the regional anaesthesia subspecialty training programme under the Ministry of Health; largely being out-numbered by the task at hand.

Effective perioperative pain management starts with multimodal analgesia, of which regional anaesthesia can commonly be achieved with one or more block techniques appropriate for that surgical procedure. In case of necessity, the anaesthesiologist needs to be equipped with knowledge and skills for various alternative regional anaesthesia techniques for this purpose. This review proposes anaesthesiologists to be familiar with the core regional block techniques available, which would be beneficial in managing perioperative pain thus shortening patients' recovery period. Figure 3 shows the core basic ultrasound-guided regional anaesthesia techniques suggested based on current practice in Malaysia.

A proper evaluation must captivate and harmonise the postgraduate trainee and anaesthesiologist to regularly practise basic regional anaesthesia as one of the core competencies for all anaesthesiologists, similar to airway management, perioperative monitoring, intensive care, and pain management. There are three key components suggested to make positive changes toward promoting provision of regional anaesthesia (Figure 4).

These work-based evaluations are mostly done with the current state of simulation-based education, deliberate practice, and curriculum designed on competency-based progression. The latest developments in web-based learning have seen emerging technologies for teaching and assessment and alternate reality learning systems as the new methods for regional anaesthesia training.[17]

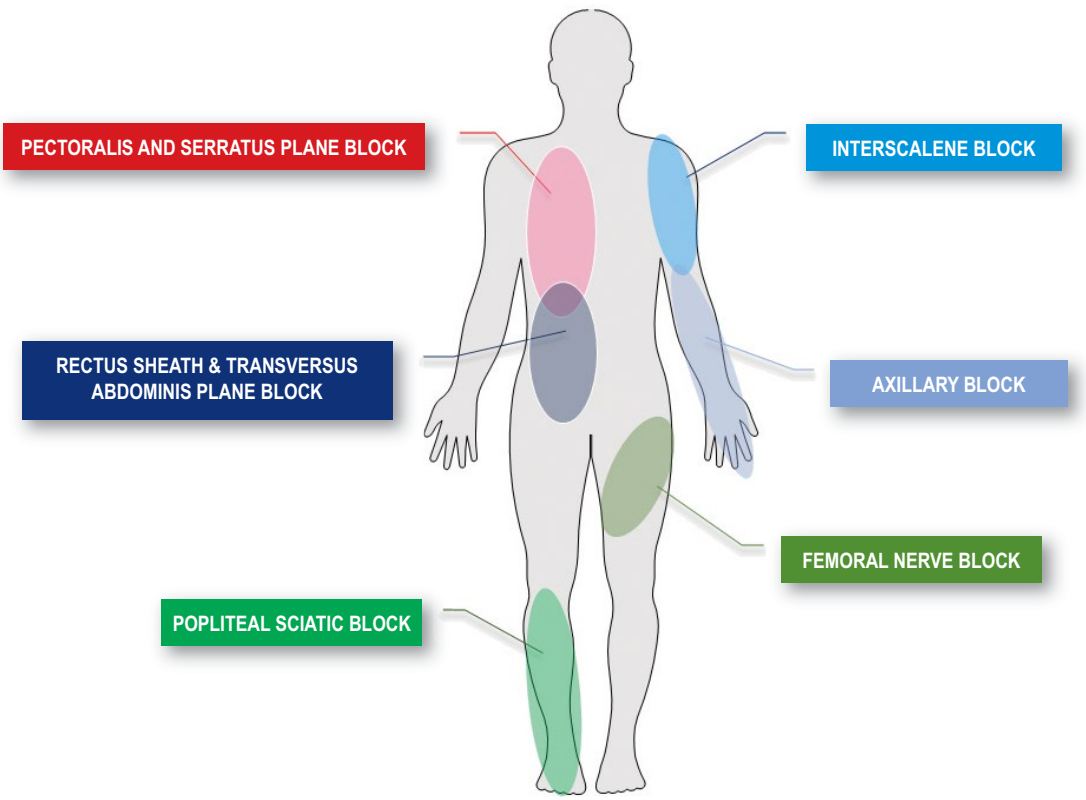

Figure 3: Suggested basic ultrasound-guided regional anaesthetic techniques. Adapted from Johnston.[14]

Figure 4: Vital components to increasing patient access to regional anaesthesia. Adapted from Turbitt.[16]

Deliberate practice is an excellent training method in which the trainee or practitioner is (1) given an assignment surpassing his or her current expertise level, (2) propelled to practice extensively and move forward, (3) given with thorough and sufficient feedback, and (4) incited to reflect on the learning experience and understanding.[16]

The hindrance in relying on technology is that it is costly, and plays a significantly limited role, whereby hands-on activities are not often possible. Other technological limitations need also be considered; Do practitioners have the internet bandwidth to receive the video stream? Can they install the necessary plug-ins and platforms? Do they have access to hearing aid devices to listen to the audio? Can we set all the features (audio, screen viewing, chat) necessary for a compelling experience? The considerations need to be addressed to ensure practical training can be conducted especially in regional anaesthesia.

Alternate reality simulators have been used for training and education in other industries for many years. It has made its way into extensive applications for medical education, from undergraduate anatomy to surgical training in recent years. Evidence for using this technology as an educational tool, like virtual reality and augmented reality technology, can bridge the gap between hospital working yield, postgraduate student work hour limitations, and the need for gaining experience on clinical, technical skills. Learners have found that virtual reality learning systems are delightful, which increase motivation to understand and acquire the skills to explore at one's speed leisurely.

Virtual reality has utilised haptic business gadgets due to cost benefit considerations. These gadgets are fit for delivering power input when a virtual needle connects with tissue, but the ergonomics and central part of the haptic gadget can be a restricting factor for ultrasound-guided regional anaesthesia training. With the coming of 3D printing, models have been created to alter the business gadgets and fuse genuine needle centre points to improve the face legitimacy of the virtual environment. Apart from hardware interface limitations, studies in virtual reality education have identified four other concerns, including overhead costs related to equipment and training; usability of hardware and software; lack of feedback and lack of engagement.[17]

We must look for innovative alternative education tools and methods to teach trainees and practitioners during a dedicated regional anaesthesia rotation and for the consultant or advanced clinical fellow, to learn new techniques. Each of the discussed options give an advantage to learning, however, no single methodology is sufficient for the assortment of abilities needed in the training, performance and mastering regional anaesthesia practices. Thus, educators must employ a balanced approach that considers patient outcomes and the limits of their financial plan.

Along with all the training requirements, many obstacles may be overcome by a deeper understanding and the realisation of the potential role regional anaesthesia has towards improved patient-centred outcome parameters providing better patient experience, early beneficial postoperative patient-reported results and long-term results, while at the same time curtailing institutional costs by reducing length of stay, re-admissions or treatment of inadequate analgesia and its related side effects.

CONCLUSION

The future of regional anaesthesia is still yet to be realised. We have discussed possible factors that impedes its growth and proposed methods to promote and enhance interest in regional anaesthesia by highlighting its benefits and facilitating its learning among medical officers, postgraduate trainees and anaesthesiologists by focusing on high value regional anaesthesia techniques. We explored emerging technologies for teaching and assessment with alternate reality learning systems as the new method for regional anaesthesia training, which can bridge the gap between hospital working yield, postgraduate student work-hour limitations, and the need for gaining experience in clinical, technical skills. Above all, there has to be a significant

paradigm shift in how regional anaesthesia, and nerve blocks in particular, is being viewed amongst anaesthesiologists and the realisation that they are not the belittled poorer class anymore.

References

1. Warman P, Conn D, Nicholls B, Wilkinson D. Regional Anaesthesia, Stimulation, and Ultrasound Techniques, 1st edition. Oxford University Press 2014, pp4-6

2. Angaramo G, Savage J, Arcella D, Desai MS. A Comprehensive Curriculum of The History of Regional Anesthesia. *Journal of Clinical Anesthesia and Pain Medicine* 2019;**026**:2-5

3. Chin, K. J., E. R. Mariano, and K. El-Boghdadly. Advancing towards the next frontier in regional anaesthesia. *Anaesthesia* 2021;**76**:3-7

4. Goerig M, Bacon D, van Zundert A. Carl Koller, Cocaine,and Local Anesthesia: Some Less Known and Forgotten Facts. *Reg Anesth Pain Med* 2012;**3**:318-20

5. López-Valverde A, De Vicente J, Cutando A. The surgeons Halsted and Hall, cocaine and the discovery of dental anaesthesia by nerve blocking. *British Dental Journal* 2011;**10**:285-6

6. Hadzic A. Textbook of Regional Anesthesia and Acute Pain Management, 2nd edition. McGraw-Hill Education 2017, pp10-12

7. Mulroy A. The Wondrous Story of Anesthesia: A History of Regional Anesthesia, 1st edition. Springer New York 2014, pp861-862

8. Waurick K, Waurick R. History and Technique of Epidural Anaesthesia. *Anästhesiol Intensivmed Notfallmed Schmerzther* 2015;**50**:476-82

9. Klein SM, Melton MS, Grill WM, Nielsen KC. Peripheral Nerve Stimulation in Regional Anesthesia. *Reg Anesth Pain Med* 2012;**4**:38-4

10. Gadsden JC. The role of peripheral nerve stimulation in the era of ultrasound-guided regional anaesthesia. *Anaesthesia* 202;**76**:65-73

11. McLeod GA. Novel approaches to needle tracking and visualisation. *Anaesthesia* 2021;**76**:160-70

12. Uppal V, Sondekoppam RV, Landau R, El-Boghdadly K, Narouze S, Kalagara HKP. Neuraxial anaesthesia and peripheral nerve blocks during the COVID-19 pandemic: a literature review and practice recommendations. *Anaesthesia* 2020;**75**:1350-63

13. Desai N, Kirkham KR, Albrecht E. Local anaesthetic adjuncts for peripheral regional anaesthesia: a narrative review. *Anaesthesia* 2021;**76**:100-09

14. Johnston DF, Turbitt LR. Defining success in regional anaesthesia. *Anaesthesia* 2021;**76**:40-52

15. McCombe K, Bogod D. Regional anaesthesia: risk, consent and complications. *Anaesthesia* 2021;**76**:18-26

16. Turbitt LR, Mariano ER, El-Boghdadly K. Future directions in regional anaesthesia: not just for the cognoscenti. *Anaesthesia* 2020;**75**:293-7

17. Ramlogan RR, Chuan A, Mariano ER. Contemporary training methods in regional anaesthesia: fundamentals and innovations. *Anaesthesia* 2021;**76**:53-64

Evolution of Mechanical Ventilation: From Clinician-Oriented to Patient-Oriented

Shahir Asraf Abdul Rahim, Allison Yeoh Sin Yi, Wong Shee Ven, Mohd Basri Mat Nor
Department of Anaesthesiology and Intensive Care, Kulliyyah of Medicine, International Islamic University Malaysia, Pahang, Malaysia

Mechanical ventilation is the key intervention in the critically ill with respiratory failure. It provides temporary respiratory support for patients' oxygenation and ventilation while they are fighting for their lives, and gives hope for recovery. This article provides an overview of the advancement of mechanical ventilators from the early phase and its progression to the current and future practice. The practice of mechanical ventilation has evolved from clinician-oriented ventilation towards a more recent development of patient friendly or patient-oriented ventilation. This evolution occurs to improve patient-ventilator interaction and to protect the lung and diaphragm from over-assistance.

INTRODUCTION

Mechanical ventilation is the main intervention to support the cardiorespiratory function of critically ill patients. The goal of respiratory support has been improvised to not only provide effective life-support, but also to reduce iatrogenic complications and better synchronisation between patients' need and mechanical breaths. The ability of the mechanical ventilators to provide effective oxygenation and ventilation has been progressively refined with increasing awareness of its potential to cause ventilator-induced lung injury, hemodynamic disturbances, and ventilator-associated infection. In the past, mechanical ventilation process was an unpleasant process that usually requires profound sedation and may require paralysis. However, to date this has been replaced with contemporary machines which offer opportunities to reduce work of breathing, better comfort and synchrony. In this article, we will discuss the aspects of transition from clinician-oriented positive pressure ventilation era to the innovative approaches of patient-oriented mechanical ventilation.

THE BEGINNING OF MECHANICAL VENTILATION

Positive pressure mechanical ventilation became the standard technology with the start of the contemporary Intensive Care Unit (ICU) in the early 1960.[1] At the time, negative pressure mechanical ventilation equipment was replaced with a positive pressure machine that was more practical. In the early days, Drinker-Shaw and Emerson machines or the 'iron lung' were introduced into medical practice.[2] It was successfully used during the polio pandemic in the early 1950s. Unfortunately, the negative pressure iron lungs were cumbersome, and only feasible for patients who were conscious enough to maintain a patent airway and not suitable for those with full-blown respiratory failure. Based on this experience and the increase in need of mechanical ventilation during the two world wars, the value of advancement in life-support technology has become more evident.

The beginning of positive-end-expiratory pressure (PEEP) and non-invasive ventilation can be tracked in these initial years.[3] The 1960s were the monumental time in the progress of mechanical ventilation, due to the developments in physiology and surgery to address the postoperative atelectasis and the respiratory insults during war. Pressure cycled machines that gave cycled positive pressure breath were used in the common wards to minimise basilar collapse of lungs. At the same time, life-support machines that separately regulate inflation and deflation phases of breathing were introduced in then the newly established ICUs.[4] The pioneer of ICU ventilators was the Puritan-Bennett® MA-1. This ventilator was compact, powerful, durable, and more innovative in function and design compared to the other options at the time. However, it was inflexible compared to the current standard mechanical ventilators because it only has a time-cycled, flow

regulated breath with a needle indicator for airway pressure monitoring and a standardised exhalation bellows for tidal volume monitoring. There was no display monitor for flow and pressure waveforms. In addition, the key alarms were attached outside of the ventilator which did not allow a closed-suction system. Interestingly, it also delivered a scheduled sighs breath when delivering smaller breath.[5]

The prescription for ventilation at the time were big tidal volumes of 10-20ml/kg to prevent atelectasis in healthy lungs during surgery and normal blood gas parameters were targeted for all, including those with catastrophic respiratory failure.[6] Only one variable can be manipulated at a time, therefore only permitting sequential adjustment of frequency, flow rate and tidal volume without pressure assisted modes available. Positive End Expiratory Pressure (PEEP) was included by adding an external valve with high resistance to the breathing circuit.[7] Initially, the main objective for mechanical ventilation was to restore patient oxygenation and ventilation according to the physician's interpretation of patients' need (Figure 1(a)).

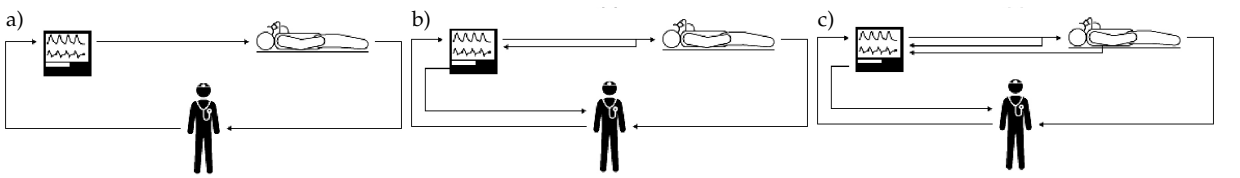

Figure 1: Evolution of mechanical ventilation concept: (a) The first mechanical ventilation was not equipped with sensors, (b) Mechanical ventilators monitor all the ventilation parameters, allowing both closed-loop control of the generated waveforms and providing information to the clinicians, and (c) Mechanical ventilator monitors the condition of the patients and automatically adjusts the ventilation parameters on the basis of patients' needs. Reproduced with permission of the © ERS 2021: Breathe Jun 2017, 13 (2) 84-98; DOI: 10.1183/20734735.007817

THE CONVENTIONAL OR CLINICIAN-ORIENTED MECHANICAL VENTILATION

Adult respiratory distress syndrome (ARDS) was described in late 1960s and the role of PEEP has been part of its treatment.[8,9] The only available trigger assisted mode for adult patients at the time was the assist-control ventilation with square wave flow. Ventilation prescription at that time gave rise to problems of barotrauma. Hence, this has become a central drive to develop new approaches of ventilation for respiratory failure to prevent issues with barotrauma. Prolonged ventilation using high pressure endotracheal intubation often gave rise to significant and perpetual tracheolaryngeal injuries. Other issues such as partially assisted ventilation, methods to mend the respiratory muscles and assessment of patient readiness to be liberated from mechanical ventilation were among the preoccupying concerns of the time.[10]

To address these issues efficiently, the newer ventilators offer a better monitoring of performance and introduction of new modes such as the synchronised intermittent mandatory ventilation (SIMV) and PEEP without assisted breathing.[11] Further advancement includes microprocessor controls and screen display of pressure and flow into the machine, allowing more significant findings related to work of breathing, ventilator synchrony and the impacts of tunings of the ventilator parameters such as frequency, PEEP, peak flow, and triggering.[12] Findings from laboratory and clinical investigations throughout the 1970s and 1980s revealed the potential hazards caused by mechanical ventilation thus highlighting the importance of partial assistance mode and integrated pressure and flow waveform display.[13,14] This allowed clinicians to set the ventilator and the ventilator will monitor the feedback and display in the monitor for the clinicians to adjust accordingly (Figure 1(b)).

Pressure regulated modes of ventilation such as pressure support, pressure control and their variants were developed to improve the safety of the ventilation changes requirements of patients with cardiorespiratory failure. Pressure support ventilation with the ability to adapt to the patient's changing flow demands was developed in the mid-1970s.[15] Since then, pressure support, assist-control and SIMV with either flow-controlled or pressure-controlled ventilation have become the modes of choice for more than 30 years. Various research and clinical trials have been conducted on mechanical ventilation assessing the efficiency of gas exchange and approaches of lung protection strategies.[16,17]

Current generation technology allows numerous knowledge related to iatrogenic upper airway injury, lung parenchymal injury, and effects of dyssynchrony.[18] Patient interaction with the ventilator, specifically the inappropriate timing and delivery of a mechanical breath in response to patient effort-termed ventilator dyssynchrony (VD) - likely further potentiates ventilator induced lung injury (VILI).[19] These hazardous patient ventilator interactions have recently been termed patient self-inflicted lung injury (P-SILI) and minimising such interactions to reduce volutrauma, barotrauma, atelectrauma, and biotrauma has been the main focus of research. Conventional mechanical ventilation approaches are more clinician-oriented despite the integration of pressure support ventilation.

PROPORTIONAL MODES AS PATIENT-ORIENTED MECHANICAL VENTILATION

The increasing awareness regarding the deleterious effects of conventional mechanical ventilation and the advancement of the microprocessor technology had allowed the modern ventilator to provide more complex functions that can easily be adjusted by selecting different modes or programmes e.g., changing from a volume-control to a pressure-control mode. In addition, modern ventilators can analyse the sophisticated signal processing of the measurements provided by the sensors, leading to better accurate measurements and better algorithms to filter noise and artifacts, and capable of generating new information by analysing and integrating multiple parameters. This extended information enables the ventilator to optimise the ventilation according to the patient's need. These "close-loop" ventilation strategies are the focus of patient-oriented mechanical ventilation (Figure 1(c)).

Recently, ventilator developments are focused on patient-oriented or more physiologic in nature such as proportional assist ventilation and neurally adjusted ventilatory assist. However, more studies are needed to unravel the imperfect integration with patients' neural demands and physiologic requirements. The emphasis of current scientific investigations in mechanical ventilation are still with regards to patients' safety and synchrony.

Proportional mode of ventilation operates by amplifying the effort of the patient's respiratory muscle activity leading to the delivery of required amount of support thus adjusting the imbalance between patient's capacity and demand and at the same time achieving the patient's ventilation goal. This mode can provide protection to the lung and respiratory muscle by preserving the patient's control of ventilation against overdistention and over-assistance by mechanical ventilators, therefore minimising the development of diaphragm disuse atrophy.[20,21] Proportional mode is profoundly different from other conventional partially assisted modes of mechanical ventilation. In this mode, the assisted inspiratory breath provided is in synchrony with the patient's attempt during the total inspiratory cycle that directly responds to the changes of patient's ventilatory demands.[22] In conventional partially supported modes such as pressure support ventilation (PSV), similar pressure is delivered for each breath regardless of the patient's demand, effort and timing. Therefore, patient-ventilator dyssynchrony and ventilator over-assistance are common and often unnoticed by clinicians when conventional mode such as PSV are being used.[23,24]

Proportional modes available in current practice are proportional assist ventilation with load-adjustable gain factor (PAV+)[25] and neurally adjusted ventilator assist (NAVA).[26] Both have similar physiological

effects but differ in the signal used to estimate the patient's demand. The PAV+ mode estimates the patient's demand in proportion to the flow and volume generated by the patient's inspiratory effort or muscular pressure (Pmus) which was derived from continuous automatic measurements of respiratory mechanics of the equation of motion of the respiratory system. Meanwhile, the NAVA mode uses the diaphragm electrical activity (EAdi) as a surrogate of central respiratory drive.[27] Proportional modes are able to simplify delivery of assisted mechanical ventilation as the patient himself/herself can control the amount of assist that is needed from the mechanical ventilation.[28] A vital task is to titrate the optimal inspiratory assist level at the bedside that varies between patients and throughout the duration of respiratory support.

The important barrier in practicing proportional mode is inexperience with the settings which differ from the conventional modes. The main bedside challenge is that inspiratory assist setting is not based on the commonly used variables such as tidal volume or partial pressure carbon dioxide. Furthermore, the safe respiratory effort target varies between patients, depending on the seriousness of lung disease and diaphragmatic function. Uncertainties of inspiratory support with PAV+ and NAVA is one of the reasons for limited data that prove clinical benefits on patient outcomes as compared to conventional mode.[29] However, recent evidence showed clinical advantages of NAVA in comparison to PSV in difficult-to-wean critically ill patients.[30]

Another option of a patient-oriented or close-loop ventilation system is the automated or 'smart' mechanical ventilation. It is a dual control system where the clinician sets a target tidal volume, and the ventilator microprocessor monitors tidal volume for decision making while adjusting the inspiratory pressure to maintain the generated tidal volume within specified limits.[31] This automated control of the pressure support ventilation system or smart ventilator aims to keep patients in "comfort zone" that is defined by a combination of tidal volume, respiratory rate, and end tidal carbon dioxide. It also targets to gradually reduce the inspiratory pressure. This not only benefits the patients, but it will also reduce the workload of clinician and may reduce the complications related to human error.[32]

THE FUTURE OF SMART MECHANICAL VENTILATION

The future ventilator should not only be able to deliver adequate oxygenation and ventilation but also be able to recognise the ineffective efforts or dyssynchrony and adapt to the patient's need that varies at different points of the course of mechanical ventilation. It also should be able to offer meaningful alarms that would assist the attending clinician to recognise dyssynchrony and to empower the patient to further enhance their work of breathing that should be improved with treatment, with minimal discomfort or events. This is possible with the high accuracy sensors and the utilisation of artificial intelligence to optimise the ventilation according to the patient's need at any point of time.

CONCLUSION

The concept of mechanical ventilation is changing from the conventional clinician-oriented approach to the patient-oriented approach. Conventional mechanical ventilation with partially assisted breath which is a clinician-oriented approach often results in ventilator over-assistance and poor patient-ventilator coordination, which are often overlooked. The evolution to a patient friendly mechanical ventilation that is more physiologic will improve the synchrony between patient and ventilator, and potentially provides protection to both lung and diaphragm during mechanical ventilation of the critically ill. Patient-oriented ventilation requires clinician to set parameters to attain a certain ventilatory goal compared to clinician-driven ventilator parameters adjustment in conventional ventilation.

References

1. Weil MH, Tang W. From intensive care to critical care medicine: a historical perspective. *Am J Respir Crit Care Med* 2011;**183**:1451-3

2. Drinker P, McKhann CF. Landmark article May 18, 1929: The use of a new apparatus for the prolonged administration of artificial respiration. I. A fatal case of poliomyelitis. By Philip Drinker and Charles F. McKhann. *JAMA* 1986;**255**:1473-5

3. Barach Al, et al. Studies on positive pressure respiration; general aspects and types of pressure breathing; effects on respiration and circulation at sea level. *J Aviat Med* 1946;**17**:290-32

4. Colice, Gene L. "Historical perspective on the development of mechanical ventilation." Principles and practice of mechanical ventilation 2 1994:1-36

5. Housley E, Louzada N, Becklake MR. To sigh or not to sigh. *Am Rev Respir Dis* 1970;**101**:611-4

6. Bendixen HH, Hedley-Whyte J, Laver MB. Impaired oxygenation in surgical patients during general anesthesia with controlled ventilation. A concept of atelectasis. *N Engl J Med* 1963;**269**:991-6

7. Marini JJ, Culver BH, Kirk W. Flow resistance of exhalation valves and positive end-expiratory pressure devices used in mechanical ventilation. *Am Rev Respir Dis* 1985;**131**:850-4

8. Ashbaugh DG, Bigelow DB, Petty TL, Levine BE. Acute respiratory distress in adults. *Lancet* 1967;**2**:319-23

9. Derenne JP, Macklem PT, Roussos C. The respiratory muscles: Mechanics, control, and pathophysiology. Part 2. *Am Rev Respir Dis* 1978;**118**:373-90

10. Downs JB, Klein EF Jr, Desautels D, Modell JH, Kirby RR. Intermittent mandatory ventilation: a new approach to weaning patients from mechanical ventilators. *Chest* 1973;**64**:331-5

11. Pepe PE, Marini JJ. Occult positive end-expiratory pressure in mechanically ventilated patients with airflow obstruction: the auto-PEEP effect. *Am Rev Respir Dis* 1982;**126**:166-70

12. Dreyfuss D, Saumon G. Ventilator-induced lung injury: lessons from experimental studies. *Am J Respir Crit Care Med* 1998;**157**:294-323

13. Webb HH, Tierney DF. Experimental pulmonary edema due to intermittent positive pressure ventilation with high inflation pressures. Protection by positive end-expiratory pressure. *Am Rev Respir Dis* 1974;**110**:556-65

14. Darioli R, Perret C. Mechanical controlled hypoventilation in status asthmaticus. *Am Rev Respir Dis* 1984;**129**:385-7

15. Ip T, Mehta S. The role of high-frequency oscillatory ventilation in the treatment of acute respiratory failure in adults. *Curr Opin Crit Care* 2012;**18**:70-9

16. Acute Respiratory Distress Syndrome Network, Brower RG, Matthay MA, Morris A, Schoenfeld D, Thompson BT, Wheeler A. Ventilation with lower tidal volumes as compared with traditional tidal volumes for acute lung injury and the acute respiratory distress syndrome. *N Engl J Med* 2000;**342**:1301-8

17. McIntyre RC Jr, Pulido EJ, Bensard DD, Shames BD, Abraham E. Thirty years of clinical trials in acute respiratory distress syndrome. *Crit Care Med* 2000;**28**:3314-31

18. Thille AW, Rodriguez P, Cabello B, Lellouche F, Brochard L. Patient-ventilator asynchrony during assisted mechanical ventilation. *Intensive Care Med* 2006;**32**:1515-22

19. Gilstrap D, MacIntyre N. Patient-ventilator interactions. Implications for clinical management. *Am J Respir Crit Care Med* 2013;**188**:1058-68

20. Vaporidi K. NAVA and PAV+ for lung and diaphragm protection. *Curr Opin Crit Care* 2020;**26**:41-46

21. Younes M. Proportional assist ventilation, a new approach to ventilatory support. Theory. *Am Rev Respir Dis* 1992;**145**:114-20

22. Suarez-Sipmann F; Acute Respiratory Failure Working Group of the SEMICYUC. New modes of assisted mechanical ventilation. *Med Intensiva* 2014;**38**:249-60

23. Kondili E, Prinianakis G, Georgopoulos D. Patient-ventilator interaction. *Br J Anaesth* 2003;**91**:106-19

24. Colombo D, Cammarota G, Alemani M, Carenzo L, Barra FL, Vaschetto R, Slutsky AS, Della Corte F, Navalesi P. Efficacy of ventilator waveforms observation in detecting patient-ventilator asynchrony. *Crit Care Med* 2011;**39**:2452-7

25. Sinderby C, Navalesi P, Beck J, Skrobik Y, Comtois N, Friberg S, Gottfried SB, Lindström L. Neural control of mechanical ventilation in respiratory failure. *Nat Med* 1999;**5**:1433-6

26. Younes M, Kun J, Masiowski B, Webster K, Roberts D. A method for noninvasive determination of inspiratory resistance during proportional assist ventilation. *Am J Respir Crit Care Med* 2001;**163**:829-39

27. Xirouchaki N, Kondili E, Klimathianaki M, Georgopoulos D. Is proportional-assist ventilation with load-adjustable gain factors a user-friendly mode? *Intensive Care Med* 2009;**35**:1599-603

28. Telias I, Brochard L, Goligher EC. Is my patient's respiratory drive (too) high? *Intensive Care Med* 2018;**44**:1936-9

29. Hadfield DJ, Rose L, Reid F, Cornelius V, Hart N, Finney C, Penhaligon B, Molai J, Harris C, Saha S, Noble H, Clarey E, Thompson L, Smith J, Johnson L, Hopkins PA, Rafferty GF. Neurally adjusted ventilatory assist versus pressure support ventilation: a randomized controlled feasibility trial performed in patients at risk of prolonged mechanical ventilation. *Crit Care* 2020;**24**:220

30. Branson RD, Johannigman JA, Campbell RS, Davis K Jr. Closed-loop mechanical ventilation. *Respir Care* 2002;**47**:427-5

31. Dojat M, Harf A, Touchard D, Lemaire F, Brochard L. Clinical evaluation of a computer-controlled pressure support mode. *Am J Respir Crit Care Med* 2000;**161**:1161-6

Evolution and Assessment of Biomarkers in Perioperative and Critical Care Medicine

Azrina Md Ralib[1,2], Afif Hakimi Aidid[2], Mohd Amiruddin Mohd Nor[2], Ahmad Akmal Aziz[2], Soo Ki Yang[1]

[1]Department of Anaesthesiology and Intensive Care, Kulliyyah of Medicine, International Islamic University Malaysia, Pahang, Malaysia

[2]Department of Anaesthesiology and Intensive Care, Sultan Ahmad Shah Medical Centre (SASMEC@ IIUM), Pahang, Malaysia

There has been increasing interest in the use of biomarkers in the medical fraternity. Specifically, in perioperative and critical care medicine, biomarkers are usually used for diagnostic, risk stratification and prognostic purposes. However, over-emphasising on biomarkers alone could be misleading, hence the role of biomarkers should be utilised concomitantly with clinical parameters. This article provides an overview of the roles of biomarkers in the perioperative and critical care medicine, with brief description of the current and novel biomarkers. Further depth on sepsis biomarkers is discussed due to its high prevalence and high mortality in our setting. Finally, assessment of biomarkers performed in the research setting is also discussed, as this could assist clinicians to evaluate the available evidence and plan for future research.

INTRODUCTION

Precision-based medicine has gained popularity over the past decades. It uses the available clinical, biological, and environmental data of patients to guide clinical decisions.[1,2] Biomarkers can assist in delivering precision-based medicine. By definition, a biomarker is *"a characteristic that is objectively measured and evaluated as an indicator of normal biological processes, pathogenic processes or pharmacological responses to a therapeutic intervention."*[3] The term biomarker historically is referred to analytes in biologic samples that predict a patient's disease state. Over time, the term has evolved to any biologic measurements including genomic or proteomic analyses that could indicate an underlying physiologic and pharmacologic mechanism.[4]

The ideal biomarker should be capable of discriminating pathological from normal cases, expressed early in disease progression, easy to assay, inexpensive, well tolerated, convenient, and reproducible. Up to date, there are thousands of new biomarkers that are being studied and identified each year. This could assist clinicians in providing a better understanding of their pathophysiology mechanism, which is helpful in the process of clinical decision. However, postoperative and critically ill patients usually had varying degrees of inflammation, infection, and concomitant organ dysfunction or failure, and these pose challenges in biomarker development and use in this area. We explore the use of current and novel biomarkers specifically in the perioperative and critical care medicine.

Sepsis, a condition characterised by a dysregulated host response to an infection, afflicts millions of people worldwide each year.[5] It was the leading cause of mortality in hospitals and hence a major financial burden on our national healthcare system. About 52.0% and 52.8% in-hospital mortality occurred due to sepsis in 2016 and 2017 respectively.[6,7] Diagnosing sepsis early has become of importance as early administration of antibiotics can reduce the morbidity and mortality associated with sepsis. Microorganism-directed test is considered the gold standard to diagnose infection, however this takes at least 24 to 48 hours to process.[8] In addition, almost half of patients with a suspected systemic infection have negative culture results.[9] Biomarker for sepsis was discussed in a separate subchapter.

Finally, we discussed the statistical methods commonly employed in assessment of biomarkers. This is important as understanding the method of assessment of biomarkers conducted in a clinical research setting could assist clinicians in evaluating available evidence and planning for future research.

BIOMARKERS IN PERIOPERATIVE MEDICINE

Generally, the main roles of a biomarker includes diagnosis of a disease, severity assessment, risk assessment, predictions of drug effect and monitoring effect of drug or progression of disease. A biomarker may serve a variety of roles as it may provide a diagnosis or be used for risk/severity assessment. The purpose of diagnostic and prognostic settings differs, in the diagnostic setting, the outcome has occurred, whereas in the prognostic setting, the outcome remains to be determined and can only be projected as a probability or a risk. In perioperative medicine, biomarkers have potential roles in diagnosis, monitoring and therapy throughout the preoperative assessment, intraoperative period and postoperative outcomes (Table I).[10] This framework could guide researchers and clinicians in developing specific biomarkers for the various aspects of the perioperative period.

Table I: Potential Roles of Biomarkers in the Perioperative Period

Stages	Diagnosis	Monitoring	Therapy
Preoperative assessment	Undiagnosed comorbidity Sub-clinical organ damage Immunosuppression Metabolism of drugs Risk of postoperative nausea and vomiting	Primary prevention Secondary prevention of underlying disease	Postoperative care environment Preventive measures Pre-emptive drug therapy Informed consent
Intraoperative period	Early organ injury Coagulation dysfunction Drugs interactions	Organ function Coagulation Depth of anaesthesia Response to drugs	Fluid therapy Organ protection Titration of drugs
Postoperative outcomes	Infection Thrombosis Organ Injury Drug interactions	Organ function Immune recovery Physical recovery Psychological recovery Response to drugs	Organ protection Regional antibiotic use Drug/fluid therapy Immunomodulation Rehabilitory therapy

Adapted from Edwards *et al.*, (2011)[10]

The number of patients undergoing major surgeries is increasing and most of them have associated comorbidities and are in the older age groups.[11] Hence, preoperative risk stratification utilising multifactorial assessment of clinical information and biomarkers is important. A good and reliable biomarker could add important new information and influence the risk stratification process. The most important parameter for reliable biomarkers is the ability to appropriately allocate patients to both higher or lower risk categories.[12] Identification of higher risk groups would be significantly beneficial as necessary steps and treatment will be taken preoperatively.

Preoperative biomarker work has mainly focused on cardiovascular risk, in particular, cardiac ischaemia. However, other risk factors including kidney, infection/inflammation, respiratory, and haematological have become increasingly important as these factors have been shown to have negative impact on perioperative morbidity and mortality. Development of novel biomarkers that could assess these risks should be made a priority as this can greatly help reduce the percentage of morbidity and mortality of high risk patients going for surgery (Table II).[10,13] These biomarkers are developed based on the mechanistic understanding of the pathophysiology specific to each organ, however there are lack of researches available in exploring

the impact of these biomarkers on perioperative morbidity and mortality. In addition, biomarkers should not be used as a standalone, but must be analysed concomitantly with clinical parameters.

In the past 30 years, several risk indices for perioperative cardiac mortality and morbidity have been developed, including the Goldman Cardiac Risk Index,[14] Lee's Revised Index,[15] and more recently, the American College of Surgeons National Surgical Quality Improvement Program.[16] These indices incorporate clinical parameters along with biomarkers assays. Future works could concentrate in incorporating these novel biomarkers with clinical parameters to produce a more refined clinical risk prediction.

Acute Kidney Injury (AKI) is common, occurring in 10 to 30% perioperatively,[17] and this can lead to increased morbidity and mortality. Current consensus of AKI definition was based on serum creatinine and urine output criteria as in the Kidney Disease in Improving Global Outcome (KDIGO) 2012 guideline.[18] However, both have limitations for early detection, and this present a diagnostic challenge that precludes good interventional study that impede development of novel pharmacologic therapy. Newer biomarkers offer a better diagnostic opportunity and provide better risk stratification, however is limited by cost and availability.

Table II: Current and Novel Perioperative Biomarkers in Preoperative Risk Assessment

Domain	Current Biomarkers	Novel Biomarkers	Potential Utility
Cardiovascular	Cardiac troponins T and I Brain natriuretic peptide and N-terminal pro-BNP Creatine kinase, Creatine kinase MB isoenzyme Lactate dehydrogenase Aspartate aminotransferase	Heart-type fatty acid binding protein MicroRNA Cardiac MRI	Early marker of postoperative cardiac injury Non-invasive detection of coronary artery disease
Kidney	Serum Creatinine Urine Output Blood Urea Nitrogen	Neutrophil gelatinase associated lipocalin Interleukin-18 Kidney injury molecule 1 Liver-type fatty acid binding protein Cystatin C	Early postoperative markers of kidney injury
Infection/ inflammation	C-Reactive Protein	Monocyte HLA-DR expression	Lower HLA-DR associated with increased mortality in trauma and sepsis
		Procalcitonin	Marker of sepsis severity
Respiratory	PaO_2/FiO_2	Exhaled nitric oxide and inflammatory markers in exhaled breath condensate	Explored as markers of airway inflammation in asthma/chronic obstructive pulmonary disease
Haematological	Platelet PT/APTT D-Dimer Fibrinogen	Thromboelastography	Predicts thrombotic postoperative complications

Adapted from Edwards *et al.*, (2011)[10] and Janković *et al.*, (2017) [13]

BIOMARKERS IN CRITICAL CARE MEDICINE

Although the development of biomarkers has increased exponentially, the use of biomarkers in critical illness has been much slower. This is partly due to the heterogeneous nature of critical illness, rather than consisting of clearly defined, homogeneous as in other disease states.[19] Generally, biomarkers used in this area can be divided into diagnostic and response biomarkers (Table III). Diagnostic biomarkers enable identification of disease states in the critically ill, and it can include assessment of susceptibility/risk, prognostic and predictive functions. Response biomarkers include monitoring, pharmacodynamic and safety assessments, and it can help guide treatment decisions to optimise patient outcomes.

Table III: Potential Roles of Biomarkers in Critical Care

General Roles	Specific Roles	Examples
Diagnostic	Diagnostic	Infection for early antibiotic therapy
	Susceptibility/risk	ARDS, risk of respiratory arrest
	Prognostic	Risk of multiple organ failure/death
	Predictive	Good outcome for ICU discharge
Response	Monitoring	Fluid status for fluid management
	Pharmacodynamic/response	Serial sepsis biomarkers to guide duration of antibiotic therapy
	Safety	Chloride levels to stop saline infusion

Adapted from Vincent *et al.*, (2020)[19]

In addition, biomarkers can provide important information in regard to organ function in critically ill patients. There is an increasing trend in developing biomarkers that can detect specific organ injury or trauma with the advancement of proteomic and genomic techniques. Each organ express its own molecular biomarkers. The concentration of these molecular biomarkers are highest in the presence of organ injury.[20] The most important form of diagnostic assessment for organ injury is by clinical examination and imaging, however augmenting information with molecular biomarkers provides advantages. There are several types of novel molecular biomarkers presented as protein or its cleaved fragments, a post-translationally modified protein, modified lipid, metabolite, messenger RNA or microRNA (Table IV). The presence of these biomarkers could offer information on specific signals occurring in each organ that has specific therapeutic implications.[19]

Table IV: Organ Specific Biomarkers

Organ	Signal	Current Biomarkers	Novel Biomarkers	Examples of therapeutic Implications
Brain	Encephalopathy Cell alterations		SB100 Neurone- Specific Enolase Ubiquitin carboxyl-terminal esterase-L1 Glial Fibrillary Acidic Protein	Cerebral/metabolic support Adapted monitoring Therapeutic limitation

Organ	Signal	Current Biomarkers	Novel Biomarkers	Examples of therapeutic Implications
Respiratory	Overdistension/ parenchymal alterations Respiratory muscle and diaphragmatic dysfunction	PaO_2/FiO_2	Club cell protein 16 Leukotrine B-4 Soluble receptor for advanced glycation end products Soluble intracellular adhesion molecule-1 Von Willebrand factor	Decrease tidal volume Adjust PEEP level Start corticosteroids
Cardiovascular	Risk of myocardial ischemia Altered cell oxygen supply	Cardiac troponins T and I Brain natriuretic peptide and N-terminal pro-BNP Creatine kinase, Creatine kinase MB isoenzyme Lactate dehydrogenase Aspartate aminotransferase	Heart-type fatty acid binding protein MicroRNA Cardiac MRI	Need for percutaneous coronary angioplasty Antiplatelet agent Myocardial protective substance
Kidney	Altered perfusion Impending injury	Serum Creatinine Urine Output Blood Urea Nitrogen	Neutrophil gelatinase-associated lipocalin Clusterin Kidney injury molecule 1 Liver-type fatty acid binding proteins	Fluids Renal protective agents Specific vasoactive agent Start renal replacement therapy Expect long-term failure
Haematology	Subtle coagulopathy Endothelial activation	Platelet PT/APTT D-Dimer Fibrinogen Protein C		Adjust (anti) haemostatic agents Give an anticoagulant/ endothelial
Gastrointestinal/ Pancreas	Dysfunction		Intestinal-type fatty acid binding protein	Withhold enteral nutrition Give a specific nutrient
Pancreas	Dysfunction	Serum Lipase and Amylase	miR-216a	Diagnose trauma for early intervention

Organ	Signal	Current Biomarkers	Novel Biomarkers	Examples of therapeutic Implications
Spleen	Dysfunction		Howell-Jolly bodies pitted cell counts	Diagnose trauma for early intervention
Liver	Dysfunction	Alanine aminotransferases (ALT) Aspartate aminotransferases (AST) Alkaline phosphatase Gamma glutamyl transferase Bilirubin	AST Type 1 Ratio of AST/ALT Caspase-generated fragments of cytokeratin-18 Arginosuccinate synthetase Sulfotransferase 2A1 Carbamoylphosphate synthase-1	Liver protective agent Need for liver transplantation
Metabolic/ Immune	Deficiencies Inflammation/ Infection	Thiamine Lactate Procalcitonin C-Reactive Protein		Add proteins, amino acids Add vitamins and other trace elements

Adapted from Vincent *et al.*, (2020),[19] and Jeter *et al.*, (2014)[5]

SEPSIS BIOMARKERS

Biomarkers could improve clinical management in critically ill patients with sepsis by serving three functions, namely (1) to improve infection diagnosis, (2) to help in the early risk stratification and prognostication, and (3) to optimise therapeutic decisions, for example in antibiotic stewardship.[9] At least 178 different sepsis biomarkers have been reported in the literature in 2010, reflecting the complex pathophysiology of sepsis which includes inflammation, complement, coagulation, and apoptosis.[9] If sepsis results in organ dysfunction, specific organ specific biomarkers can be used to evaluate the extent of organ injury and are useful for prognostication (Table III).

Serum procalcitonin is the most promising biomarker in sepsis and has been used in clinical practice.[21,22] However, its use is limited due to cost and its utility in patients undergoing renal replacement therapy which is common in the critically ill.[23] Several other potential biomarkers for sepsis have been recognised, but none has adequate specificity or sensitivity to characterise by itself (Table V).[24,25] Due to the complexity of sepsis pathophysiology, a combination of several sepsis biomarkers from distinct pathways with clinical parameters may be more specific and sensitive in diagnosing sepsis and predicting outcome.[26] Nevertheless, advance research is needed to investigate the optimal use of biomarkers in fusion with microorganism-directed tests.

Table V: Diagnostic and Prognostic Biomarkers of Sepsis

Biomarkers	Physiology
Procalcitonin (PCT)	A prohormone of calcitonin produced by C-cells of the thyroid gland and intracellularly cleaved by proteolytic enzymes into the active hormone. PCT secretion is up-regulated by microbial toxins and bacterial-specific mediators.
C-Reactive Protein (CRP)	Acute phase plasma protein synthesised by hepatocytes, its plasma concentration rises in response to infection or systemic inflammation.
Presepsin	A protein that is generated as the body response to bacterial infection. Its production is induced by phagocytosis of bacteria. The level of presepsin reflect the severity of infection rather than the degree of inflammation.
Plasma chitotriosidase activity	Synthesised and secreted by specifically activated macrophages.
Interleukin-27	A heterodimeric cytokine formed by antigen presenting cells upon expose to microbial products and inflammatory stimuli.
Hepcidin	A peptide hormone of hepatic origin that interfere with the access of microorganism to iron. Its synthesis in the liver is induced by IL-6 in response to inflammation.
Macrophage migration inhibitory factor	Produced by a variety of cell types in addition to immune cells such as monocytes/ macrophages, B- and T-cells. Rapidly released in response to stimuli, such as microbial products, proliferative signals and hypoxia.
Adrenomedullin Proadrenomedullin	Upregulated in different tissues in several conditions (systemic inflammatory response syndrome, shock, cellular hypoxia, oxidative stress, myocardial injury, and sepsis).
Endothelial Markers	Endothelial dysfunction during sepsis and its association with adverse outcomes has been found to be an important contributor to sepsis morbidity.
Genetic Sepsis Markers	Association between specific DNA polymorphisms and function of the gene products produced in response to pathogenic stimuli. Have been implicated in sepsis mortality.

Adapted from Eva *et al.*, (2019),[9] Limongi *et al.*, (2016)[23] and Schuetz *et al.*, (2015)[24]

ASSESSMENT OF BIOMARKER PERFORMANCE: STATISTICAL METHOD AND MACHINE LEARNING

Understanding the method of assessment of biomarkers conducted in a clinical research setting is important to assist clinicians in evaluating available evidence and planning for future research. There is no standardization of the methodology and biostatistics of the biomarkers' studies, and they are often presented with poor biostatistics and methodologic issues that limit reliable and reproducible scientific message.[27] We describe four commonly used assessments that have been used in the development and evaluation of biomarkers in literature.

Receiver Operating Characteristics

The use of the area under curve (AUC) of the receiver operating characteristic (ROC) curve has become the most popular metric for assessment of new biomarkers against a gold standard.[28] It is a measure of discrimination; that is how well a given test separates those with and without disease as determined by the gold standard.[29] The ROC curve is a graphical plot of sensitivity (true positive rate) against 1-specificity (false positive rate) across a series of cut-off points (e.g. biomarkers concentration). The AUC ranges from 0.5 (no discrimination) to 1 (perfect discrimination), with clinical validity assumed at more than 0.70. The calculation of the AUC is based on rank, merely considering the comparative rank between those with and without the disease. It does

not consider the extent of change of the biomarker or its distribution. Any change of rank in those at low distribution will have the same impact in those at high distribution.

Risk Stratification Analysis

Due to the limitation of the AUC, there is a growing interest in new metrics using a more comprehensive risk stratification analysis to assess improvement of biomarker performance to the established marker. These include the integrated discrimination improvement (IDI) and net reclassification improvement (NRI).[30,31] These analyses consider both the improvement in risk in prediction of an event, and the reduction of risk in prediction of a non-event. Limitation of NRI is the need for pre-determined risk cut-off points to allocate patients to risk groups. NRI is calculated based on the direction of change in risk for each individual from the reference test, however, the extent of change is not considered. The IDI was designed to address this issue. The IDI measures the extent of change of increased risk for those who had an event (IDI_{event}) and decreased risk for those without the event ($IDI_{non\text{-}event}$). Several studies in AKI biomarkers have integrated the use of IDI or NRI in the analysis of biomarker performance.[32-34]

Decision Curve Analysis

Decision curve analysis is a new concept that can be used to evaluate a predictor for an event as a probability threshold (outcome) is varied.[35] It calculates a clinical "net benefit" for a prediction model or diagnostic test, defined as the minimum probability of disease at which further intervention would be warranted, as net benefit = sensitivity x prevalence - (1 - specificity) x (1 - prevalence) x w where w is the odds at the threshold probability.[36,37] Decision curve plot has the y-axis as the benefit of a model or test (correctly identified), and the x-axis as the preference (or outcome), and it includes results for "intervention for all" and "intervention for none". Recent years have showed an increasing use of this analysis and has been recommended by top journals.[36]

Machine Learning Prediction Model

In recent years, machine learning techniques have gained more popularity and have been widely applied in biomarker discovery.[38,39] Machine learning applies mathematical approaches to train a model to learn from data for a particular task. It comprises a collection of algorithms that can support the procedure of classification, prediction, and pattern recognition.[40] Several studies have shown that the machine learning prediction models performed better than the traditional risk predictors, including in sepsis prediction.[38,39,41]

CONCLUSION

Development of biomarkers in the postoperative and critically ill patients present challenges due to the presence of varying degrees of inflammation, infection, and concomitant organ dysfunction or failure. The availability of highly sensitive and specific biomarkers could assist clinicians to objectively diagnose, risk-stratify, monitor response and predict outcome. Several biomarkers that are available could be incorporated with other clinical parameters to assist the clinical decision making. Novel biomarkers that are being developed allow in-depth understanding of the pathophysiology involved and open avenues for further research in this area. Biomarkers have a strong impact on clinical medicine and have changed the way we care for patients today.

ACKNOWLEDGEMENT

This was partly funded by the Ministry of Higher Education Fundamental Research Grant Scheme (FRGS/1/2019/SKK02/UIAM/02/1, FRGS19-184-0793)

References

1. Collins FS, Varmus H. A new initiative on precision medicine. *N Engl J Med* 2015;**372**:793-5

2. Seymour CW, Gomez H, Chang C-CH, et al. Precision medicine for all? Challenges and opportunities for a precision medicine approach to critical illness. *Crit Care* 2017;**21**:257

3. Atkinson AJ, Colburn WA, DeGruttola VG, DeMets DL, Downing GJ, Hoth DF et al. Biomarkers and surrogate endpoints: Preferred definitions and conceptual framework. *Clin Pharmacol Ther* 2001;**69**:89-95

4. Baker M. In biomarker we trust? *Nature Biotechnol* 2005;**23**:297-304

5. Fleischmann C, Scherag A, Adhikari NKJ, Hartog CS, Tsaganos T, Schlattmann, P et al. Assessment of Global Incidence and Mortality of Hospital-treated Sepsis. Current Estimates and Limitations. *Am J Respir Crit Care Med* 2016;**193**:259-72

6. Ling TL, Har LC, Nor MRB, Ismail NIB, & Ismail WNB. Malaysian Registry of Intensive Care Report for 2016. www.mric.org.my

7. Ling TL, Har LC, Nor MRB, Ismail NIB, & Ismail WNB. Malaysian Registry of Intensive Care Report 2017. www.mric.org.my

8. Carrigan SD, Scott G & Tabrizian M. Toward resolving the challenges of sepsis diagnosis. *Clin Chem* 2004;**50**:1301-14

9. Eva Heilmann, Claudia Gregoriano, Philipp Schuetz Biomarkers of Infection: Are They Useful in the ICU? *Semin Respir Crit Care Med* 2019;**40**:465-75

10. Edwards M, Whittle J & Ackland GL. Biomarkers to guide perioperative management. *Postgrad Medical J* 2011:**87**:542-549

11. Bettelli G. Preoperative evaluation in geriatric surgery: comorbidity, functional status and pharmacological history. *Minerva Anestesiol* 2011;**77**:637-46

12. Tzoulaki I, LiberopoulosG, Ioannidis JP. Use of reclassification for assessment of improved prediction: an empirical evaluation. *Int J Epidemiol* 2011;**40**:1094-105

13. Jankovi RJ, Markovi DZ, Sokolovi DT, Zdravkovi I & Sorbello M. Clinical indices and biomarkers for perioperative cardiac risk stratification: an update. *Minerva Anestesiol* 2017;**83**:392-401

14. Goldman L, Caldera DL, Nussbaum SR, Southwick FS, Kroqstad D, Murray B et al. Multifactorial index of cardiac risk in noncardiac surgical procedures. *N Engl J Med* 1977;**297**:845-50

15. Lee TH, Marcantonio ER, Mangione CM, Thomas EJ, Polanczyk CA, Cook EF, et al. Derivation and prospective validation of a simple index for prediction of cardiac risk of major noncardiac surgery. *Circulation* 1999;**100**:1043-9

16. Gupta PK, Gupta H, Sundaram A, Kaushnik M, Fang X, Miller WJ et al. Development and validation of a risk calculatorfor prediction of cardiac risk after surgery. *Circulation* 2011;**124**:381-7

17. Canet E, & Bellomo R. Perioperative renal protection. *Curr Opinion In Crit Care* 2018;**24**:568-74

18. Kellum J A, Lameire N, Aspelin P, Barsoum R S, Burdmann E A, Goldstein S L, et al. Kidney disease: improving global outcomes (KDIGO) acute kidney injury work group. KDIGO clinical practice guideline for acute kidney injury. *Kidney Int Suppl* 2012;**2**(1):1-138

19. Vincent JL, Bogossian E, & Menozzi M. The Future of Biomarkers. *Crit Care Clin* 2020;**36**:177-87

20. Jeter C, Hylin MW, Hergenroeder GL, Hill JR, Johnson DA, Barrera J et al., Biomarkers of Organ Injury. *Recent Pat. Biomark* 2014;**2**:98-109

21. Mat-Nor MB, Ralib AM, Abdulah NZ, & Pickering JW. The diagnostic ability of procalcitonin and interleukin-6 to differentiate infectious from non-infectious systemic inflammatory response syndrome and to predict mortality. *J Crit Care* 2016;**33**:245-51

22. Mat Nor MB & Md Ralib A. Procalcitonin clearance for early prediction of survival in critically ill patients with severe sepsis. Crit Care Res Pract 2014 Article ID 819034

23. Limongi D, D'Agostini C & Ciotti M. New sepsis biomarkers. *Asian Pac J Trop Biomed* 2016;**6**:516-9

24. Schuetz P & Plebani M. Can biomarkers help us to better diagnose and manage sepsis? *Diagnosis* 2015;**2**:81-7

25. Honore PM, Jacobs R, Hendrickx I, De Waele E, Van Gorp V, Joannes-Boyau, et al. Biomarkers in critical illness: have we made progress? *Int J Nephrol Renovasc Dis* 2016;**9**:253

26. Shukeri WFWM, Md-Ralib A, & Mat-Nor MB. Derivation of A New Bioscore for Predicting Mortality in Sepsis. Int Medical J Malaysia 2019;18

27. Ray P, Manach YL, Riou B, Houle TT, & Warner DS. Statistical evaluation of a biomarker. *J Am Soc Anesthesiol* 2010;**112**:1023-1040

28. Hanley JA, McNeil BJ: The meaning and use of the area under a receiver operating characteristic (ROC) curve. *Radiology* 1982;**143**:29-36

29. Cook NR: Use and misuse of the receiver operating characteristic curve in risk prediction. *Circulation* 2007;**115**:928-35

30. Pencina MJ, D'Agostino RB, Sr., D'Agostino RB, Jr., Vasan RS: Evaluating the added predictive ability of a new marker: from area under the ROC curve to reclassification and beyond. *Stat Med* 2008;**27**:157-72

31. Pickering JW, Endre ZH: New Metrics for Assessing Diagnostic Potential of Candidate Biomarkers. *Clin J Am Soc Nephrol* 2012;**7**:1355-64

32. Parikh CR, Devarajan P, Zappitelli M, Sint K, Thiessen-Philbrook H, Li S et al. Postoperative biomarkers predict acute kidney injury and poor outcomes after pediatric cardiac surgery. *J of Am Soc Nephrol* 2011;**22**:1737-47

33. Ralib AM, Pickering JW, Shaw GM, Than MP, George PM, & Endre ZH The clinical utility window for acute kidney injury biomarkers in the critically ill. *Crit Care* 2014;**18**:1-13

34. Mat-Nor MB, Ralib AM, Abdulah NZ & Pickering JW. The diagnostic ability of procalcitonin and interleukin-6 to differentiate infectious from noninfectious systemic inflammatory response syndrome and to predict mortality. *J Crit Care* 2016;**33**:245-51

35. Vickers AJ, van Calster B, & Steyerberg EW. A simple, step-by-step guide to interpreting decision curve analysis. *Diagn Progn Res* 2019;**3**:1-8

36. Vickers AJ, Van Calster B, Steyerberg EW. Net benefit approaches to the evaluation of prediction models, molecular markers, and diagnostic tests. *Br Med J* 2016;**352**:i6

37. Fitzgerald M, Saville BR, Lewis RJ. Decision curve analysis. *JAMA* 2015;**313**:409-10

38. Dzaharudin F, Ralib AM, Jamaludin UK, Nor MBM, Tumian A, Har LC. & Ceng TC. Mortality prediction in critically ill patients using machine learning score. *IOP Conference Series: Materials Science and Engineering* 2020;**788**:012029

39. Zhang Z. Machine learning method for the management of acute kidney injury: more than just treating biomarkers individually. Future Med 2019;1251-3

40. Wernick MN, Yang Y, Brankov JG, Yourganov G, & Strother SC. Machine Learning in Medical Imaging. *IEEE Signal Processing Magazine* 2010;**27**:25-38

41. Fleuren LM, Klausch TLT, Zwager CL, Schoonmade LJ, Guo T, Roggeveen LF et al. Machine learning for the prediction of sepsis: a systematic review and meta-analysis of diagnostic test accuracy. *Intensive Care Med* 2020;**46**:383-400

Painless Labour Experience: The Past and the Way Forward

Iqbalmunauwir Ab Rashid[1,2], Nurmunirah Mohd Sobri[2], Nuraiman Imam Supaat[2]
[1]Department of Anaesthesiology and Intensive Care, Kulliyyah of Medicine, International Islamic University Malaysia, Pahang, Malaysia
[2]Department of Anaesthesiology and Intensive Care, Sultan Ahmad Shah Medical Centre (SASMEC@ IIUM), Pahang, Malaysia

Labour pain has been described over centuries in medical practice and in religious scribes including in Islam and Christianity. Labour analgesia has progressed from simple and orthodox methods to more advanced and complicated techniques. Current techniques of labour analgesia involve pharmacological and non-pharmacological methods. Various techniques have been described, explained, and explored over the centuries, of these, neuraxial labour analgesia being the most used and most effective. Advancement in the neuraxial labour analgesia has improved safety to the mother and foetus. Further evaluation of non-pharmacological techniques should be encouraged to improve maternal satisfaction, without compromising the well-being of the fetus.

INTRODUCTION

Delivery of a baby has been a norm for all living mammals, including in human beings as well. Childbirth should be a joyful and memorable experience for the new mother; however labour pain may be a frightening prospect. Typically, labour and birth in humans can be divided into three phases. The first phase leads to dilatation of cervix, and this can be further subdivided to latent phase (where cervix start to soften and dilate up to four centimeters in diameter with variable duration depending on parity) and followed by an active phase (where the cervix further dilates to full dilatation of ten centimeters in diameter in a more predictable timing). The second phase starts from fully dilated cervix to expulsion of the foetus. Finally, the third phase ends with expulsion of the placenta. To better understand the process and progression of labour, all three 'P' components that are the passage (pelvis), the passenger (baby) and the power (uterine contraction and maternal effort) should be in optimal conditions.

In general, pain is defined by the International Association for the Study of Pain (IASP) as *'an unpleasant sensory and emotional experience associated with actual or potential tissue damage or described in terms of such damage'*. This definition can be applied to all types of acute and chronic pain experiences. However, the definition may not well explain labour pain as it is associated with delivery of baby which is not pathological but is the most basic and fundamental life experience.

THE HISTORY AND LABOUR ANALGESIA EVOLUTION

Labour pain had been described thousand years back as the most severe pain ever experienced by a human being, not only in Holy book of Islam, Al-Quran,[1] but also in many books of the Old Testament of the Bible.[2] Figure 1 summarised the history of labour pain relief or analgesia. In modern literature, it was first described in 1591, when Eufeme MacCalyean was convicted for requesting a witch to relieve the pain of childbirth, in addition to other charges.[2]

The history of labour pain relief started in 1777, when Anton Mesmer introduced the mesmerism technique, but was only suggested by Grubert of Lyon in 1836. However, due to a strong bound to religious faith and fear of practice against religious teaching, it had only been practised in the year of 1844 by JP Laynell of Manchester and in 1846 by WB Fahnestock of Lancester.[2] Almost a decade later, in 1847, ether, given as inhalation was introduced by James Young Simpson of Edinburgh. Chloroform was introduced in the same year and was used by Queen Victoria during her eighth and ninth childbirths in 1853 and 1857, respectively. Administration of nitrous oxide with oxygen as labour pain relief was introduced by Stanislav Sigismund Klikovich of Russia in 1880. However, it was not until 1961, that

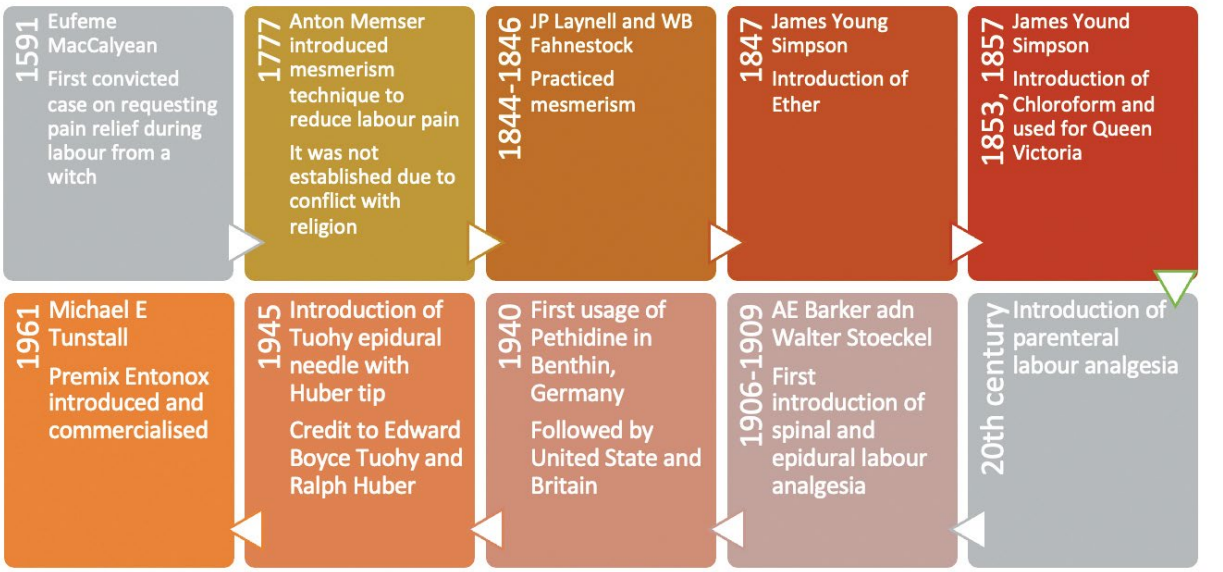

Figure 1: Historical timeline of labour pain relief

an equal mixture of nitrous oxide and oxygen was produced as premix and commercialised as Entonox® by Michael E Tunstall of England. Entonox was then gaining fast popularity for labour analgesia.[3] In the early 20th century, the use of parenteral pain relief for labour pain was introduced. This includes the use of morphine, hyoscine and barbiturates. Pethidine was introduced in 1940 when it was first used in Benthin in Germany, and subsequently in the United States of America and Britain.[2]

The concept of regional analgesia for labour pain was, again, linked back to James Young Simpson in 1848, but only made possible in 1900 by Oskar Kreis of Switzerland, after the introduction of cocaine as a local anaesthetic.[2] Both spinal and epidural analgesia were introduced for labour analgesia in the year of 1906 to 1909, by AE Barker of England and Walter Stoeckel of Germany respectively.[4,5] In the early years, both techniques were less popular due to the belief of the adequacy of inhalational and parenteral techniques and to known complications of regional techniques.[2] Proper epidural needle was only introduced in 1945 by Edward Boyce Tuohy of the United States. He used a needle with Huber point (designed by Ralph Huber of the United States), and this has benefit in avoiding plugging of tissues and enabling choice of direction of catheter through the needle.[6]

OBLIGATION AS A MUSLIM TO SEEK FOR PAIN RELIEF

Several concepts with regards to pain and its management have been discussed by Islamic scholars. First is the concept of taking care of one's body. All Muslims are obliged to care for their health, as the body and mind are entrusted from Allah (God) to all human beings. It was clearly mentioned in the Al-Hadith by Tardmizi and Baihaqi, as the Prophet Muhammad (Peace Be Upon Him) mentioned *"A servant of Allah will remain standing on the day of judgment, until he is questioned about his age and how he spends it, about his knowledge and how he utilised it, about his wealth and how he acquired it, and about his body and how he used it."*[7] Second is the concept of seeking treatment (particularly seeking pain relief). Al-Imam Bukhari mentioned in his book *"A companion asked Prophet Muhammad (PBUH) "O Prophet of Allah, when we are ill, should we seek treatment, or should we have faith in Allah and not seek treatment as Allah will cure us?"* Prophet Muhammad (PBUH) replied *"O servant of Allah, you must seek for treatment for your illness as Allah did not create a sickness but has created a treatment for it (except old age)."*[7]

These two hadiths clearly mentioned that we need to care for our body as it is entrusted to us. This

includes to maintain good health and seek medical treatment in case of illness and to seek for good pain relief during labour. It was mythical that the pain during labour is a part of punishment and redemption.[2] However, Islam views childbirth as a joyous moment and children are seen as gifts from God. Throughout the process of labour, Islam encourages its followers to seek treatment, either spiritually by praying to God or physically by medicine given by doctors and nurses.[1] Spirituality is now considered as part of pain management, as more and more people turn their faith into their religion and belief as mechanisms to relieve and cope with painful experiences. This has opened fields for future research linking spirituality and pain relief in medicine.[8]

LABOUR PAIN PATHWAY

Pain during labour can be divided into the first and second stage labour pain, or visceral and somatic type of labour pain. The first stage of labour marks from the beginning of regular contraction of the uterus until the fully dilated cervix. Pain passes through afferent nerves from the uterus and cervix, representing visceral pain, which are poorly localised and diffuse. These pain signals pass through A-δ and C fibers and end in nerve bodies lying in the dorsal root ganglia of T10 to L1.[9,10] The second stage of labour marks from the fully dilated cervix to the expulsion of the foetus. Afferent nerves from the vagina and perineum transmit the somatic pain, which are well localised and intense. The stimulus passes through A-δ fibres and ends in the dorsal root ganglia of S2 to S4. With this understanding, effective labour analgesia should have coverage of the dorsal root from T10 down to S4, with minimal motor blockade, to cover for both first and second stage of labour.[10]

Apart from being unpleasant physically and emotionally, pain may lead to potential physiological and psychological adverse effects. This includes hyperventilation with subsequent hypocapnia and metabolic alkalosis causing reduce placental blood flow and reduced off-loading of oxygen; hypertension resulted from increased cardiac output and sympathetic stimulation; catecholamine release causing vasoconstriction and reduced placental flow; delayed gastric emptying with increased risk of aspiration; and lastly psychologically disturbance from unrelieved labour pain may contribute to postpartum depression and post-traumatic disorder.[10]

CURRENT PRACTICE FOR LABOUR ANALGESIA

Labour analgesia can be divided into two main categories, non-pharmacological and pharmacological techniques. Non-pharmacological techniques involve no use of any medications or drugs, and they can be further subdivided into three categories (Figure 2), which are (1) reduction of painful stimuli, (2) activation of peripheral sensory receptors and (3) enhancement of descending inhibitory neural pathway.[10]

Reduction of painful stimuli can be achieved by movement, positioning, and counter pressure mechanism. This includes mobilisation of labouring mothers into standing, walking, and changing position that could help in accelerating the labour process and help in reducing pressure from the descending fetal head. Counter pressure over the hip area with strong consistent pressure may help reduce transmission of painful stimuli. Multiple methods have been advocated to stimulate peripheral sensory receptors, examples being temperature modulation, hydrotherapy, massage and reflexology, acupuncture and acupressure, transcutaneous electrical nerve stimulation, intradermal sterile water injection and aromatherapy.[12] These groups of interventions have limited clinical evidence in reducing pain during labour. There was no strong suggestion from previous studies, however, none showed serious side effects that may be considered undesirable during the process of labour.[10]

Enhancing the descending inhibitory neural pathway can be achieved with education, attention focusing and distraction, relaxation, music and audio analgesia, hypnosis and biofeedback.[10] Hypnosis *per se* is not a new method during labour, as it was proposed by Anton Mesmer back in 1777, even though it was not yet accepted during that

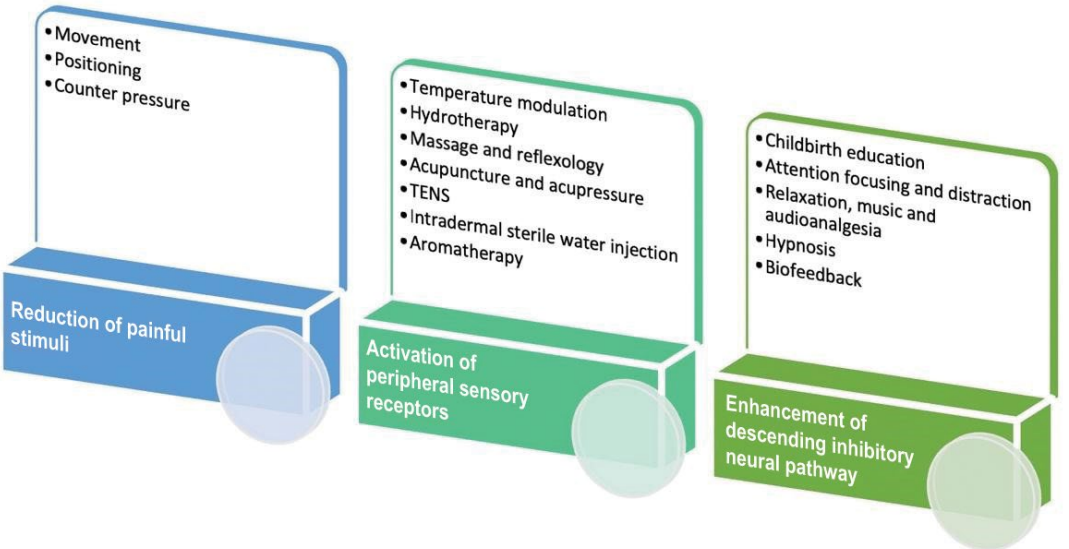

Figure 2: Sub-classification of non-pharmacological techniques for labour analgesia

period.[2] Combination of these methods is more effective than any single intervention alone.[13] As the intensity of pain increases in the second stage of labour, non-pharmacological methods alone might not be effective.[14]

Birthing companion or partner, or commonly known as doula may influence the process of labour. Doula, which comes from the Greek word for servant, is a well-trained personnel handling the mother on non-medical issues, including breathing pattern, soothing massage, and comfortable positioning.[14] The use of doula has been shown to reduce pain score in the second stage of labour and shorten the active phase of labour. This can be considered as a cost-effective way in reducing labour pain, anxiety, and the need for caesarean section.[15]

Pharmacological techniques as discussed in the history earlier includes inhalational gases, parenteral drugs and regional central neuraxial blocks.[2] Inhalational gases include equal pre-mix nitrous oxide and oxygen in a cylinder, inhaled intermittently by parturients during labour. Although evidence of its efficacy was lacking, it remains as the main choice of analgesia during labour worldwide.[10] Historically, ether was the agent of choice,[2] but with the emergence of newer anaesthetic agents, sevoflurane has become favourable due to its short onset and offset.[10] However, few studies showed that the effect of reduced conscious state with use of sevoflurane may be disadvantageous.[12]

Other medications which have been used for labour analgesia include paracetamol, non-steroidal anti-inflammatory drugs, ketamine, barbiturates, phenothiazine, benzodiazepines and opioids.[10] In general, the use of non-opioid analgesia alone is not effective in controlling labour pain. Opioid medications may have side effects, including maternal sedation, nausea and vomiting, or fetal sedation, metabolic acidosis, neonatal respiratory depression, and changes in heart rate variability. These side effects collectively reduce the use of systemic opioids for labour analgesia.[10,12] However, with the introduction of ultra-short acting opioids with the available patient-controlled analgesia (PCA) regime, the use of opioids such as remifentanil has become increasingly popular, enabling better control of labour pain and better ability to control labour.[10] The use of PCA remifentanil has a more favourable finding, with reduction of conversion rate to epidural analgesia by half, compared to the use of intramuscular pethidine.[16]

Neuraxial labour analgesia is the most popular technique nowadays for relieving pain during the labour process.[12] Several factors need to be considered prior to initiation of neuraxial labour analgesia, which include suitability of neuraxial techniques in terms of labour progress and fetal condition, choice of techniques, initiation and maintenance of neuraxial analgesia, choices of local anaesthetics, need of adjuvant drugs and possible complications.[18] Options for neuraxial labour analgesia include single shot spinal, continuous spinal analgesia, caudal analgesia, epidural analgesia, and combined spinal epidural analgesia. The usual regimes for maintenance of analgesia using epidural catheter include intermittent top-up, continuous epidural infusion (CEI) and patient-controlled epidural analgesia (PCEA).[12] However, there is evidence of increasing instrumental deliveries with the use of labour epidural.[19]

Midwives, pregnant ladies, and obstetricians all had an agreement on the need for pain relief during the labour. However, conflicting views were seen in terms of methods of pain relief, where midwives prefer physical methods, obstetricians prefer pharmacological methods and parturients have views in between these two methods. For example, a group of midwives view epidural technique as a method of medicalisation of natural labour, which is in contrast with their principle on maintaining natural de-medicalised labour as a normal labour.[20]

ADVANCEMENT IN LABOUR ANALGESIA

In recent years, there has been advancement in providing labour analgesia, in terms of (1) better understanding of technical advances, (2) pharmacological advances, (3) technological advances, and (4) newer evidence toward mythical and controversies about previous techniques (Figure 3).[21]

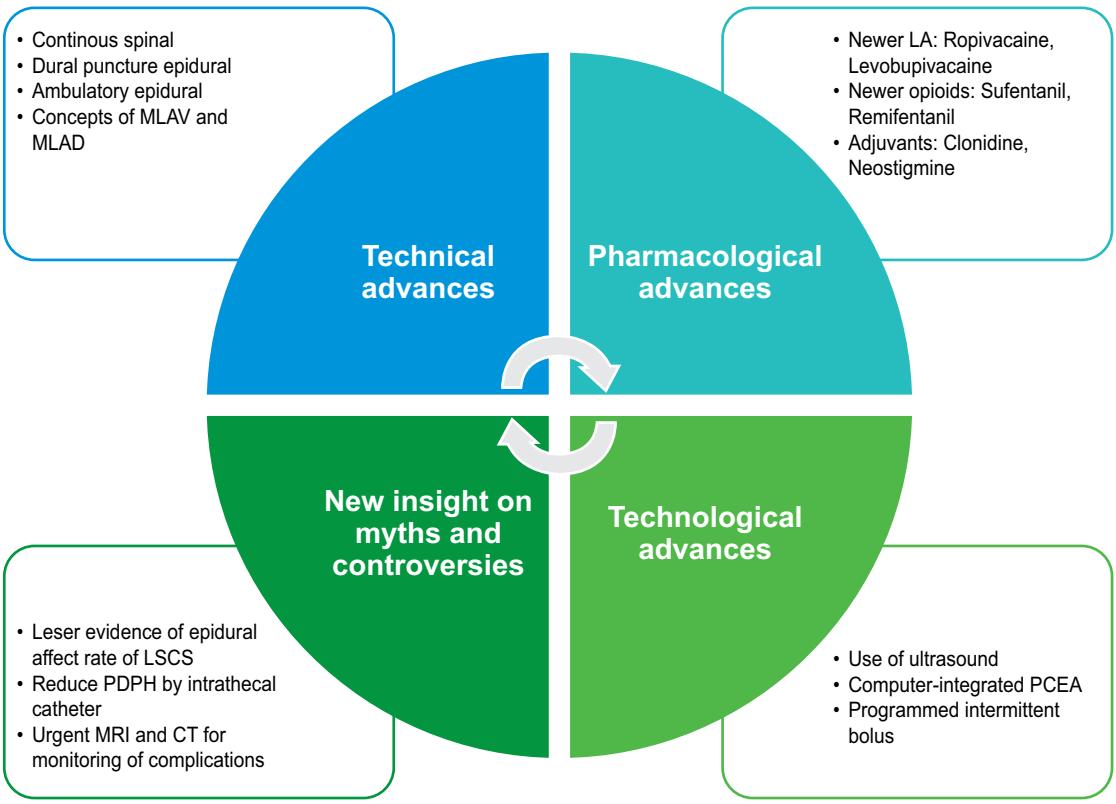

Figure 3: Advancement in labour analgesia

It is worth mentioning here the usage of Minimum Local Anaesthetic Volume (MLAV) and Dose (MLAD), which improve the safety margin of local anaesthetics without compromising the analgesic effects.[21] Dural puncture epidural (DPE) has gained popularity for its comparable onset of analgesia effect and lower side effect as compared to epidural or combined spinal epidural, including lesser side effects such as itchiness, hypotension, and asymmetrical block effect.[22,23] The use of Computer-integrated PCEA (CIPCEA) has better maternal satisfaction as compared to PCEA with constant basal infusion.[12] Programmed intermittent epidural bolus (PIEB) combined with PCEA has shown more advantages compared to CEI with PCEA. This method showed lower risk for instrumental delivery, lower local anaesthetics consumption, yet provides better pain control with higher maternal satisfaction and longer analgesia duration.[12,24] Unfortunately, incidence breakthrough pain was found to be similar in both groups.

CONCLUSION

In conclusion, labour analgesia is one of the ever-developing fields in anesthesiology and pain medicine, as parturient would continually seek for better experience during labour. Maternal satisfaction is important, as well as maintaining fetal well-being. Further studies should be encouraged to discover the best technique alone or in combination, to achieve these goals.

References

1. Karra, W. and Kutty, H. 2011. Gifts from God: Childbirth and Postpartum Care in Islam. [https://www.lamaze.org/Connecting-the-Dots/gifts-from-god-childbirth-and-postpartum-care-in-islam]. Accessed June 29, 2021

2. Meckenzie, A.G.. Oxford Textbook of Obstetric Anaesthesia. First edition. Glasgow: Oxford University Press, 2016. Chapter 1, Historic timeline of obstetric anaesthesia; pp 3-27

3. Tunstall, M.E.. Obstetric analgesia; the use of a fixed nitrous oxide and oxygen misture from one cylinder. *Lancet* 1961;**2**:964

4. Lee, J.A. Arthur Edward James Barker 1850-1916: British pioneer of regional analgesia. *Anaesth* 1979;**34**:885-91

5. Doughty, A. Walter Stoeckel (1871-1961); a pioneer of regional analgesia in obstetrics. *Anaesth* 1990;**45**:468-71

6. Maltby, J.R. Notable Names in Anaesthesia. Royal Society of Medicine Press. 2002; pp216-18

7. Arshad, M. 2016. Islam & Chronic Pain Information Leaflet for Muslim Patients. [https://ppa.csp.org.uk/system/files/islam_and_chronic_pain.pdf]. Accessed June 29, 2021

8. Dedeli, O. and Kaptan, G. Spirituality and religion in pain and pain management. *Health Psychol Res* 2013;**1**:29

9. Kingsley, C. and McGlennan, A. 2019. Anaesthesia Tutorial of the Week. [www.wfsahq.org/resources/update-in-anaesthesia]. Accessed June 29, 2021

10. McClune, G. and Hill, D. Oxford Textbook of Obstetric Anaesthesia. First edition. Glasgow: Oxford University Press, 2016. Chapter 13, Non-pharmacological methods of pain relief and systemic analgesia in labour: pp201-226

11. Devlieger, R. and Smet, M.E. Oxford Textbook of Obstetric Anaesthesia. First edition. Glasgow: Oxford University Press, 2016. Chapter 12, Obstetric management of labour, delivery, and vaginal birth after caesarean delivery; pp179-200

12. Lam, K.K., Leung, M.K.M. and Irwin, M.G.. Labour analgesia: update and literature review. Hong Kong Med J 2020;26

13. Desmawati, Kongsuwan, W. and Chatchawet, W. Effect of Nursing Intervention Integrating an Islamic Praying Program on Labor Pain and Pain Behaviors in Primiparous Muslim Women. Iran J of Nurs & Midwifery Res 2019;24

14. Virginia Beach Obstetrics and Gynaecology. What is the difference between a Midwife and a Doula. 2018. [https://www.virginiabeachobgyn.com/blog/what-is-the-difference-between-a-midwife-and-a-doula/]. Accessed July 12, 2021

15. Safarzadeh, A., Beigi, M., Salehian, T., Khojasteh, F., Burayri, T., Navabirigi, S.D. et al. Effect of Doula Support on Labour Pain and Outcomes in Primiparous Women in Zahedan, Southeastern Iran: A Randomized Controlled Trial. *J Pain Relief* 2012;**1**:5

16. Wilson, M.J.A., MacArthur, C., Hewitt, C.A., Handley, K., Gao, F., Beeson, L. et al. Intravenous remifentanil patient-controlled analgesia versus intramuscular pethidine for pain relief in labour (RESPITE): an open-label, multicentre, randomised controlled trial. *Lancet* 2018;**392**:662-72

17. Desmawati. Non-Pharmacological Pain Management in Islamic Tenet to Reduce Labor Pain: A Literature Review. Adv in Health Sci Res 2020;30

18. Rofthooft, E., Devroe, S. and Velde, M.V. Oxford Textbook of Obstetric Anaesthesia. First edition. Glasgow: Oxford University Press, 2016. Chapter 14, Initiation of neuraxial labour analgesia; pp227-243

19. Auni, A., Brotmet, S., Grytskog, K.H. and Sperstad, E.B. Epidurals during normal labour and birth - Midwives' attitudes and experiences. *Women & Birth* 2021;**34**:384-9

20. Madden, K.L., Turnbull, D., Cyna, A.M., Adelson, P. and Wilkinson, C. Pain relief for childbirth: The preferences of pregnant women, midwives and obstetricians. *Women & Birth* 2013;**26**:33-40

21. Pandya, S.T. Labour analgesia: Recent advances. Indian J of Anaesth 2010;54

22. Clinical Trial. Chau, A., Bibbo, C., Huang, C.C., Elterman, K.G., Cappiello, E.C., Robinson, J.N. et al. Dural Puncture Epidural Technique Improves Labor Analgesia Quality With Fewer Side Effects Compared With Epidural and Combined Spinal Epidural Techniques: A Randomized. *Anaesth & Anal* 2017;**124**:560-9

23. Abd Rahman, M.I. Comparison of Dural Puncture Epidural Technique (DPE) versus Lumbar Epidural Technique (LE) for Labour Analgesia. Int Med J Malays 2021;5

24. Xu, J., Zhou, J., Xiao, H., Pan, S., Lui, J., Shang, Y. et al. A systematic Review and Meta- Analysis Comparing programmed Intermittent Bolus and Continuous Infusion as the Background Infusion for parturient-Controlled epidural Analgesia. *Nature* 2019;**9**:2583

Chronic Low Back Pain in Malaysia: Overview of the Current Practice and Future Direction

Abdul Hadi Mohamed[1,2], Ahmad Akmal Aziz[2], Mohamed Asri Mohamed Zaini[2]
[1]Department of Anaesthesiology and Intensive Care, Kulliyyah of Medicine, International Islamic University Malaysia, Pahang, Malaysia
[2]Department of Anaesthesiology and Intensive Care, Sultan Ahmad Shah Medical Centre (SASMEC@ IIUM), Pahang, Malaysia

Low back pain is one of the most common presentations of pain with prevalence in about 12% of adults in Malaysia, with direct impact on economic burden towards a country. Lumbar facet joint arthropathy constitutes the most common type of back pain, followed by sacroiliac joint arthropathy. Among the approaches which are currently available in managing back pain are multimodal analgesics, cognitive behavioural therapy, and interventional pain procedures. The purpose of this review is to describe the incidence and approaches in management of low back pain available in Malaysia, and its future direction.

INTRODUCTION

Musculoskeletal pain is the most common pain complaint, with low back pain (LBP) being the most frequent variety reported. LBP bears a huge burden towards individuals, health care systems and even social care systems.[1] Four out of every five adults will experience LBP at some point of their life.[2] Natural changes which occur in the spine as the age progresses may increase the chances of developing LBP with highest incidence in the middle age group especially in men when compared to women.[3] Patients with LBP may limit social activities up to three times more than normal persons, hence this may result in poor quality of life.[4] Sedentary lifestyle and poor postural habits worsen this prevalence.[4,5] In the past 30 years, disability incidences due to LBP has increased globally by 54%.[4,5]

The most common aspect of life affected includes firstly reduced productivity during work due to physical limitations that may result in lesser earning capacity. Secondly, high financial impact associated with back pain either directly through healthcare cost on prescription medications, or indirectly through absenteeism and low productivity. Finally, psychological effects as a result of low self-esteem. These include feelings of sadness, worthlessness and hopelessness which may lead to depression or aggression. Psychological effects are increased in adults with back pain when compared to those without back pain.[6]

DEFINITION

In the past, LBP was often defined as a symptom of an underlying cause. However recent studies suggest that LBP indeed is a disease itself.[2,7] In acute episodes where back pain lasts less than three months (90% of cases), under or over treatment without properly addressing the problem is not advisable as it causes more harm than cure. Acute pain shall involve recognition and prompt treatment to avoid any chronification of the pain resulting from altered pain modulation, central sensitisation, neuroplastic changes, and other changes to the pain neuromatrix. Chronic low back pain (CLBP), defined as *'back pain lasting more than three months'*, accounts for less than 10% of cases but remains as one of the greatest health problems in industrialised societies. LBP symptoms of nociceptive or neuropathic origin can appear in a sudden or gradual manner and remain intermittent or continuous in nature.[7]

INCIDENCE

LBP that can affect all spectrum of ages bears impact on the social and economy. A study by Nor Azlin et al. showed that in a younger population, functional disability associated with LBP might not cause major concern in the beginning of the illness.[8] However, early in life, LBP potentially progressed to recurrent and chronic LBP. It is estimated that about 10% to 31% incidence of LBP were reported in developed countries in comparison to 12% prevalence in Malaysia as shown in a study by Hani SS et al.[9] LBP

also was rated as the ninth and fifth most common complaints between August to November 2012.[9] In the Malaysian setting, guidelines for assessment and treatment of acute LBP are readily accessible, however, not as many recommendations were published toward prognostication, prevention, and management of CLBP. A guideline was released by the Malaysian Association for the Study of Pain in 2012 to address these issues in Malaysia.[10]

RISK FACTORS

The number of hours spent in sitting position especially more than four hours per day of a person, had significant association to the development of LBP.[9] Several occupational risk factors which may contribute to development of LBP, amongst the most common risks, are improper workplace design, inappropriate equipment, prolonged sitting in non-ergonomic chairs, and lifting and handling heavy objects.[9] Repetitive or static awkward body postures such as during prolonged sitting may result in muscle fatigue and injuries, increase spinal compression load, and tissue micro-damage which eventually in the long run resulting in significant back pain.[11] All these factors eventually reduce the mobility, exertion of force, energy consumption, circulatory demands, coordination and motion control which then lead to body vibration and muscle fatigues.[11,12] A high incidence of LBP was found in the transport industry that was associated with excessive usage of body parts and long sitting.[13] Other occupational risk factors are vibration, cold temperature and extrinsic stress as well as repetitive movement of arms and hands.[12-14] Psychosocial risk factors at work which include perceived high pressure on time and workload, low job control, job dissatisfaction, monotonous work and low support from co-workers together with inappropriate management can also lead to back pain.[11-14] Mood disturbances can also influence biomechanical load through change in posture, movement and exertion of forces which increase the muscle tension and hormonal excretion.[15]

AETIOLOGIES

Most LBP are considered to be non-specific, and the assumption that the causes of 80% to 90% of LBP cases are unknown has persisted for decades. It is globally acknowledged that the most common causes of LBP are mechanical and soft tissue injury. These injuries may cause compression of nerve roots by herniated disc, displacement of the spinal joints, and disruption to the intervertebral discs by degenerative process or due to trauma or poor body ergonomic. They can occur due to muscle overuse, non-ergonomic posture, inappropriate working place, poor body posture during working, sports injuries or ageing process such as disc degeneration and prolapse of the disc.[16,17] The most common disc affected are both the lower lumbar and cervical discs. If not treated, surrounding nerves are compressed and patients will experience nerve-related symptoms which include tingling, numbness, sciatic pain, weakness, paralysis, bladder and bowel dysfunction. The symptoms developed usually depend on the extent of nerves involved, along with LBP. Degenerative process causes both pain and stiffness due to distortion and osteoarthritis of facet joint of the spine.[18] Some LBP are due to secondary causes such as spondylo-arthritis which is part of the autoimmune diseases such as systemic lupus erythematosus, rheumatoid arthritis and inflammatory bowel disorders.[19] Osteoporosis, causing the vertebrae thinning and brittleness, may also collapse easily with simple trauma leading to LBP.[20] Other pathologies such as infections and tumours can cause LBP directly or indirectly by injuring the vertebrae, facet joint or surrounding tissues.

TYPES

Despite numerous researches and publications carried out by the International Association for the Study of Pain, medical communities are still perplexed by the use of certain definitions such as LBP, radicular pain and some other terms. For instance, in fibromyalgia, muscle tension and spasm are typically regarded as the main cause of LBP while there are, as a matter of fact, many other different pain generators which may be

involved. This warrants an exploration in patients presented with nociceptive and neuropathic pain characteristics, such as radicular, facet joint, sacro-iliac pain, or other pain.

Radicular Pain

Radicular pain is a type of neuropathic pain described as pain originating from the back and gluteal area radiating into the lower limbs. It typically follows a dermatomal distribution without any neurological impairment, and generated by ectopic discharges fired by the injured dorsal roots.[21,22] The common cause is by direct compression of herniated disc due to leak of nucleus polposus or prolong nerve root compression, and others by inflammation of the affected nerve.[22] Radicular pain differs from radiculopathy in several aspects, for example, in radicular pain it mostly involves sensory fibres, while in radiculopathy both sensory and motor fibers (myotomal) are affected including the reflexes.[22] To identify LBP with radiculopathy, specific signs can be elicited from the clinical examination such as Lasègue sign, crossed Lasègue sign, manual muscle testing, or supine straight leg raises. In a patient who is highly suspected of having radicular pain, the most appropriate non-invasive test to confirm this would be MRI scan. Management may involve an invasive intervention or surgery.[22]

Facet Joint Syndrome

Around 30% of CLBP cases, the nociceptive pain is originating from the synovial membranes, the hyaline cartilages, the bones, or the fibrous capsules of the lumbar zygapophyseal, also known as the facet joints. These facet joints have a large amount of free and encapsulated nerve endings supplied by the medial branches of the dorsal rami and are also modulated by sympathetic efferent fibres.[23,24] Diagnosis of facet joint syndrome is not typically easy, and patients usually complained of nociceptive LBP often referring to the thigh until the level of above knee or to the groin.[24,25] Normally, there is no radiculopathy, and LBP tends to be from off-spinous process. The pain intensity is usually exacerbated after prolonged sitting or standing, and is associated with morning stiffness. The pain also becomes intense with extreme movements of the spine. There is no pathognomonic finding on radiological imaging, therefore may pose a challenge to reach a diagnosis of the lumbar facet joint syndrome. However, history and clinical examination are most crucial for the diagnosis by looking for pain aggravating, and performing clinical test such as facet loading test, localised facet pain on palpation and confirmed by diagnostic block.[24,25]

Sacroiliac Joint Pain

Upper body stability and flexibility are supported by the sacroiliac joints (SIJ) which are also involved in sacral movement. SIJ is innervated by L5 dorsal primary ramus and lateral branches of the dorsal sacral rami from S1 to S3.[26,27] Inflammation or intra-articular wear and tear of its ligaments, capsules or joints are the cause of CLBP. It should be highly suspected if a patient presents with postural LBP that is aggravated in a sitting position. It is very essential to differentiate between LBP originating from the SIJ or from the facet joint by performing a stress test, where the SIJ pain will be attenuated by pressing down on the iliac crest (pelvis) or upper thigh.[26,27] Once the injury healed itself within six weeks, the pain should be subsided.[28,29]

'Red Flags'

About 85% patients can be classified as having a non-specific LBP after a brief diagnostic triage, on the basis of recognising the "red flags" with partial neurological and musculoskeletal examination.[30-32] Nevertheless, it is very crucial to identify and manage them early, to prevent life threatening condition or grave permanent disabilities.[31-33] In order to diagnose LBP, specific "red flags" signs and symptoms of spinal disorders pointing towards vertebral fractures, tumours, or other severe pathologies, need to be ruled out based on the features in Table I.[34]

Table I: Common Features of 'Red Flags' in Chronic Low Back Pain

The common features of 'red flags' history and physical signs
History
1. History of trauma, cancer (present or past), osteoporosis, significant loss of weight, use of systemic steroids, HIV infection, drug or alcohol abuse
2. Onset of pain at age < 20 years or > 55 years
3. Thoracic pain
4. Unrelenting night pain or pain at rest
5. Fever ≥ 38ºC for 48 hours
6. Sudden onset or unexplained changes in bowel or bladder control (incontinence or retention)
7. Sudden onset or otherwise unexplained bilateral leg weakness, or progressive motor weakness in the legs with gait disturbances
8. Saddle numbness or anaesthesia (anus, perineum or genitals)
Physical Sign
1. Fever ≥ 38ºC
2. Structural spinal deformity
3. Severe restriction of lumbar flexion
4. Widespread neurological deficit
5. Saddle anaesthesia

Adapted from The Malaysian Low Back Pain; Management Guidelines.
https://www.masp.org.my/view_file.cfm?fileid=7

INVESTIGATION

Diagnostic imaging tests are usually being reserved for patients with underlying co-morbidities or those indicated for surgery.[35,36] Although the management of some of the LBP is conservative, imaging such as Computed Tomography scan or Magnetic Resonance Imaging (MRI) are being utilised to rule out red flags such as radicular compressions, discitis, and other pathologies. The demand for the imaging studies should be made based on clinical decisions which are patient-related (e.g. to find the source of the pain), clinician-related (e.g. to avoid missing of red flag), or related to the therapeutic interaction (e.g. to confirm that there is no physical abnormalities).[37,38] Around 85% of LBP are benign in nature and studies had shown that about 40% of physical abnormalities detected via MRI are asymptomatic.[25,39]

ASSESSMENT

The main reason patients seek treatment is due to the LBP. It is vital to pay attention to the complaint of pain as it is a part of the treatment to focus on this issue.[28,40] Two most common reported outcomes from the treatment are the pain intensity which is defined as how much a person hurts and the frequency, where both need to be monitored by time. There are three types of scales which are commonly used to measure pain intensity: visual analogue scales, verbal rating scales, and numerical rating scales. The scales yield no difference in patients' rating response, and all are validated as tools for prediction of pain. The numerical rating scale is commonly utilised due to the ease of use and its practicality. Others validated methods may be time consuming.[41,42]

MANAGEMENT: CURRENT PRACTICE AND FUTURE DIRECTIONS

Patients' expectations and psychosocial issues need to be considered seriously before planning any treatment process.[37,38] Proper clarification and reassurance regarding the pain need to be endorsed during and after clinical examination or therapy.[15,37] Long term planning needs to be considered and a positive approach may improve overall patient's quality of life. This should include enhancing patients' self-control, reducing symptoms burden, and improving psychological issues.[15,37,38] Most of the issues related to the LBP can be resolved by educating patients on managing themselves and keeping the pain under control without surgical intervention.[41] Multimodal analgesics are important to be considered as the short-term management.

CLBP patients should be advised to improve or maintain their physical fitness, stretching regularly and utilising appropriate pacing technique when necessary. Over time, potential flare-ups and severe pain intensity will be under control and permit prolonged endurance for any activities.[41,42] They need to resume normal activities despite the flare-ups and practise regular active exercise as part of non-surgical pain management. Patients need to understand that the pain is chronic and, to a certain degree, is a part of their life. Cognitive behavioural therapy is available in certain centres in Malaysia which can impart to the patients the methods in managing their pain with specific skills such as coping skill through relaxation techniques, pacing and stress control.[42,44]

Regular physical exercise could help build strength and endurance toward pain, maintain the muscle tone to support the spine, and improve the joint flexibility. Adjusting a healthy lifestyle with a proper diet will help to achieve good body weight. Learning a correct ergonomic posture for certain activities will help prevent LBP from worsening. Adjustment at workplace with regular pacing are crucial. If possible, certain weight bearing activities such as the lifting of heavy load should be minimised or using pacing.[42,44] Patients must use proper ergonomic posture while lifting heavy objects which is to keep the spine straight. Routine physical therapy needs to be performed with caution and under guidance of an expert trainer to help in reducing potential LBP by stretching and strengthen para-spinal and abdominal muscles.

In lieu of surgical alternatives, there are rising invasive pain management procedures like medial branch blocks or radiofrequency ablations as an alternative to overcome moderate to severe pain with definite diagnosis and absolute indication.[24-26] Future advances in invasive pain management procedures might allow doctors a few options to overcome pain in certain LBP and discomfort through non-surgical means and improve the quality of life globally.[25-27] Currently, surgical treatments are offered for following red flags:[25-27] (1) LBP associated with specific pathology like infection and tumours, (2) pain associated with bladder and bowel dysfunction, (3) pain associated with symptoms of nerve compression, like sciatica, and numbness or weakness in the limbs, and (4) increasing severity of pain and recurrent pain disturbing normal activities of daily living.

Future study should focus on simplifying the classification and identification of particular subgroups of CLBP patients. It was proposed that rather than concentrating on allocating pathoanatomical labels to subgroups, it is time to adopt the gold standard by developing clinical prediction rules based on the initial set of signs, symptoms, and functionality, as being utilised in acute and subacute LBP. To prevent or minimise the occurrence of CLBP among patients, future research should look at practical and cost-effective therapies. The prediction rules should constitute a big step forward in aiming to eliminate the "one-size-fits-all" approach to patient care of non-specific LBP once they have been validated in larger, more varied groups of patients on a prospective basis and in randomised trials.

CONCLUSION

In conclusion, the majority of LBP are caused by natural ageing changes in the spine, which are often accompanied by poor posturing and work habits. Most CLBP and pain may be controlled and managed without the need for significant surgical operations by maintaining a healthy body weight, remaining active with regular workouts, and paying attention to precautionary action. LBP must always be treated as a complicated condition in which precise identification of pain generators is required before any therapy can begin. Many of the current recommendations emphasise the necessity of a multimodal and multidisciplinary approach in order to develop a plan that addresses the possible factors rather than just relieving the symptomatic pain.

References

1. Vassilaki M, Eric LH. Perspectives on Pain in the Low Back and Neck: Global Burden, Epidemiology, and Management. *Hawaii J Med Public Health* 2014;**73**:122-6

2. Federico B, Anne FM, Ferran P, Christine C. Non-specific Low Back Pain. *The Lancet Seminar* 2012;**379**:482-91

3. Yì Xiáng J. W, Jùn-Qīng W, Zoltán K. Increased low back pain prevalence in females than in males after menopause age: evidences based on synthetic literature review. *Quant Imaging Med Surg* 2016;**6**:199-206

4. Arnold YLW, Jaro K, Dino S. Low back pain in older adults: risk factors, management options and future directions. *Scoliosis and Spinal Disorders* 2017;**12**:2-23

5. Zahari Z, Justine M, Dahlan A. Prevalence of low back pain and relationship between risk factors, disability and quality of life among elderly in community. *WCPT Congress 2015 / Physiotherapy* 2015;**101** Supplement 1:eS1643-eS1721

6. Jan H et al. What low back pain is and why we need to pay attention. *The Lancet* 2018;**391**:2356-7

7. Alisa LD et al. Personal and Societal Impact of Low Back Pain. *Spine* 2019;**44**:E1443-51

8. Anthony D et al. Low Back Pain Clinical Practice Guidelines Linked to the International Classification of Functioning, Disability, and Health from the Orthopaedic Section of the American Physical Therapy Association. *J Orthop Sports Phys Ther* 2012;**42**:A1-A57

9. Nor Azlin MN, Devinder Kaur AK, Lim K. Low back Pain and Associated Risk Factors among health Science Undergraduates. *Sains Malaysiana* 2014;**43**:423-8

10. Hani SS, Liew SM. The views and experiences of Malaysian primary care doctors in managing patients with chronic low back pain: a qualitative study. *Malaysian Family Physician* 2018;**13**:18-27

11. Jae-Young H, Kwang-Sup S, Jae Hwan C, Jae Hyup L. An Updated Overview of Low Back Pain Management in Primary Care. *Asian Spine J* 2017;**11**:653-60

12. Tamrin SBM et al. The association between risk factors and low back pain among commercial Vehicle Drivers in Peninsular Malaysia: A preliminary result. *Industrial Health* 2007;**45**:268-78

13. Ardalan S et al. Prevalence rate of neck, shoulder and lower back pain in association with age, body mass index and gender among Malaysian office workers. *Work* 2018;**60**:191-9

14. Crystian BO et al. Clinical practice guidelines for the management of non-specific low back pain in primary care: an updated overview. *European Spine Journal* 2018;**27**:2791-803

15. Atkinson JH. Depressed mood in chronic low back pain: relationship with stressful life events. *Pain* 1988;**35**:47-55

16. Yasufumi H. Classification, Diagnosis, and Treatment of Low Back Pain. *JMAJ* 2004;**47**:227-33

17. Babak B, Ting X. Application of advanced biomechanical methods in studying low back pain - recent development in estimation of lower back loads and large-array surface electromyography and findings. *Journal of Pain Research* 2017;**10**:1677-85

18. Brock EH, John DR. Spondyloarthritis: Clinical Suspicion, Diagnosis, and Sports. *Curr Sports Med Rep* 2009;**8**:29-34

19. Toshitaka N. Low Back Pain Accompanying Osteoporosis. *JMAJ* 2003;**46**:445-51

20. Lee, Gupta S, Price C, Baranowski AP. Low back and radicular pain: a pathway for care developed by the British Pain Society J. *British Journal of Anaesthesia* 2013;**111**:112-20

21. Massimo A et al. Mechanisms of low back pain: a guide for diagnosis and Therapy. *F1000 Research* 2016;**5**(F1000 Faculty Rev):15

22. Cristopher EA, Mathew V. Lumbosacral Facet Syndrome. StatPearls Publishing, Treasure Island (FL), 20 Jul 2017

23. Ashok J. Low Back Pain due to Lumbar Facet Joint Arthropathy and its Management. *Jadon, Gen Med (Los Angeles)* 2016;**4**:3

24. Romain P et al. Facet joint syndrome: from diagnosis to interventional management. *Insights Imaging* 2018;**9**:73-89

25. Khushali T, Kailash K, Rupal P. Sacroiliac Joint: A Review. *Indian Journal of Pain* 2018;**32**:4-15

26. Cohen SP, Chen Y, Neufeld NJ. Sacroiliac joint pain: a comprehensive review of epidemiology, diagnosis and treatment. Expert Rev. *Neurother* 2013;**13**:99-116

27. Atlas SJ, Richard AD. Evaluating and managing acute low back pain in the primary care setting. *J Gen Intern Med* 2001;**16**:120-31

28. Wong TS, Teo N, Kyaw MO. Prevalence and Risk Factors Associated with Low Back Pain Among Health Care Providers in a District Hospital. *Malays Orthop J* 2010;**4**:23-8

29. Samad RA, Shafei MN, Yaacob NA, Yusoff A. Prevalence and Associated Factors of Back Pain among Dental Personnel in North-Eastern State of Malaysia. *Int J Collab Res Intern Med Public Health* 2011;**3**:576-86

30. Arianne PV, Aron D, Nahid PO, Chris M, Bart WK. Red flags presented in current low back pain guidelines: a review. *Eur Spine J* 2016;**25**:2788-02

31. Wami SD, Abere G, Dessie A, Getachew D. Work-related risk factors and the prevalence of low back pain among low wage workers: results from a cross-sectional study. *BMC Public Health* 2019;**19**:1072

32. Lim MQ, Vinodhkumar R. Prevalence of Musculoskeletal Disorders and Associated Risk Factors among Selected Factory Workers in Penang, Malaysia. INTI Journal 2019;22

33. The Malaysian Low Back Pain Management Guidelines. 1st Edition

34. Shern TZ, Ambusam S, Purushothaman VK. Prevalence of low back pain and associated risk factors among car mechanics in Malacca, Malaysia. INTI Journal 2020;37

35. Reddy N, Four out of five adults will experience lower back pain 2020 [https://www.thestar.com.my/lifestyle/health/2020/04/30/four-out-of-five-adults-will-experience-lower-back-pain]

36. Hong JY, Song KS, Cho JH, Lee JH. An Updated Overview of Low Back Pain Management in Primary Care. *Asian Spine J* 2017;**11**:653-60

37. Nadine EF et al. Prevention and treatment of low back pain: evidence, challenges, and promising directions. *The Lancet* 2018;**391**:2368-83

38. Dinesh, Gaelyn S, Chris S, Reetu G, Sukhwinder JSS. The Use of Imaging in Management of Patients with Low Back Pain. *J Clin Imaging Sci* 2018;**8**:30

39. Umile GL, Mattia L, Luca D, Nicola M, Vincenzo D. Rating scales for low back pain. *British Medical Bulletin* 2010;**94**:81-144

40. Bart WK, Maurits van T, Chung-Wei CL, Luciana G., James M, Chris M. An updated overview of clinical guidelines for the management of non-specific low back pain in primary care. *Eur Spine J* 2010;**19**:2075-94

41. Lee FS, HS Minhat, SA Ahmad. Non-pharmacological treatment uptake for chronic musculoskeletal pain among community-dwelling older adults in Petaling District, Selangor. *Mal J Med Health Sci* 2020;**16**:219-29

42. Min Y et al. A comparison between the low back pain scales for patients with lumbar disc herniation: validity, reliability, and responsiveness. *Health and Quality of Life Outcomes* 2020;**18**:175

43. Mary C, Zubaidah JO, Michael N, Lois T, Amanda W, Khuzaimah AA, Ramli MA, Norhana Mohd D. Self-management of chronic pain in Malaysian patients: effectiveness trial with 1-year follow-up. *TBM* 2012;**2**:30-7

Technology-Enhanced Learning and Teaching in Anaesthesia: Is it the Time to Move Forward?

Nur Fariza Ramly[1,2], Nurfatihah Alias[2], Saw Yee Horng[1], Noor Liyana Mohamad Saad[1]
[1]Department of Anaesthesiology and Intensive Care, Kulliyyah of Medicine, International Islamic University Malaysia, Pahang, Malaysia
[2]Department of Anaesthesiology and Intensive Care, Sultan Ahmad Shah Medical Centre (SASMEC@ IIUM), Pahang, Malaysia

In the midst of the COVID-19 pandemic, medical education in hospitals and universities is severely affected. On the verge of sudden conversion to online education, there are many different aspects of it that triggers discomfort to the educators and the students. However, there are also many areas that have proven to be beneficial for medical education. Adapting the online technology into medical education should be blended with the conventional model of teaching and learning, not to replace or move away from it. A more precise online model of teaching and learning should be developed by including the concept of adult learning and implementing the model based on knowledge acquisitions, clinical skills development, communication skills and professionalism. A flexible model that is learner-centric, incorporates active participation and networking, with microlearning modules, is an ideal model for medical education, including anaesthesia education.

INTRODUCTION

Recently we are hit with the COVID-19 situation which demanded most of our attention and expertise. We are greeted with the urgency to cope with the COVID-19 pandemic while struggling to adapt with the limited medical resources to match the outgrowing clinical service needs. Since the high service load compels everyone to be involved with pandemic preparedness, having knowledge and skills in anaesthesia and intensive care are considered of value in the wake of this scenario. Maintaining continuing medical education activities during this pandemic is a challenge to the medical fraternity.[1]

INFORMAL ANAESTHESIA EDUCATION IN HOSPITAL SETTING

In Malaysia, the junior doctors (or medical officers) in anaesthesia are trained to achieve a certain level of competence in their clinical work in order to provide high quality and safe medical care.[2] Similar with any medical disciplines, practising anaesthesia also requires medical knowledge, clinical skills and professionalism. In the hospital setting, the young doctors learn anaesthesia first-handedly by engaging with real patients, thus in a way equipped them with the required social and professional skills of a good clinician.[2,3] Nevertheless, the teaching in hospitals still follows the conventional approach of work-place trainings, which are predominantly competency-based. The junior doctors usually learn new skills and techniques from the senior colleagues or the specialists by observing how they were done, and then performed these themselves while under supervision. That is traditionally one of the informal but effective ways of assessing competency in anaesthesia skills such as central line insertion, intubation and bag-mask ventilation. As they become more experienced, they will then be responsible for training and supervising the other more junior doctors. The *'see one, do one, teach one'* concept of training became relevant for this type of informal training of junior doctors especially in hospital settings. An observation by Kotsis and Chung, into a surgical residency program that utilises this *'see one, do one, teach one'* method of teaching, despite still being applicable, they suggested for *'see many, learn for the outcome, do many with supervision and learn from the outcome, and finally teach many with supervision and learn from outcome'*.[4]

In spite of this scenario in hospital settings, without a structured framework of clinical anaesthesia education, the perceptions of learning are more passive and teacher-oriented.[3] Their whole learning activities are usually evaluated by simple observational assessment by the more senior doctors or specialists. The continuing medical education, the webinars and the online anaesthesia websites

became additional resources for their informal learnings and usually are duly adequate to enhance their knowledge and skills. Nowadays, while becoming priorities to provide services in the heat of the pandemic, the routine activities of teaching and learning in hospital settings are facing a major interruption.

ANAESTHESIA EDUCATION IN PANDEMIC

In the university scenario, the pandemic affects the education ecosystem in a different continuum, and medical education is equally hit hard.[1,5-7] All the aspects of face-to-face teaching and learning activities are not allowed to mitigate the risk of COVID-19 infection among students. As a result, the teaching and learning activities are moved to e-learning platforms which implicate a digital divide among the students. One of the transformation goals in Malaysia Education Blueprint of Higher Education 2015-2025, mentioned towards globalised online learning, but unfortunately the internet penetration rate in Malaysia only stands around 84.2%.[8] Limited access to good online facilities required for online learning such as a reliable computer with supported software and hardware, and a stable internet connection, usually are the basis of the digital divide among students. This also becomes financial and logistic burdens to some of the less fortunate students. In response to these, in October 2020, the Ministry of Higher Education has announced a 'Data Plan and Device Package' focusing on the less fortunate students, with the assistance amounting up to RM 24 million.[9] This is mainly aimed to abolish the digital discrimination and to provide good facilities for online teaching and learning activities to everyone in universities.

The education programme also requires restructuring to fit the online capacity and constraint. The method of assessments had to be revisited to ensure the online model of formative and summative assessments are able to achieve the similar par, if not higher, with its face-to-face equivalent. This can become substandard in anaesthesia education where the expected level of competencies and clinical skills are difficult to be assessed through online platforms.

Due to the overnight conversion to online education, the educators also bear the brunt of education divide, where the work-place training is no longer a choice.[6] In the beginning of the pandemic, the educators struggled to provide online classes alongside the clinical services demand. This is due to the fact that the operation theatre or the intensive care unit can no longer be the educational field for anaesthesia students and doctors.

The valuable student-patient direct interaction is not permitted in the pandemic era to prioritise the students' safety.[6] This precipitates concern on the lack of hands-on experience especially in the specialties that required clinical and interpersonal skills such as anaesthesia. This affects the postgraduate students doing clinical attachment also, as the caseloads are lesser in number and variety due to the major shift of elective surgeries to selective semi-emergency cases only in most hospitals. This duly disrupts the experiential learning opportunities, including in subspecialties training.

These seismic events affecting the anaesthesia education, will stay on our shore as long as the COVID-19 threats are within the nation. Perhaps this is the time to change our strategies and upscale our effort in the anaesthesia education arena. Embracing the technology, instead of being miserable by it, might be the best choice to upgrade the anaesthesia education in parallel with the advances of tele-education.

ADOPTING THE CONCEPT OF ADULT LEARNING IN ONLINE ANAESTHESIA EDUCATION

According to Malcolm Knowles, an American educator who coined the concept of adult learning or andragogy, adults learn things differently, as compared to children.[10-13] In his theoretical framework, there are five assumptions of the characters of adult education. Firstly, adults are usually self-driven and independent. This is a favourable characteristic for online learning, where the learning is more active and student-centered. Adult learners are normally able to self-motivate towards their own goal, which is the second

character of andragogy. They drive their motivation mainly with the intention to become sustainable and relevant in the field.

As a person matures also, he/she accumulate a reservoir of personal or professional experiences that form the foundation of his/her continuous learning process. This third andragogy characteristic differentiate between adult and children learning; the good and bad experiences assimilated with his/her new understandings to enhance the knowledge. In medical practice, clinical experiences are highly regarded as precious possession.

The two last characteristics are readiness and orientation, where adult learners are usually more ready to engage and can orientate or apply their knowledge to solve the specific issues or gaps. This is so relevant in medical education where the knowledge and skills built up the competency level.

TECHNOLOGY-ENHANCED LEARNING AND TEACHING: FORMULATING A RELEVANT DESIGN

While an andragogy concept is agreed upon as a good substance for e-learning, a revelant model of online learning is still required to achieve all the matrices of learning outcomes. For instance, a two-hour face-to-face lecture may not achieve the same impact when it is done online. There will be a lack of real-time feedback in terms of limited two-way communication. Long hours online lectures also may become a challenge to the students to focus on the screen. Jeffries in his book, 'An Introduction to Medical Teaching'[14] purported that a typical adult learner's attention span wanes after about 15 to 20 minutes.

Online teaching, which is a backstabbing spear when it is done incorrectly, can become a stress factor for the medical educators. In Malaysia, the educators in the anaesthesiology fraternity also have to balance the time between teachings, research activities, clinical services, and administrative duties. Therefore, they need a teaching strategy that is dynamic and flexible to fit their time. The conventional online live lectures, where the educators repeat the similar contents to different groups or batches of students, may be redundant and not relevant anymore.

It may also become troublesome to explain certain practical skills to new students through online lectures without using proper media. Imagine trying to explain the rapid sequence induction on the online platform to the fresh undergraduate students; the task is indeed less hassle during conventional hands-on sessions in hospital.

A study by O'Doherty *et al.*[15] identified the barriers of development and implementation of online learning in medical education. They are related to familiar themes of inadequate technical skills among the medical educators, limited resources, lack of institutional strategies and support, and the negative attitudes of the educator himself/herself. In the paper, they suggested some solutions, which are neither impossible nor costing a lot of money, but mainly need a healthy change of attitude towards this new norm.

Online or distance learning is defined as the use of electronic technology and media to deliver, support, and enhance both learning and teaching that involves communication between learners and teachers utilising the online contents. It can encompass a wider learning outcome matrix when it is not only limited to lectures or webinars, customised to the adult learning needs, while fulfilling the pillars of medical education in knowledge, skills and professionalism.

There are many benefits that can be gained from online learning such as the flexibility and the accessibility. Most people in Malaysia have digital literacy and are comfortable with online interactions. This includes the familiarity with knowledge acquisition from the various forms of open sources and media, that provide unlimited access to materials that are more readily updated than conventional written data. There are many applications that can be used as teaching and learning tools that can attract the students and also provide a concept of gamification in learning.

Instead of using the normal presentation slides to deliver a lecture, the educators can convert the slides into voice annotated slides or an interactive slide deck for self-learning. Singhal *et al.*[16] came up with twelve brilliant ideas to incorporate gamification in medical education.

A positive attribute of the online model, to be able to provide synchronous and asynchronous learning, can benefit both students and educators alike. A synchronous learning, where the content delivery occurs with the presence of both students and educators, can be designed as teacher-led learning, such as interactive lectures;[17] or it can be student-led activities such as problem-based learning (PBL)[18,19] or group discussions. An interactive session between the educator and students can allow real-time feedback through this model. The timing and location of the sessions can be flexible to suit both educators and students. For maximal gain, the lecture-based model should adopt the microlearning strategy,[20] where splitting contents into smaller sections, no longer than 1 hour, can enhance student engagement with better chance of information retention.

In asynchronous learning, the content delivery does not involve the interaction in real-time between the students and the educator. Example is the flipped classroom model[21] where the instructions are given to students for a specific task prior to the classes. This instructional strategy may include giving the student a task to review some articles relating to a certain topic, listen to podcasts, or to watch a pre-recorded lecture prior to lessons. Therefore, during the actual lesson, the interaction will be more beneficial and involves more educated discussion instead of a teacher-led session. This model is suitable for young doctors in hospital settings and also for undergraduate and postgraduate students.

There are also a variety of skill-based simulator learning techniques in anaesthesia without involving the real patients, which become relevant during this era of COVID-19. Simulation using standardised patients through online platforms can be used as a training in history taking during preoperative assessment. From there, the student can formulate anaesthesia management for the patient. Some virtual reality applications and high-fidelity mannequin simulators also can be used to train in crisis management and also relevant procedures such as bronchoscopy, line insertion, regional blocks and echocardiography.

Online learning also can nurture both solo learning and collaborative learning. Tasks can be given on an individual basis or as a group work. Thus, the students should not feel isolated during the distance learning, as it is still possible to have positive interaction between group members.[22] Activities such as PBL, roleplays and case discussions are all based on collaborative learning and relevant to anaesthesiology education.

On the other hand, there is an angle of online learning that requires consideration, which is the assessment modality. Thus far in Malaysia, the summative assessment in anaesthesia postgraduate programme involves written and viva voce modalities. The examination activities were heavily affected during this COVID-19 pandemic due to the ban on interstate travel for the students and examiners. Universities have to adopt decentralised examinations for the written paper, where the examinations are held in the candidates' service hospitals. Due to the format of the written examination which involves multiple choice questions and short answer questions, it is difficult to convert the examinations into online examinations. Some other non-medical disciplines already adopt the remote proctoring examination model[23] that enables students to take a timed examination while the proctoring software, with or without a remote human proctor, monitors the students' desktop, webcam audio and video. The software can detect any attempt of cheating while disabling the online searches on the desktop during the examination, whereas the human proctor will help with the identification of the candidates and observing for any suspicious cheating behaviour during the examination.

Another new trend in the online education scenarios is the massive open online courses (MOOCs). MOOC

utilises both the synchronous and asynchronous learnings with more dynamic contexts around its content. Some of the examples of popular international platforms for MOOC are edX and Coursera that offer open online courses. The MOOC model can also be adopted in our anaesthesia education, where a very structured program can be developed by credentialled educators, aiming at providing a formal extra-hour education that can benefit young doctors in hospitals or other related healthcare personnel.[24-26]

IS ONLINE LEARNING SUITABLE FOR ANAESTHESIA EDUCATION?

Despite the fact that this current situation forced us to convert to online learning, and there are models to personalise the online learning towards medical education, a solely distance learning model may not be ideal for anaesthesia education. There is still a need to blend the online learning with the traditional didactic method to fully achieve the level of competency. While it can be utilised in both synchronous and asynchronous ways to provide knowledge-based education, the lacking matrices in clinical and communication skills still require hands-on clinical training with real patients in hospital. Therefore, it is about time that we move on to include the technology-enhanced teaching and learning models in our medical education system, but not to replace it.

References

1. Papapanou M, Routsi E, Tsamakis K, et al. Medical education challenges and innovations during COVID-19 pandemic. *Postgrad Med J* 2021;**0**:1-7

2. Smith AF, Greaves JD. Beyond competence: defining and promoting excellence in anaesthesia. *Anaesthesia* 2010;**65**:184-91

3. Ramani S, Leinster S. AMEE Guide no. 34: Teaching in the clinical environment. *Med Teach* 2008;**30**:347-64

4. Kotsis S v., Chung KC. Application of the "see one, do one, teach one" concept in surgical training. *Plast Reconstr Surg* 2013;**131**:1194-201

5. Ferrel MNN, Ryan JJ. The Impact of COVID-19 on medical education. *Cureus* 2020;**12**:7492

6. Sneyd JR, Mathoulin SE, O'Sullivan EP, et al. Impact of the COVID-19 pandemic on anaesthesia trainees and their training. *Br J Anaesth* 2020;**125**:450-5

7. Algiraigri AH. Postgraduate medical training and COVID-19 pandemic: should we stop, freeze, or continue? *Health Prof Educ* 2020;**6**:123-5

8. Ministry of Education Malaysia. Malaysia Education Blueprint 2015-2025 (Higher Education); 2013

9. Badarulzaman MH. Manfaat pakej pelan data internet, Berita Harian [Internet]. 2021 Feb 18 [cited 2021 Feb 18]. Available from: https://www.bharian.com.my/rencana/minda-pembaca/2021/02/787436/manfaat-pakej-pelan-data-internet

10. Abela J. Adult learning theories and medical education: a review. *Malta Medical Journal* 2009;**21**:11-18

11. Cooper AZ, Richards JB. Lectures for adult learners: breaking old habits in graduate medical education. *Am J Med* 2017;**130**:376-81

12. MAP Newsletter [internet]. Terrytown NY: ISMPP; 2020. A new dawn in medical education: applying adult learning principles to virtual delivery; 2020 [cited 2020 Sep 9]; | Available from: https://ismpp-newsletter.com/2020/09/09/a-new-dawn-in-medical-education-applying-adult-learning-principles-to-virtual-delivery

13. Reed S, Shell R, Kassis K, et al. Applying adult learning practices in medical education. *Curr Probl in Pediatr Adolesc Health Care* 2014;**44**:170-81

14. Jeffries WB. An introduction to medical teaching. Springer Netherlands, pp.11-26

15. O'Doherty D, Dromey M, Lougheed J, et al. Barriers and solutions to online learning in medical education - An integrative review. *BMC Med Educ* 2018;**18**:130

16. Singhal S, Hough J, Cripps D. Twelve tips for incorporating gamification into medical education. *MedEdPublish* [internet]. 2019 [cited 2019 Nov 26]; Available from: https://www.mededpublish.org/manuscripts/2678 doi: 10.15694/mep.2019.000216.1

17. Steinert Y, Snell LS. Interactive lecturing: strategies for increasing participation in large group presentations. *Med Teach* 1999;**21**:37-42

18. Car LT, Myint Kyaw B, Dunleavy G, et al. Digital problem-based learning in health professions: systematic review and meta-analysis by the digital health education collaboration. *J Med Internet Res* 2019;**21**:e12945

19. Howlett D, Vincent T, Gainsborough N, et al. Integration of a case-based online module into an undergraduate curriculum: what is involved and is it effective? *E-learning and Digital Media* 2009;**6**:372-84

20. De Gagne JC, Park HK, Hall K, et al. Microlearning in health professions education: scoping review. *JMIR Med Educ* 2019;**5.2**:e13997

21. Hurtubise L, Hall E, Sheridan L, et al. The flipped classroom in medical education: engaging students to build competency. J Med Educ Curric Dev 2015;S23895

22. Wiecha J, Barrie N, Anderson MB. Collaborative online learning: a new approach to distance CME. *Acad Med* 2002;**77**:928-9

23. WhatNext [internet]. London: WhatNext Global plc; 2021. AI & augmented reality enabled medical proctoring; 2021 Available from: https://www.whatnextglobal.com/post/ai-augmented-reality-enabled-medical-proctoring

24. Harder B. Are MOOCs the future of medical education? BMJ 2013;346

25. Marks L, Meek S. Blending MOOCs into medical education. MedEdPublish 2018:7

26. Olivares Olivares SL, Hernández RIE, Corolla MLT, et al. MOOC learning assessment in clinical settings: analysis from quality dimensions. *Med Sci Educ* 2021;**31**:447-55

Artificial Intelligence versus Human Intelligence in Anaesthesia: Who is Winning?

Nazhan Afeef Mohd Ariff @ Ghazali
Department of Anaesthesiology and Intensive Care, Kulliyyah of Medicine, International Islamic University Malaysia, Pahang, Malaysia

Artificial intelligence (AI) plays a significant role especially in the light of the COVID-19 pandemic. The position of anaesthesiologists and their role in providing anaesthetic services initially was dominant. The AI ability to overtake the human's capability in providing an accurate medical treatment may threaten the role of a doctor. The integration of AI in anaesthesia has been tremendous. Challenges in using this technology in anaesthesia are to determine, design, test the practicality, maintain dynamicity and market the technology. In the future, we hope AI may become the strongest weapon for anaesthesiologists to deliver the best anaesthesia services to patients and not as an enemy.

INTRODUCTION

Artificial intelligence is defined as the ability of a computer or computer-controlled robot to perform task commonly associated with intelligent being.[1] Alan Turing has been regarded as the Father of AI due to his ability and his team effort to break the secret code by the Enigma Machine used by the German armies during the World War II.[2] The development of anaesthesia starts from the finding of ether to the advanced robotic keyhole surgery or refined anaesthetic and intensive care drug delivery techniques that are AI based.[3] COVID-19 has taught us a lot in anaesthesia and surgery.[4] Any anaesthetic procedures especially one that involves aerosols generating procedure (AGP) must be performed by the safest means.[5] Can AI help anaesthesia and intensive care teams to better protect health care workers during this COVID-19?

In the old days, intraoperative monitoring using a patient's skin colour to determine perfusion, intermittent sphygmomanometer mercury blood pressure readings and pulse characteristics were the main method.[6] The role of machines taking over the human function has been tremendous. New medical officers are not used to isoflurane or enflurane and even nitrous oxide! We always say that a machine is only an aid for us, but how many of us rely on them almost 100%?

We believe in the numbers that appear on the screen, regardless of what is happening under the surgical drape. The term vigilant anaesthesiologist now can be a vigilantly looking-at-the-screen anaesthesiologist with all the gadgets and online stuff that the eyes are now even looking less on the monitor! That could be exaggerating, but whatever there is with the technology that we have, the safety of the patient is our top priority. That is where a knowledgeable vigilant anaesthesiologist is the most important 'tool' than any existing tools.[7] But what are the limitations? Can an AI challenge put an end to the 'smartest' so-called doctor on earth?

Utilising advanced monitoring in anaesthesia requires careful steps (Figure 1). Preoperative management includes prompt work-out and investigations. Problems related to anaesthesia need to be properly addressed and anaesthetic management prior to the operation needs to be discussed with parties involved. This includes the advantages and disadvantages of the chosen anaesthetic techniques and monitoring. Final check on the check-list before the patient is called to the operation theatre is a must to minimise the intraoperative complications. The decision to continue the monitoring postoperatively needs to be justified and the integrity of the monitoring must be maintained.

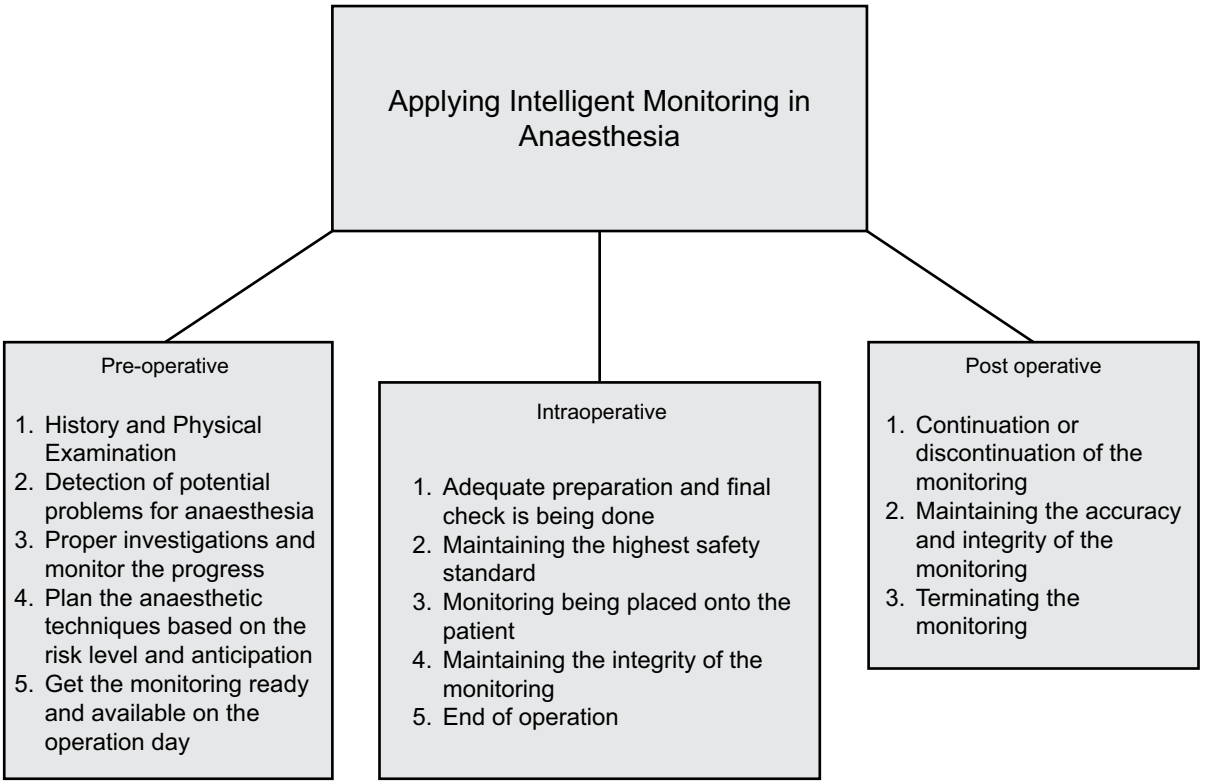

Figure 1: Perioperative Management for Patients Planned for Intelligent Monitoring

THE DEVELOPMENT OF MODERN MONITORING IN ANAESTHESIA: WHERE ARE WE?

Depth of anaesthesia (DOA) monitoring is one of the finest examples for AI monitoring advancement in anaesthesia (Table I).[8] Bickford in 1950 introduced the application of electroencephalogram (EEG) to monitor the awareness in anaesthesia.[8] From the sophisticated EEG to as simple as Cerebral State Monitoring, this technology is considered acceptable and reliable in comparison to previous End-Tidal Anaesthetic Agent Concentration method.[8]

Table I: Depth of Anaesthesia Monitors[9]

Depth of Anaesthesia Monitors	Year introduced	Awake to deep anaesthesia (time delay)	Deep anaesthesia to awake (time delay)	Electromagnetic interference	Correlation with clinical signs
BIS	1992	61 s	63 s	Moderate	Yes
Entropy	2003	Not available	Not available	High	Yes
Narcotrend	2000	26 s	90 s	Moderate	Yes
EP monitor/2	2001	No data	No data	No data	Yes
PSA 4000	2001	No data	No data	No data	No data
CSM	2004	55 s	106 s	Moderate	Yes

BIS = Bispectral Index, AEP = Auditory Evoked Potential, PSA = Patient State Analyser, CSM = Cerebral State Monitoring

Johnson & Johnson Company introduced the United States Food and Drug Administration (USFDA) approved SedaSys system to maintain hypnosis assisted by DOA.[9] However, due to poor sales, SedaSys was withdrawn from the market in 2016. Good AI monitoring does not guarantee the survivability of the monitoring, unfortunately. Maybe it was the fault of the marketing. The McSleepy System which was used in laparoscopic robotic prostatectomy however proved that the AI system could function (Figure 2). However, due to the surgical limitation, as not many centres have the feasibility of robotic surgery, the usage still is limited.

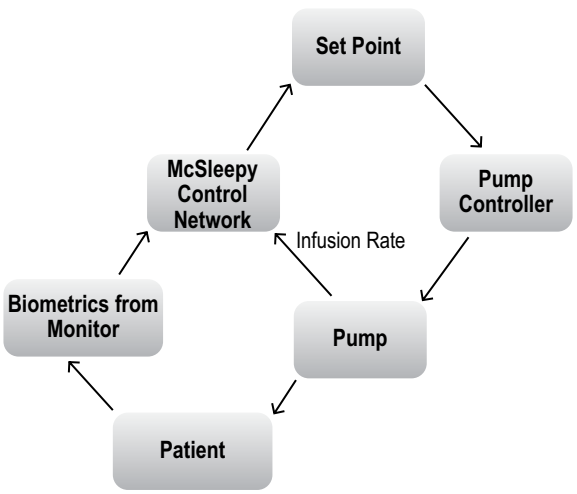

Figure 2: McSleepy System. Adapted from McGrath[9]

DOA monitoring integrated with Target Controlled-Infusion (TCI) provides a better grip in providing refined Total Intravenous Technique.[10] TCI has been bread and butter in anaesthesia practice nowadays. Not knowing TCI application in and out can be a problem in tertiary hospitals. Looking at the application of such in daily practice, the AI potential is limitless, but the benefit will be maximised provided certain criteria are met.

Human robotic intubation was documented to be performed as early as in 2012.[11] Twelve patients with Mallampati score II and less had the success rate of 91%. A concept study called Robotic Endoscope-Automated via Laryngeal Imaging for Tracheal Intubation (REALITI) involving seven anaesthesiologists and seven non-trained personnel, out of 84 attempts on manikins via automated and manual techniques, the success rate was above 95% for both groups.[12]

Up to now, no robotic human intubation has yet been performed in Malaysia. In fact, this matter is important as per COVID-19 protocol, as we (anaesthesiologists) are the ones who need to perform the intubation on COVID-19 patients. If robotic intubation can be integrated in our practice, an anaesthesiologist with proper training shall be able to perform human intubation even from outside the isolation room comparable to being inside the room performing the manual intubation while wearing the Personal Protective Equipment and all.

PROBLEMS AND CHALLENGES IN DEVELOPING AN ARTIFICIAL INTELLIGENCE EQUIPMENT IN ANAESTHESIA

Determining the Best AI and Area in Anaesthesia

Anaesthesia involves a vast field of techniques for various types of surgeries. The choice of AI application should be based on which application may improve the patients' outcome and the most cost-effective method. DOA monitoring, anaesthetic delivery system, event prediction, ultrasound-guided anaesthesia procedures, pain management and operating room logistics are examples mentioned where AI application has been integrated.[13] The choice might be simple or the opposite. Therefore, a proper AI application that is to be selected must be properly scrutinised and challenged in various aspects.

Designing the AI Itself

This involves multidisciplinary discussions and team effort with the software engineers, computer analysts, hardware engineers and, of course, anaesthesiologists and others depending on the type of AI that is going to be developed. We are talking about how the data are being taken and recorded.

This data will be directed to multiple channels and be interpreted according to the state the patients are in (Figure 3). The next step is to decide what will be the next action that needs to be taken by the AI to maintain the two states.

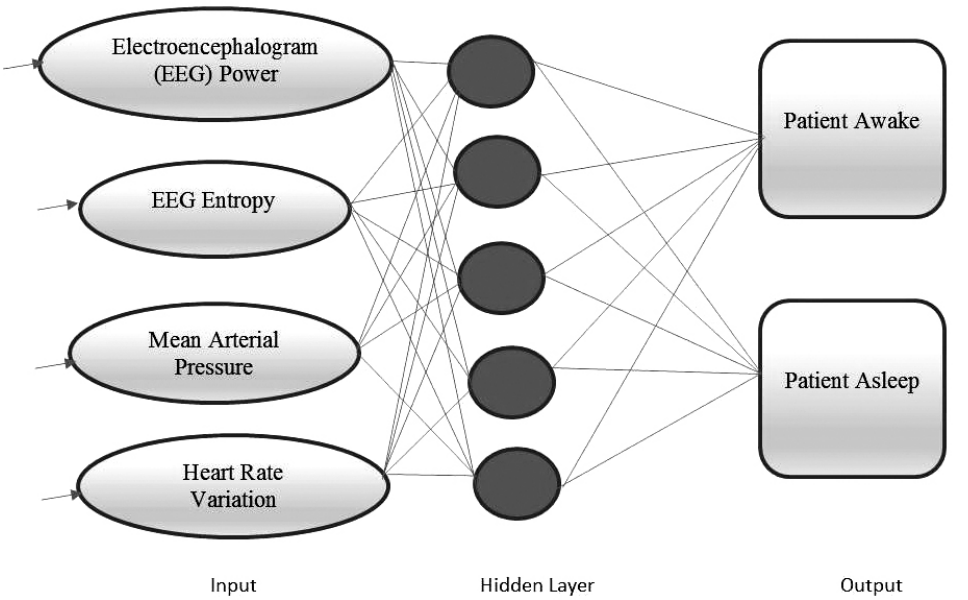

Figure 3: Three neural layers network. Adapted from Hashimoto[13]

Testing the Feasibility and Practicality of an AI

Getting the first few runs done successfully might come to a question whether the system can be maintained and give the same desired outputs all the time. Next is whether the system is durable enough. The setting up of the system must be user-friendly as well.

Creating an Adaptive and Dynamic AI System

The development of new drugs or equipment might require an AI system which is adaptive and able to cope with these changes at all times. However, developing this system cost a lot of resources and might not be practical anymore at one time. This is an ideal concept of AI in anaesthesia but looking at what happened to SedaSys, further evaluation needs to be done.

Marketability and After Sales Services

This might be the biggest challenge of all - marketing. Despite all the efforts given from scratch, everything can just simply go to waste just because of bad marketing strategy. Marketing specialists should be included in the early process to make the product well known to the marketer before the product is being sold. Many products have seen to fail to perform due to poor marketing despite its good application. The key is to produce an AI product at the right time, place, and price.[14] Bad after sales service made matters even worse.

FUTURE PROSPECT

Robotic intubation has been mentioned above. The next step maybe is the remote anaesthesia monitoring with the ability to intervene away from the patient. This will help to train junior medical officers as well helping anaesthesiologists to always being able to monitor despite not being physically present in the operation theatre. TCI application for pain management based on nociceptive index has been studied too,[13] but no intensive studies have been performed. Perioperative AI-based pain management including chronic pain hopefully may reduce pain consultant visits in the future.

In critical care, for example, the application of AI in helping intensivists to better manage ventilators and drug delivery system in order to achieve better therapeutic range in patients who have been known to have altered physiological state is something continuously ongoing.[15,16] However, despite the intense attempt to make AI play a role in anaesthesia and critical care area, vigilant anaesthesiologists and intensivists have always and, probably, will never be replaced.

CONCLUSION

Humankind still wins the battle against AI, as for now. In the future, we do not know if AI in the form of robotic personnel will be walking in the operation theatre, Intensive Care Unit or anaesthesia clinic doing all clinical tasks replacing the anaesthesiologists. But always remember, behind so-called the most advanced AIs are always human or maybe the time will come like The Judgement Day in The Terminator movie, who knows?

References

1. Copeland J. Artificial Intelligence: A Philosophical Introduction. 1993; Wiley-Blackwell; United States of America

2. Britannica T. Editors of Encyclopaedia. Enigma. Encyclopedia Britannica; June 8, 2021. [https://www.britannica.com/topic/Enigma-German-code-device] Accessed June 28, 2021

3. Robinson DH, Toledo AH. Historical development of modern anesthesia. *J Invest Surg* 2012;**25**:141-9

4. Kirkby-Bott J. Surgery and COVID-19: Three lessons that have improved patient care. 2020. [https://www.topdoctors.co.uk/medical-articles/surgery-and-covid-19-three-lessons-that-have-improved-patient-care#) Accessed on June 5, 2021

5. Soma M, Jacobson I, Brewer J, Blondin A, Davidson G, Singham S. Operative team checklist for aerosol generating procedures to minimise exposure of healthcare workers to SARS-CoV-2. *Int J Pediatr Otorhinolaryngol* 2020;**134**:110075

6. Reich DL, Reich DL. The history of anesthesia and perioperative monitoring. In Kahn RA, Mittnacht AJC, Leibowitz AB, Stone ME, Eisenkraft JB, editors. Monitoring in Anesthesia and Perioperative Care. Cambridge: Cambridge University Press; 2011;p.1-8

7. Jones CPL, Fawker-Corbett J, Groom P, Morton B, Lister C, Mercer SJ. Human factors in preventing complications in anaesthesia: a systematic review. *Anaesthesia* 2018;**73**:12-24

8. Lobo FA. Advances in anaesthetic monitoring- is DOA monitoring the magic bullet? *Anaesth Int* 2014;**1**:14-16

9. McGrath H, Flanagan C, Zeng L, Lei Y. Anaesthesia Monitoring using Artificial Intelligence Techniques. *Int J Anesthetic Anesthesiol* 2019;**6**:098

10. Guarracino F, Lapolla F, Cariello C, Danella A, Doroni L, Baldassarri R. et al. Target controlled infusion: TCI. *Minerva Anestesiol* 2005;**71**:335-7

11. Hemmerling TM, Taddei R, Wehbe M, Zaouter C, Cyr S, Morse J. First robotic tracheal intubations in humans using the Kepler intubation system. *Br J of Anaesth* 2012;**108**:1011-6

12. Biro P, Hofmann P, Gage D, Boehler Q, Chautems C, Braun J et al. Automated tracheal intubation in an airway manikin using a robotic endoscope: a proof of concept study. *Anaesthesia* 2020;**75**:881-6

13. Hashimoto DA, Witkowski E, Gao L, Meireles O, Rosman G. Artificial Intelligence in Anesthesiology: Current Techniques, Clinical Applications, and Limitations. *Anesthesiology* 2020;**132**:379-394

14. Gitman LJ, McDaniel C, Shah A, Reece M, Koffel L, Talsma B et all. Introduction to Business 2018. [http://cnx.org/contents/4e09771fa8aa-40ce-9063-aa58cc24e77f@8.2.] Accessed on June 25, 2021

15. Gutierrez G. Artificial Intelligence in the Intensive Care Unit. *Crit Care* 2020;**24**:101

16. Williams K, Hinojosa-Kurtzberg M, Parthasarathy S. Control of breathing during mechanical ventilation: who is the boss? *Respir Care* 2011;**56**:127-36

Burnout amongst Anaesthesiologists: The Forgotten Issue

Suhaila Nanyan, Nadiah Hamdan, Najibah Syakirah Ab Rahman
Department of Anaesthesiology and Intensive Care, Kulliyyah of Medicine, International Islamic University Malaysia, Pahang, Malaysia

Burnout is a psychological syndrome that is seen particularly affecting those who are chronically exposed to high levels of stress especially at work. The COVID-19 pandemic had tremendously increased workloads and exposed the healthcare worker to burnout. Risks for burnout include challenges in anaesthetic fields, long working hours, limited resources, professional conflicts, and intrinsic factors such as vulnerable personality. Burnout affects both physical and psychological wellbeing of an individual. As such, it may increase erroneous and legal suits which can be detrimental to both the organisation and the individual. Burnout is managed by socio-psychological training aiming at both individual and organisation levels and it requires multilevel prevention to reduce its incidence among healthcare workers. Detection, treatment, and prevention should be actively carried out to make sure that healthcare workers' wellbeing is in the optimum state especially during the COVID-19 pandemic.

INTRODUCTION

The deadly disease of COVID-19 first started in December 2019 in Wuhan, China. It then rapidly spread worldwide and became a pandemic. The first reported case of COVID-19 in Malaysia was on 20th January 2020. Since the start of COVID-19 pandemic, healthcare workers have been working tirelessly even more so now than before. Anaesthesiologists along with physicians, infectious control teams and community medicine physicians are among the most affected by this pandemic. The number of intensive care unit (ICU) bed requirements increase tremendously as the pandemic progresses. Most hospitals received more than double the number of critically ill patients compared to previously. In June 2021, daily ICU patients in Malaysia were around 800 to 900 persons per day. More than half of these patients require respiratory support and ventilation. The wellbeing of the healthcare workers should be equally important as well as the care of these critically ill patients. This is crucial because the wellbeing of the healthcare workers will indirectly reflect the quality of patients' care. Overworked healthcare workers are prone to psychological problems such as burnout and depression.

DEFINITION

Burnout is a psychological syndrome that is seen particularly affecting those who are chronically exposed to high levels of stress especially at work.[1,2] Burnout starts in stages. A readily accepted responsibility may progress to onset of stress which later progresses to chronic stress. Chronic stress at the workplace that is not successfully managed will result in burnout. Burnout is characterised by energy depletion, emotional exhaustion, negative mindsets related to the job and reduced professional efficacy.[3] The final stage of burnout is habitual burnout when the symptoms are embedded in life.

ASSESSMENT TOOLS

The Maslach Burnout Inventory (MBI) is one of the assessment tools available to evaluate risks for burnout. It was developed by Maslach and Jackson in 1981 (updated in 1996) from surveys among various healthcare professionals.[4,5] It was validated and well recognised for assessment of risks for burnout in several countries. MBI consists of 22 items assessing three different aspects of burnout.[6] It is sub-grouped into emotional exhaustion (9 items), depersonalisation (5 items) and lack of personal accomplishment (8 items). The scores are 0-54, 0-30 and 0-48, respectively. Higher total score indicates higher risk of burnout. Another commonly used assessment tool for burnout is the Copenhagen Burnout Inventory (CBI). CBI is an instrument to measure occupational burnout with excellent

psychometric properties and is available in the public domain. It has three dimensions that include personal-related (6 items), work-related (7 items), and patient-related burnout (6 items). Each item is rated on a scale of always/to a very high degree (100), often/to a high degree (75), sometimes/somewhat (50), seldom/to a low degree (25), and never/to a very low degree (0).

PREVALENCE

In general, burnout prevalence among physicians is between 20-60%.[6,7] Study by the European General Practice Research Network Burnout Study Group involving 1,400 family medicine physicians in 12 European countries revealed that 43% of respondents scored high for emotional exhaustion, 35% for depersonalisation, and 32% for low personal accomplishment. A total of 12% of participants suffered from burnout in all three dimensions.[1] A recently published study on prevalence of burnout in Malaysia healthcare workers revealed that personal related burnout, work related burnout and patient related burnout were 53.8%, 39.1% and 17.4% respectively.[3] Most studies revealed that anaesthesiologists are having moderate stress.[8,9] A study in Finland showed as high as 68% anaesthesiologists were stressed. One study conducted in Malaysia in the year 2020 reported that 55.3% of anaesthesiologists had burnout during the COVID-19 pandemic, of which 31.8% had emotional exhaustion, 47.1% had depersonalisation and 63.5% had lack of personal accomplishment.[7,10]

RISK FACTORS

Stressors for healthcare workers can either be work related, home related, patient related or combinations of these factors.[2] Age and gender are independent risk factors. Younger anaesthesiologists have higher prevalence.[11] In 2017, the Royal College of Anaesthetists reported that 85% of anaesthesiology trainees were at a higher risk of burnout.[12] Although females are at higher risk of burnout compared to male anaesthesiologists, a few studies have shown that it was not statistically significant.[8,9] Among the identified major stress at work was the lack of control in a situation. Anaesthesia is one of the toughest medical fields that consists of challenges which are sometimes unpredictable.[8] Even after carefully planning a case, the case might not go as smoothly as expected. Anaesthesiologists face difficult situations in their daily practice, in which at times the lives of the patients are already compromised by their illnesses. Occasionally, anaesthesiologists need to promptly perform difficult procedures to save the patients' lives. In certain circumstances, anaesthesiologists need to make ethically difficult decisions which will impact the patients and their families. These decisions need to be made correctly and immediately in order to save the patients' lives. Overworked (working more than 60 hours per week) and chronic sleep deprivation (having more than two on calls per week) are additional risks for burnout.[8] Insufficient resources or equipment malfunctions especially in high demand situations which can be associated with bureaucracy issues can further increase the stress level.[6,13,14] Despite the difficult and tiresome work, anaesthesiologists still need to give their full commitment at all times. Occasionally, there will be disagreements between surgeons and anaesthesiologists which can cause conflicts and hence increase the psychological and physical burden.[15]

Anaesthesiologists who are in the academic field will have additional stress factors. There is increased requirement on productivity, regulation, and bureaucracy in combination with decreased funding for research purposes. The rapidly expanding medical field requires up-to-date knowledge through training which has to be done despite having limited time and this increases the burden for both academicians and trainees. On the other hand, anaesthesiologists in the private sector have the stress of having to depend on patients' billing as their source of income. Increase in financial demand will lead to increased workloads to meet those demands and hence higher risk of burnout.

Conflicts between family members and the demand to work contributes to home-related burnout. Having young children in the family requires higher responsibilities and this increases burnout. For

example, frequent work schedule changes to cover for colleagues on home quarantine will disrupt the workflow and home stability and this predispose the anaesthesiologists to burnout. Inadequate leisure time as well as poor family support will further increase vulnerability to burnout.[2,9] Apart from extrinsic factors mentioned, intrinsic factors such as the personality and previous history of psychiatric issues contributes to a higher risk of burnout. Perfectionists or individuals who cannot cope with stressful conditions are at higher risk.

MANIFESTATION/PRESENTATION

Manifestations of burnout are non-specific; it can be in the form of physical illness, emotional deterioration, or behavioral aberration of intellectual dysfunction. Physical illness involves multiple systems such as cardiovascular, central nervous system, gastrointestinal system, musculoskeletal system and general wellbeing. Elevated blood pressure, increased basal heart rate and coronary diseases are among the most common presentations in the cardiovascular system. Burnout individuals might also experience headache, nausea, gastritis, peptic ulcer disease, colitis and hyperventilation. Spontaneous abortion, weight change, depression of immune system and accelerated ageing process might also be the result of burnout. Emotionally, the individual might have chronic anxiety, depression, labile personality, fatigue, frustration, anger or undefined fears. Behavioral changes such as impulsive or aggressive, complaint compulsively or substance abuse are reported as manifestations of burnout.[11] Poor task performance, difficulty in concentrating, forgetfulness or diminished alertness can be one of the intellectual dysfunctions that are reported as manifestations of burnout.[6]

OVERCOMING STRESS

Burnout carries both personal and professional consequences. At a personal level, burnout increases personal problems such as accidents, substance abuse, suicidal ideation, broken relationships and greater risk of cardiovascular disease. These situations affect the wellbeing as well as the quality of medical care and this will jeopardise patients' safety. Burnout is also associated with medical errors and malpractice suits. After identifying the stress behavior, it is very important to recognise the triggering factors in order to overcome burnout.[11] The focus is to eliminate the individual, environmental and collective stressors.[6] Intervention should then be considered at both individual and environmental levels. Socio-psychological training helps in reducing the level of burnout and positively improves susceptible personality in an individual.[16] After training, symptoms improvement will usually be seen in most participants. Individual-intervention programs are beneficial in reducing burnout in up to six months, while a combination of both personal and organisational programs have a longer lasting positive effect which may persist up to 12 months or even more.[1]

Meditation and exercise therapy can help in overcoming burnout. Mindfulness is a self-directed practice for relaxing the body and calming the mind through focusing on present-moment awareness. The concept of mindfulness emphasises on staying in the present moment, with a non-judging and non-striving attitude of acceptance. Mindful meditation is a complementary therapy that helps to reduce the negative stress and the extraneous factors that lead to burnout. Mindfulness-based stress reduction interventions efficiently reduce psychological distress and 'negative vibes' and encourage empathy while significantly enhancing healthcare workers' quality of life.[17]

Balint session is another known common therapeutic strategy that reduces stress and burnout. It is a group session, applying a patient centered-approach which focuses on doctor-patient relationship. Exercise also helps in reducing burnout. A simple ten minutes stretching exercise has been proven to reduce symptoms of exhaustion and indirectly improve mental and physical health of affected individual.[2] Several mechanisms to reduce stress among healthcare workers have been suggested. This includes allowing contracted hours for non-clinical work, individuals taking the responsibility for self-care in and out of work, cultural acceptance

and embedding wellbeing support in formal and informal organisations; however these require further evaluation on their effectiveness.[12]

STRESS MANAGEMENT IN ANAESTHESIA PRACTICE

Since anaesthesia is a challenging field, it might help to simplify any problems that may be encountered. This can be done by solving the most obvious and simple problems first. The nature of the job is difficult and demanding. Therefore, it is important to recognise our limitations as an individual as well as a healthcare worker. The support from other colleagues is very beneficial. Discussions and opinions from senior colleagues will help in problems solving, even ethically difficult decisions can be made with an open mind. Anaesthesiologists should be able to embrace the high work commitments. They need to learn to prioritise and perform one task at a time. Simpler work can be delegated to other parties such as nurses and medical assistants. Communication plays a vital role in harmonising the relationship of anaesthesiologists with other specialties. Good communication skills despite living in a stressful environment can reduce the arguments and disagreements, and this can lead to a better work outcome.[15]

SOCIAL SUPPORT AT WORKPLACE

Supportive environment is important to compensate for the stressful work life.[17] A disorganised department, professional isolation and social isolation can limit the capability of an individual to respond to the period of stress. Multidisciplinary interventions such as changes in the work environment along with stress management programs showed promising solutions in managing burnout.

PREVENTION

Prevention can be divided into three groups - primary, secondary and tertiary prevention. Primary prevention focuses on individuals where the triggering factors of burnout should be avoided or removed. Awareness and education on burnout might help affected individuals to recognise their symptoms and encourage them to seek help. Secondary prevention can be achieved by early recognition and intervention by the institution. Regular assessment and good work life balance should be encouraged. The institution must intervene early and provide immediate support to those at risk. Finally, tertiary prevention focuses on coping with the consequences, rehabilitation and prophylaxis of relapse or prevention of recurrence.[6,10]

CONCLUSION

In conclusion, burnout is not uncommon among healthcare workers, but it may be under-reported. It affects almost all specialties including anaesthesia. Detection of risk factors and symptoms are very crucial since it carries an impact to both individuals and profession. The precipitating factors should be tackled systematically, and intervention and prevention should be offered at both individual and institution levels. Despite the unsurmountable effort in battling the COVID-19 pandemic, healthcare workers' well-being should not be left behind. Physical and mental well-being of these healthcare workers should be taken care of. We are working very hard in preventing COVID-19 from killing our patients, but please do not let burnout kill us.

References

1. Romani M, Ashkar K. Burnout among physicians. *Libyan J Med* 2014;**9**:23556

2. Prasad A, Zou M, Mangwiro R, Kingsley C, Chisholm B. 2021.Wellbeing during COVID-19 [https://resources.wfsahq.org/wp-content/uploads/atow-444-00.pdf] Accessed March 30, 2021

3. Roslan NS, Saiful M, Yusoff B, Asrenee AR, Morgan K. Burnout prevalence and its associated factors among Malaysian healthcare workers during COVID-19 Pandemic: An embedded mixed-method study. *Healthcare* 2021;**9**:90

4. Van der Walt N, Scribante J, Perrie H. Burnout among anaesthetists in South Africa. *SAJAA* 2015;**21**:169-72

5. Maslach C, Jackson SE, Leiter M. The Maslach Burnout Inventory Manual, 3rd edition. Palo Alto CA, Consulting Psychologist Press. 1996, pp191-218

6. Sousa ARC, Mourão JI de B. Burnout in anesthesiology. *Rev Brasil Anest* 2018;**68**:507-17

7. Tait Shanafelt. Burnout in Anesthesiology. *Anesthesiology* 2011;**114**:1-2

8. Sanfilippo F, Noto A, Foresta G, Santonocito C, Palumbo GJ, Arcadipane A et al. Incidence and factors associated with burnout in anesthesiology: A systematic review. BioMed Res Int 2017:8648925

9. Balan SA, Bubenek-Turconi I, Droc G, Marinescu E, Nita E, Popa MC et al. Burnout syndrome in the anaesthesia and intensive care unit. *Rom J Anaesth Intensive Care* 2019;**26**:31-6

10. S.E.H Tsan, A Kamalananthan, C.K. Lee, C.Y. Wang, S.A. Zakaria. A survey on burnout and depression risk among anaesthetist during COVID-19: The tip of an iceberg?. *Anaesthesia* 2021;**76**:8-9

11. Khetarpal R, Chatrath V, Kaur J, Verma A. Occupational stress in anesthesiologists and coping strategies: A review. *Int J Sci Stud* 2015;**3**:188-96

12. Wainwright E, Looseley A, Mouton R, O'Connor M, Taylor G, Cook TM. Stress, burnout, depression and work satisfaction among UK anaesthetic trainees: a qualitative analysis of in-depth participant interviews in the Satisfaction and Wellbeing in Anaesthetic Training study. *Anaesthesia* 2019;**74**:1240-51

13. Sasangohar F, Sasangohar F, Jones SL, Masud FN, Vahidy FS, Kash BA et al. Provider burnout and fatigue during the COVID-19 pandemic: Lessons learned from a high-volume Intensive Care Unit. *Anest Analg* 2020;**131**:106-11

14. Zhang X, Jiang X, Ni P, Li H, Li C, Zhou Q et al. Association between resilience and burnout of front-line nurses at the peak of the COVID-19 pandemic: Positive and negative affect as mediators in Wuhan. *Int J Ment Health Nurs* 2021;**30**:939-54

15. Larsson J, Rosenqvist U, Holmström I. Enjoying work or burdened by it? How anaesthetists experience and handle difficulties at work: A qualitative study. *Br J Anaesth* 2007;**99**:493-9

16. Hu D, Kong Y, Li W, Han Q, Zhang X, Zhu LX et al. Frontline nurses' burnout, anxiety, depression, and fear statuses and their associated factors during the COVID-19 outbreak in Wuhan, China: A large-scale cross-sectional study. *EClinicalMedicine* 2020;**24**:100424

17. O'Brien JM, Goncin U, Ngo R, Hedlin P, Chakravarti A. Professional fulfillment, burnout, and wellness of anesthesiologists during the COVID-19 pandemic. *Can J Anest* 2021;**68**:734-6

Human Factors in the Provision of Safe Anaesthesia: A Continuous Effort

Farah Nadia Mohd Hanafiah, Nurhidayah Abd Halim
Department of Anaesthesiology and Intensive Care, Kulliyyah of Medicine, International Islamic University Malaysia, Pahang, Malaysia

Pursuing safe anaesthesia is a never-ending journey. Enormous progression had been made previously and this is still an ongoing process. The bulk of anaesthesia that used to be only performed in operating theatres have moved further beyond. Failure to provide a safe anaesthesia is catastrophic. Human factors played an important role, and this article will touch upon communication, teamwork, situational awareness, human error and the usage of checklists. During our current situation of COVID-19 pandemic, providing safe anaesthesia is not solely limited to patients but now it also involves the healthcare providers. Guidelines pertaining to COVID-19 management had been published for healthcare providers to follow. Ultimately, more studies and guidelines are required in our own setting in providing a safe anaesthesia.

INTRODUCTION

Historically, surgery was a terrifying option as a last resort in an attempt to save life. It is not too presumptuous to say that the evolution of surgery depends on anaesthesia. Back then to produce unconsciousness was via ethanol ingestion or herbal mixtures or even a 'knockout' blow to the head.[1] Since then, we have reached enormous progress in the field of anaesthesia. We are pursuing towards improving the delivery of anaesthesia and expanding our field. The bulk of anaesthesia that used to be only performed in the operating theatre has progressed beyond, involving non-operating room anaesthesia (NORA) which includes magnetic resonance imaging suite, angiography suite, electroconvulsive therapy, invasive cardiac laboratory and many more. Pursuing safe anaesthesia is more crucial than ever as the consequences of failure to do so is catastrophic.

We are aware that providing anaesthesia is as important as the surgery itself as it directly affects the outcomes of the surgery. A good anaesthesia provision is an important indicator of medical development. Both technical and non-technical skills are important in providing a safe yet efficient anaesthesia to the patients. Deficiency in non-technicals skills has often been proven to be one of the major factors leading to errors as well as adverse events. A lesson that we can learn from a renowned case related to safety in anaesthesia happened in 2005 which involved one Mrs B. She was a 37 year-old lady who underwent sinus surgery. In her preoperative assessment, it was noted that she had a history of fused vertebrae with slight limitation of range of movement of the neck. Other than that, she had no features of a difficult airway. Unfortunately, during the induction period, a situation of *'cannot intubate and cannot ventilate'* occurred. The initial plan was to insert a flexible laryngeal mask airway however it failed due to increased tone in the jaw muscle. She desaturated after multiple attempts, and attempts of ventilating with facemask and oral airway also proved to be difficult. Attempt of intubation was also unfeasible as the laryngoscopy view showed to be Cormack Lehane grade IV. After multiple attempts of failed intubation, the anaesthesiologists manage to ventilate using an intubating laryngeal mask which then due to failure of inserting tracheal tube via the intubating laryngeal mask, the procedures were abandoned. There was no attempt for tracheostomy despite the OT staff having actually prepared a tracheostomy set in the operating theatre. During the whole procedure, she developed hypoxic brain injury and subsequently she died 13 days later. There were a few issues highlighted in this case where it involved three experienced doctors, two senior anaesthesiologists and one otorhinolaryngology surgeon. However, the ongoing situation of *'can't intubate and can't ventilate'* was not being communicated thus possibly why the Difficult Airway Society (DAS) guideline was not being followed accordingly. Too much time

was taken in trying to intubate the patient instead of providing adequate oxygenation leading to a prolonged period of hypoxia. When the operating theatre staff were interviewed, they were quite surprised that tracheostomy was not performed and one of the suggestions from the inquiry was to provide an environment where all staff members should be comfortable in making suggestions to the treatment. Additionally, in this scenario, there was no clear leadership nor teamwork between the operating theatre members.[2]

The 4th National Audit Project (NAP 4) was a prospective study of all major complications of airway management in the United Kingdom that occurred during anaesthesia, in the intensive care unit as well as in the emergency department. It was an audit in a period of 12 months and was published in March 2011. In NAP 4, human factors were emphasised to be the cause of 40% of adverse events being reported.[3] Most often in a crisis, there are usually more information that can be processed, and this may impair decision-making leading to clinician losing the sight and become fixated as with our earlier case of Mrs B. Guidelines, such as DAS guidelines were created with an explicit instruction for the team to 'stop and think' in order to reduce the extent of damage.[4]

COMMUNICATION

One of the human factors being emphasised by the DAS guidelines which predispose to loss of situational awareness was poor communication.[4] It was also being concluded in NAP 4 that many problems associated with airway adverse event can be solved by a strong good communication between all the specialties involved during the crisis.[3] Ineffective communication is a common cause leading to adverse events in operating theatre. Communication can be defined as *"a process by which information is exchanged between individuals through a common system of symbols, signs, or behaviour"*.[4] Thus, we understand that communication is a two-way process where information that is sent must be perceived and understood by the other party. The team members of a party must be able to share information and reach a common understanding of the event, the role of each team member as well as the ongoing treatment. Failure to communicate will only lead to delay in managing patients, escalating tension among team members, inconvenience as well as inefficiency, underutilised resources and finally it can lead to adverse events.

For communication to occur, we need to understand the obstacle to effective communication. Langard *et al.* and Halverson *et al.* classified communication schemes as errors of occasion when there is inappropriate physical or timing of communication, error of contents when information is inaccurate, error of audience when the key person is not present during communication as an example surgeon not available to discuss the positioning of the patient, error of omission when appropriate communication is absent and error of inappropriate and offensive remarks included.[5,6] The strategies to improve intraoperative communication firstly would be briefing prior to the operation. This is especially true when the case is expected to be long or problematic as all the members will be able to understand the upcoming procedure, what to expect and to be aware of during the procedures and the strategies that will be implemented should the need arises. During communication, we must encourage closed loop communication where the information or instruction given must be verbally followed by an acknowledgement. This can reduce mistakes intraoperatively.

TEAMWORK

The term teamwork can be defined as *"a distinguishable set of two or more people who interact dynamically, interdependently, and adaptively towards a common valued goal, who have each been assigned specific roles or functions to perform, and who have a limited life-span membership"*.[7] In the operation theatre, there are multidisciplinary teams consisting of anaesthesiologists, surgeons, and nurses. Each of the members has diverse professional identities, cultures, priorities, and educational background. The expectation from different teams towards a surgery might be different from each other and

this can also create a conflict among them. Another obstacle would be the presence of a perceived barrier where the members might have fear of being misjudged or embarrassing oneself or other team members of being wrong and, lastly, there might be concern regarding one's own reputation. It might be the personality of wanting to avoid conflicts which might lead to not wanting to point out issues during surgery.

Improvement of teamwork is important in improving safety in anaesthesia. Despite having a multidisciplinary team, professional relationships, and the ability to handle crises during important events should go beyond personal pride and reputation. There must be a leader, usually the anaesthesiologist to steer all the members in case of an event. The junior doctors or even staff nurses might be reluctant to challenge the authority in the operating theatre because of hierarchy. Flattening the medical hierarchy is pertinent in order to improve communication and to improve teamwork. Consultants must encourage the juniors to speak up and an inclusive environment can be created to allow assertive communication. Assertive communication must be encouraged at all times where one must be allowed to state opinion without causing offence or result in aggressiveness. The DAS 2015 guidelines also advocate the use of PACE model as a structured communication tool.[4] The advantage of using such a tool is that it can aid communication when there is concern about cognitive overload and hierarchical barriers. Any of the staff inside the operating theatre can initiate PACE model at any time to alert of ongoing crisis. It consists of probe (*Do you know that..*), alert (*Can we reassess..*), challenge (*Please stop for a while*), and escalate (*Stop what you are doing*).[8]

SITUATIONAL AWARENESS

Situational awareness is a term used to describe a process of continuous monitoring with detection of any events or changes in the environment.[7] Intraoperatively, this requires constant vigilance especially from the anaesthesiologist and the surgeon as well. Changes in clinical signs from the monitor would be the first sign in leading to situational awareness. The three questions that we need to ask intraoperatively would be *'From where have we come from?'*; *'Where are we now?'* meaning what is the current situation and *'Where are we going?'* meaning what is our aim. Failure of situational awareness can be contributed from failure to observe the signs such as omission, distraction, misperception of the data, memory failure or failure to maintain goals.

HUMAN ERROR

In October 2014, the Association of Anaesthetists of Great Britain and Ireland (AAGBI) produced a guideline of fatigue among anaesthesiologists. Fatigue has always been one of the issues in providing a safe anaesthesia. It reduces working performance, increases risk of safety to the patients and the well-being of the anaesthesiologists. Both on calls and night shifts showed poor adaptation of the circadian rhythm resulting in increased sleepiness at work, anaesthesiologists becoming less alert thus leading to poor performance and vigilance.[9] Interestingly, when the period of wakefulness extend beyond 20 hours, it is equivalent to that with a blood alcohol level of 0.1% (100mg.100ml^{-1} blood) and the alcohol limit for driving in UK was 80mg.100ml^{-1} blood.[10] Providing 24 hours of care with limited numbers of anaesthesiologist make it difficult to reduce the number of working hours. However, a few things that can be done such as ensuring good working environment - bright lightning at working area, provision of rest areas away from working environment and refreshment to reduce dehydration and gastrointestinal disturbance.[9] Anaesthesiologists should also ensure that they have a good sleep hygiene, maximise sleep prior to on call, taking naps during on call time if time permitted, plan regular breaks with help of colleague especially if microsleep occur. During the critical fatigue phase, the anaesthesiologist might walk around the operating theatre and interact with nearby personnel to increase alertness. If the on call or night shift was busy, taking a nap before going back is a must to avoid road traffic accident.[9]

CHECKLIST

Checklist was first introduced in 1930 by the aviation industry as a mechanism of preventing adverse events and it was incorporated into the WHO surgical checklist. The purpose of having a checklist is to avoid unintentional harm by accounting for mental fallibility. Having to do a checklist requires a certain amount of humility in a profession which is known for independence and authority. By using a checklist, we can reduce omissions, reduce time to perform tasks as well as improve teamwork, communication, and performance. In our daily practice, we do work with different surgical teams as well as nurses. The checklist will allow us to identify each member in the operating theatre and this will promote teamwork by introducing the team members and sharing information regarding the patients. According to the International Surgical Outcomes Study (ISOS), a study that analyse the effect of surgical checklist on patients' outcome, there is a statistically significant reduction in mortality as well as reduction in complication rates.[11] AAGBI also produced checklist for checking anaesthetic equipment and this must be part of a routine conducted by medical assistants, GA nurses and the doctors involved. Other than that, the Anaesthesia crisis algorithm should be made available in each operating theatre to ensure smooth management during a crisis.

COVID-19 PANDEMIC

On the 30th January 2020, COVID-19 was announced as a public health emergency of international concern which then was upgraded as a pandemic two months later. The numbers of cases are rising with increased tolls of death, and it has become a national burden to the country and globally. Healthcare workers who are involved with the management of COVID-19 are always at an increased risk of contracting the illness. Safety in anaesthesia is more important now than ever. Intubating a patient with COVID-19 is a high-risk procedure as we are exposed to airway secretion which carry a high viral load. All patients planned for an elective surgery must be screened for COVID-19. A dedicated OT must be prepared for positive COVID-19 patients. Correct donning and doffing of personal protective equipment (PPE) are emphasised to be the key to avoid transmission but that is not enough. Wearing PPE prevents ineffective communication through normal means. Prior to intubating or managing a COVID-19 patient in OT, team briefing is very important to ensure that everyone shares the same goals and expectations. Roles must be assigned specifically to avoid confusion. Cognitive aids must be used for communication purposes e.g., names must be put on top of PPE in order to aid communication. When wearing PPE, a clear instruction is important; it must be simple and short and closed loop communication must also be used in order to reduce mistakes. The consensus guidelines in managing airway in patients with COVID-19 also proposed a checklist to be followed as this will prevent unnecessary mistakes which can compromise not only the safety of the patients but also the healthcare provider (Table I).[12]

Table I: World Federation Societies of Anaesthesiologists COVID-19 Intubation and Extubation Checklist[13]

BEFORE PATIENT ARRIVES		INSIDE THEATRE (WEAR PPE)	
PREPARE	**PLAN**	**INTUBATION**	**EXTUBATION**
Anaesthetic Pre-op Assessment	**Anaesthesia Team Briefing** • Confirm team roles • Discuss and confirm need for intubation and anaesthetic plan	**Essential personnel only** **Apply patient monitoring** **Optimise patient position**	**Ensure patient condition stable** **No non-essential personnel in OR**

BEFORE PATIENT ARRIVES		INSIDE THEATRE (WEAR PPE)	
PREPARE	**PLAN**	**INTUBATION**	**EXTUBATION**
Prepare Airway Equipment • Check machine • Working Laryngoscope (VL if available) • ET tubes, syringe, stylet, Tie/Tape • Adjunct e.g., Bougie, LMA, Oral airway • Working suction + suction catheter • Breathing circuit + viral filter + facemask • Consider tube clamp & aerosol barrier **Prepare Drug** • Induction Agent • NM Blockade (+Reversal +/- Stimulator) • Emergency drugs e.g. Atropine, Adrenaline • Analgesics/Antiemetics • Antibiotics • Other drugs as relevant • **IV Cannulas, Fluids (+ Pumps). Blood** **Additional Items** • **e.g., Pen/Documents, Dedicated Waste bag**	**Intubation Plan** Plan A: RSI or modified RSI Plan B/C: Mask ventilation or LMA Facemask • Persons • 2-handed • Adjuncts • Low Flow • Low Pressure LMA/Supraglottic Airway (2nd generation if available) Plan D: Rescue-FONA **Team members apply PPE** • Gown, Hat, eye protection, N95/FFP mask, gloves, (anaesthesia provider double glove for airway management) **Non-essential personnel leave** **Patient transferred to theatre wearing surgical mask**	**Optimise patient condition** **Set-up any barrier methods** **Team confirm anaesthetic plan** **Pre-oxygenate > 3 mis, low flow** **Proceed with RSI/ Modified RSI** **Minimise aerosolisation** • Avoid BVM ventilation during apnoeic period unless hypoxia • Inflate cuff before ventilating • Secure tube & all connections • Avoid unnecessary disconnections • Avoid unnecessary disconnections • Consider Clamping ETT after insertion until ventilator attached **Confirm ETT placement with capnography (if available) or resource appropriate methods** **Ensure patient conditions stable** **Proceed with surgery**	**Perform suction prior to extubation** • Avoid excessive or over suctioning • Consider in-line suction if available **Extubate on OR table** • Avoid unnecessary disconnections • Keep any aerosol barrier in place **Extubate when indicated** • Minimise coughing at extubation • Apply oxygen mask or facemask when extubated **Arrange transfer when indicated** **No entry to OR without PPE until designated time post-extubation (according to OR ventilation)** **Remove PPE in designated area**

CONCLUSION

Safety in anaesthesia is more crucial now than ever. Previously, providing a safe anaesthesia is more pertinent towards the patients, however, with COVID-19 on board, safety in anaesthesia involves bigger scope not only to the patients but to the healthcare providers. A few guidelines involving perioperative COVID-19 positive patients have been published and these need to be implemented fully by us to ensure the safety in providing anaesthesia. In the future, more studies and regular audits should be conducted in our own country to identify our weaknesses and pitfalls in order to improve safety in anaesthesia.

References

1. Wildsmith T. The history of Anaesthesia. "He that sleeps feels not the toothache" [https://rcoa.ac.uk/about-college/heritage/history-anaesthesia] Accessed July 1, 2021

2. Bromiley M. The husband's story: from tragedy to learning and action. *BMJ Quality & Safety* 2015;**24**:425-7

3. Cook TM, Woodall N, Frerk C, Fourth National Audit Project. Major complications of airway management in the UK: results of the Fourth National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society. Part 1: anaesthesia. *Br J Anaesth* 2011;**106**:617-31

4. Frerk C, Mitchell VS, McNarry AF, Mendonca C, Bhagrath R, Patel A et all; Difficult Airway Society intubation guidelines working group. Difficult Airway Society 2015 guidelines for management of unanticipated difficult intubation in adults. *Br J Anaesth* 2015;**115**:827-48

5. Lingard L, Espin S, Whyte S, Regehr G, Baker GR, Reznick R, Bohnen J, Orser B, Doran D, Grober E. Communication failures in the operating room: an observational classification of recurrent types and effects. *BMJ Quality & Safety* 2004;**13**:330-4

6. Halverson AL, Casey JT, Andersson J, Anderson K, Park C, Rademaker AW, Moorman D. Communication failure in the operating room. *Surgery* 2011;**149**:305-10

7. Jones CPL, Fawker-Corbett J, Groom P, Morton B, Lister C, Mercer SJ. Human factors in preventing complications in anaesthesia: a systematic review. *Anaesthesia* 2018;**73**:12-24

8. Weller JM, Long JA. Creating a climate for speaking up. *Br J Anaesth* 2019;**122**:710-3

9. Gregory P, Edsell M. Fatigue and the anaesthetist. *Continuing Education in Anaesthesia, Critical Care & Pain* 2014;**14**:18-22

10. The Association of Anaesthetists of Great Britain and Ireland, "Fatigue and Anaesthetists." [http://www.aagbi.org/sites/default/files/webversionfatigue04.pdf] Accessed July 5, 2021

11. Abbott TEF, Ahmad T, Phull MK, Fowler AJ, Hewson R, Biccard BM, et al; International Surgical Outcomes Study (ISOS) group. The surgical safety checklist and patient outcomes after surgery: a prospective observational cohort study, systematic review and meta-analysis. *Br J Anaesth* 2018;**120**:146-55

12. Cook TM, El-Boghdadly K, McGuire B, McNarry AF, Patel A, Higgs A. Consensus guidelines for managing the airway in patients with COVID-19: Guidelines from the Difficult Airway Society, the Association of Anaesthetists the Intensive Care Society, the Faculty of Intensive Care Medicine and the Royal College of Anaesthetists. *Anaesthesia* 2020;**75**:785-99

13. World Federation of Societies of Anaesthesiologists. "COVID-19 intubation and extubation check list" [https://resources.wfsahq.org/other-resource/covid-19-intubation-extubation-checklist/] Accessed July 5, 2021

14. Marshall SD, Touzell A. Human factors and the safety of surgical and anaesthetic care. *Anaesthesia* 2020;**75**:e34-8

15. Weller JM, Merry AF. I. Best practice and patient safety in anaesthesia. *Br J Anaesth* 2013;**110**:671-3

16. John H Eichhorn, Review article: Practical current issues in perioperative patient safety. *J Can Anesth* 2013;**60**:111-8

17. Mellin-Olsen J, O'Sullivan E, Balogh D, Drobnik L, Knape JT, Petrini F, Vimlati L; Section and Board of Anaesthesiology, European Union of Medical Specialists. Guidelines for safety and quality in anaesthesia practice in the European Union. *Eur J Anaesthesiol* 2007;**24**:479-82

18. Smith AF, Mishra K. Interaction between anaesthetists, their patients, and the anaesthesia team. *Br J Anaesth* 2010;**105**:60-8

19. Catchpole K, Bell MD, Johnson S. Safety in anaesthesia: a study of 12,606 reported incidents from the UK National Reporting and Learning System. *Anaesthesia* 2008;**63**:340-6

20. Van Zundert TCRV, Barach P, Van Zundert AAJ. Revisiting safe airway management and patient care by anaesthetists during the COVID-19 pandemic. *Br J Anaesth* 2020;**125**:863-7

21. Walker IA, Reshamwalla S, Wilson IH. Surgical safety checklists: do they improve outcomes? *Br J Anaesth* 2012;**109**:47-54

Ethical Decisions in Anaesthesia and Critical Care

Ariff Osman
Department of Anaesthesiology and Intensive Care, Kulliyyah of Medicine, International Islamic University Malaysia, Pahang, Malaysia

Professionalism, medical ethics and leadership are important competencies that doctors should develop and enhanced throughout their career life. Application of universal ethical principles and Islamic medical ethics are important in resolving ethical dilemmas of end-of-life issues such as medical futility, brain death, withholding and withdrawal of life support, do-not-resuscitate (DNR) order, and advance medical directives. Cultural and religious awareness for the values of others as in the perspectives of the basic concept of dying and death of Buddhist, Hindu, Christian, and others are important for sound ethical decisions to be made that are accepted by the stakeholders (patients and/or their caretaker). Leadership competency is developed through experiential learning and task-assignment such as organising continuous medical education events, conferences, seminars, workshops, research activities and etcetera. Certainly, leaders need proper training to establish good working culture and environment, provide emotional and social support for team members and training such as coping skills to reduce or minimise the level of stress and burnout, thus improving their well-being.

INTRODUCTION

Anesthesiologists and/or intensivists often make difficult ethical decisions in their daily clinical practice. Competency in critical analysis of ethical dilemmas requires early training and exposure during undergraduate years, which many medical schools have incorporated in their curriculum.[1,2] Such experiential learning ensures medical students get accustomed with the decision-making process that doctors perform in clinical practice especially in life and death situations. Doctors working in anaesthesiology department are familiar with informed consent and refusal, high risk consent and respecting patient's consent during the pre-operative assessments of elective and emergency surgeries. They are also familiar with giving consent in life threatening emergency situations, such as giving anaesthesia for urgent evacuation of extradural clots. In the intensive care unit (ICU) set-up, where patients are unable to decide due to reduced levels of consciousness, their caretakers, as surrogate decision-makers, give consent on their behalf.

ICU beds are generally very limited and expensive, thus deciding which patients to be given life support care often poses a dilemma to doctors. Practice guidelines such as the ICU management protocol enhance quality patient care where only those with potential benefit of meaningful recovery would get priority over those who do not. ICU triaging determines the level of priorities (Priority 1, 2 and 3) and goal of care that one would provide, thus ensuring optimal and equitable use of limited intensive care resources. All ethical decision-making requires careful deliberation and analysis against the accepted ethical principles of autonomy, beneficence, non-maleficence and justice. However, unfamiliarity with the interfaith perspective of patients may complicate the decision-making process. For Muslim patients, ethical decisions should also conform to the Islamic medical ethics of the Objectives of Law, *Maqasid aI-Shari'ah* and the Principles of Law, *Qawaid al-Shari'ah*.[1] There are religious consensus or *fatwas* on issues such as brain death, medical futility, euthanasia, advanced medical directives, and end-of-life care that doctors need to consider. In a multi-religious country such as ours, doctors should be able to recognise and respect the values of others such as Buddhist, Hindu, Christian, Sikh and even the atheist. It is important to note that good ethical decisions accepted by stakeholders (patients and/or their caretakers) are dependent or rather the result of doctors exhibiting professionalism, skilful in applying ethical principles and having leadership quality that are convincing and accepted by them.[3] These are important competencies that doctors should develop and enhanced as it not only improves clinical outcomes in patients, but also improves the healthcare professional well-being by increasing workplace engagement and reducing burnout. Deliberation of these aspects of care is briefly described in this chapter.

PROFESSIONALISM

Safe medical practice includes the duty to cause no harm, updating professional knowledge and skills to remain relevant and up-to-date and getting a second opinion from another colleague if one is unsure or one's skill is limited. Furthermore, as practitioners in the country, they should know and abide to the code of medical ethics (e.g. the Malaysian Medical Association Code of Medical Ethics), medical laws in Malaysia, Clinical Practice Guidelines and Islamic *Fatwas*, which have implications on the medical practice especially in ethical decisions.[2] The public demands or expects good professionalism from the doctors, failing which they would express their displeasure such as, *'That so and so doctor is very unprofessional, not pleasant, being rude, always in a hurry, doesn't explain to me in a good manner, etcetera'*.

Developing high standard of professionalism and enhancing it throughout the career life requires dedication, discipline and leadership quality on the part of doctors that must be regarded as a great responsibility.[4] For a patient, being seen and cared by a knowledgeable and competent doctor is all what he/she wants and is anxious to know whether his/her ailment is treatable or otherwise, for he/she wants to return back to his/her premorbid state as soon as possible. Obviously, they desire for knowledgeable, competent, and well-mannered doctors whom they can trust to help solve their problems. This is the basis for defining professionalism, which is regarded as the core competency that doctors need to develop during medical training and enhanced throughout the career life. Professionalism is defined as *"a body of qualities or features as competence, skills, behaviour, characteristic, etcetera of a profession"*. It is the outward visible expression of values, behaviour and attitudes that are developed over a period of training.

There are many definitions of professionalism that generally describe a list of attributes that one needs to develop over the training period. For the practical reason of not wanting to burden learners with remembering the many attributes that they need to develop, an operational definition is necessary. It evolves around acquiring the four main attributes, namely, expertise, ethics, communication and compassion, and summarised as the 2E's and 2C's of professionalism. The 2E's stands for Expertise and Ethical while the 2C's represent *Communication* and *Compassion*. According to this definition, if one professes that he/she is a doctor, he/she should have the necessary expertise to perform the duty as a doctor, which should be delivered in the most ethical manner.[1] It requires good communication skill and portrayal of compassion so that optimal patient care could be provided. It shall be the responsibility of medical doctors to enhance these attributes of good professionalism as they interact with their patients and caretakers, especially in the setting of anaesthesiology and critical care. Committed consultants as role models, by virtue of their wisdom and experience of best practice are the best guide for younger colleagues to strengthen professionalism.[3] Additionally, one should also be aware of the medical law of the country as it has implications on ethical decisions. For example, euthanasia is illegal and getting consent for medical and surgical interventions is a necessity by Law.

MEDICAL ETHICS

Basically, medical ethics is a decision-making process that health practitioners make when they need to choose the better option over the worse one. It is not about all black or white, or all right or all wrong but in grey areas whereby one needs to make a choice. This is a challenging task that with experience, doctors should be able to identify the difference between *'what can be done'* and *'what ought to be done'*. In other words, a doctor is expected to discharge his duty ethically and professionally. Acquiring this skill during undergraduate training is rather impossible but many medical curricula have incorporated medical ethics as one of the core competencies to develop. Upon graduation and entering the fraternity, junior doctors should be able to acquire and develop the decision-making skills. Interactions with patients and guidance by senior colleagues should provide the learning experience to enhance their understanding of the ethical principles and apply them wisely to resolve

ethical dilemmas. Routine but important task such as taking patient's consent for surgery involves understanding and application of ethical principles in deliberating the issue with the patient and have his/her consent.[5]

Common ethical decisions in ICU involving critically ill patients who need life-sustaining treatment require a high level of competency in choosing which patients to admit according to the ICU management protocol and decisions to withhold or withdraw life support as when patients have reached the stage of medical futility. In certain countries, one should also find out whether patients have had advanced care planning or advanced medical directives before sound ethical decisions could be made.[6] It is also important to find out a patient's religious beliefs and cultural values before a proper decision could be made. Certainly, a high level of professionalism is needed, which requires deep understanding and respect of others particularly in interfaith perspectives as in the discussion of the basic concept of dying and death of Buddhist, Hindu, Christian and others.[1] As mentioned above, for Muslim patients the application of Islamic ethical objectives *(Maqasid al-shari'ah)* and principles *(Qawa'id al-shari'ah)* on top of the conventional ethical principles of autonomy, beneficence, non-maleficence and justice is a necessity for good practice.[7] However, the need of other faiths is not yet well addressed, which deserves much research by the medical fraternity as it has great implication in decision-making and improvement in patient outcome.

The core principle of safe patient care in anaesthesiology and critical care consists of wise and effective communication and portrayal of professionalism and leadership quality during interaction with patients and the caregivers who are the surrogate decision-makers for patients on life support machines in the ICU. Discussing about the patient's current situation should begin early when one decides that a patient needs ICU admission. Identifying the patient's caretaker is crucial as it allows the doctor and his team to communicate on the reasons for the patient's admission, the progress and response to life support measures and interventions.[9] The doctor and his team should also ensure that patients and their family members understand that all actions are meant to provide the best care possible while acknowledging constraints such as the chance of recovery and futility. It is crucial that the caretakers understand during the family discussion that the doctor's decisions involve application of ethical principles (conventional or Islamic) especially when it comes to withholding and withdrawal of life support, which depends on the presence or absence of futility, certainty of the occurrence of death and consideration of patient's religious beliefs and cultural values.[8] Excellent care should be holistic, encompassing physical (medical, surgical), psychological and spiritual aspects.[9] The conventional ethical principles that were popularised by Beauchamp and Childress (autonomy, beneficence, non-maleficence and justice) are well accepted by the medical fraternity as action guides in the ethical decision-making process.

LEADERSHIP SKILL

It is important that doctors play the role as leaders, advocators, and educators to empower their patient and/or patients' caretakers, especially in life and death situations where difficult ethical decisions take place. They require proper training that would enhance their professional commitment and competencies to deliver these aspects of patient care apart from developing positive attributes to work effectively with others in a team. The key to becoming an effective leader is to be the kind of person that others would want to follow, give their trust and support to achieve a certain goal as well as having passion to serve others.[1] This is very crucial in the duty of a doctor as his words and advice have a direct impact on patient's experience and management outcome. With adequate training, a doctor who has acquired good leadership skills would be able to educate, empower and suggest the best treatment or management option for his/her patients. Effective leadership enhances professionalism and the decision-making process as in the daily routines of taking patient's consent for surgery and breaking bad news to patient's caretaker in 'Family Meeting' at ICU counselling room mentioned above.

Doctors are often tasked to lead since most patient care requires a multidisciplinary approach involving colleagues from other disciplines, nursing staff and others. Medical consultants, as clinical leaders, need training to sharpen their leadership and management skills for a successful management of patient care and well-being that comprises junior doctors, specialists, and nursing staff. It is largely dependent on their ability to understand, internalise and actualise the institution's vision and mission into day-to-day practice and commitment to lead with passion. In leadership, the key concept is the role, duty or the expected function that a leader has to undertake and ideally be the role model for team members to emulate, which is not easy to achieve. As leaders, they are responsible to motivate team members, maintain harmony and unity, while striving together to achieve the department's and institution's vision and mission. Implementation of the ICU management protocol, for example, requires intensivists, as clinical leaders, to take the lead to ensure that the goals and standards of care are achieved. Revisiting the algorithm of care based on the current best medical evidence, enhancing professionalism through regular training of junior doctors, and encouraging research activities to improve patient care, requires good leadership. Other roles such as establishing clinical practice guidelines on ethical decision in CPR and withdrawal of life support as examples, demonstrate the importance of good leadership that would enable other dedicated members among fellow colleagues to work together and make it into reality.

Continuous medical education, morbidity and mortality discussions to debrief critical incidents and improve the standard of care, multi-disciplinary discussions of high-risk patients requiring special care for surgery, regular training on crucial topic such as 'End-of-Life Care' workshops, organising conferences and seminars and coordinating research activities all requires good leadership and management skills. Equally important, leaders are also tasked to establish a good working culture and environment, provide emotional and social support for team members and training such as coping skills to reduce or minimise the level of stress and burn out, thus improving their well-being.

CONCLUSION

From the above discussions it is obvious that doctors are responsible to attain the highest standard of professionalism as well as decision-making and leadership skills. They should be committed to this agenda to avoid or minimise vociferous criticism from the public if they do not meet the rising expectations of the society. Dissatisfaction on the part of the patients towards the standard of care they received from healthcare facilities may easily trigger claims in the court of Law. Generally substandard services are not tolerated and paternalistic approaches in the provision of care are unacceptable and considered inappropriate.[2] In the anaesthesia and critical care set-up, doctors are responsible to equip themselves with acceptable standards of professionalism, competency in medical ethics and making sound decision especially when they need to address interfaith perspectives of dying and death. The highest standards of professionalism, ethical decision and leadership skill should be the aim. Equally important, clinical leaders are responsible to educate team members with the fundamentals of law and ethics as this would ensure greater accountability, knowledge, and personal commitment in providing services to the society.

References

1. Osman A (Ed). Training Safe Doctors from the IIUM's Perspective. Application of Islamic Epistemology in Undergraduate Medical Training. IIUM Press: 2021

2. Kassim PNJ, Osman A, Muhammad RW. Educating Future Medical Professionals with the Fundamentals of Law and Ethics. International Medical Journal Malaysia 2017;16

3. Johnston C, Turpin N, Wynn-Jones W. Medical leadership in perioperative practice: I. *BJA Education* 2016;**16**:203-8

4. Laldin MA. Islamic Law, An Introduction. 4th ed. IIUM Press: 2014

5. Abu-Saud M. The Role of a Muslim Doctor. In: Shahid Athar (Ed): Islamic Medicine. Amazon co.uk. 2014

6. Abdullah F (Ed). Islamic Ethics and Character Building. IIUM Press: 2014

7. Shaharom MH, Teaching medical professionalism: An Islamic approach. FIMA Year Book 2009;57-64

8. Kasule OH. 13-year experience of integrating Islamic values in the medical curriculum in South- East Asia: FIMA Year Book 2009;1-28

9. Osman A. End-of-life decision and euthanasia from the Islamic perspective. International Medical Journal Malaysia 2007;6