Neuromuscular transmission monitoring: Beyond the electric shocks and the shaking hands

General anesthesia is a reversible pharmacologically induced state of amnesia, analgesia, loss of responsiveness, and a variable degree of skeletal muscle relaxation. In the early days of anesthesia, these effects were achieved with the use of high doses or concentration of a single anesthetic agent with consequent undesirable side-effects and a poor recovery profile. Modern anesthesia practice however coined the term "Balanced Anesthesia" to describe the use of a combination of drugs (such as hypnotics, analgesics, and neuromuscular blockers) to achieve very specific combinations of results with the least possible side-effects. The clinical demonstration of the neuromuscular blocking component of balanced general anesthesia was first reported in 1942 by Enid Johnson and Harold Griffith in Montreal, Canada.[1] Few years later Beecher and Todd[2] published a landmark audit study investigating the leading causes of post-operative mortality associated with anesthesia and surgery in a huge cohort of almost 600,000 patients. One of the main and scary findings of this study was the fact that the rate of post-operative mortality was increased six folds with the use of d-tubocurarine. It is to be noted that; however, curare was the only available long-acting cumulative neuromuscular blocker and antagonism of residual neuromuscular block was an occasional primitive practice. In line with the findings of Beecher and Todd,[2] Edwards *et al.*[3] attributed documented anesthesia related mortality in 55 patients to post-operative pharyngeal relaxation and respiratory obstruction. This was probably the first description of post-operative residual curarization (PORC). Despite the major pharmacological and monitoring developments over the past four decades, PORC continues to be frequently encountered in the post-anesthesia care unit (PACU).[4]

Intermediate acting neuromuscular blockers were introduced into clinical practice almost 30 years ago with the objective of producing a more predictable, noncumulative, and easily reversible block. These desirable pharmacological features were associated with a false sensation of security by a significant number of anesthesiologists who felt that antagonism of residual neuromuscular block could be safely eliminated especially with the use of atracurium, which is spontaneously metabolized by Hofmann elimination. A recent meta-analysis confirmed the fact that the widespread use of intermediate acting neuromuscular blockers reduced but did not eliminate PORC.[4] A parallel and an important track to optimize and ensure the safe use of neuromuscular blockers and anticholinesterase antagonists is the progress in the development of newer modes of peripheral nerve stimulation and manufacturing portable fairly reliable equipments to monitor the muscle response. Despite the well-known documented positive impact of routine objective neuromuscular monitoring on improving the quality of recovery and reducing the incidence of PORC,[5] unfortunately most anesthesiologists do not adopt this plausible practice.[6] In fact, neuromuscular blockade is the only component of general anesthesia that could be reliably and objectively monitored. In contrast, monitoring of the depth of anesthesia is much more expensive and is less reliable.[7]

In this issue of the Saudi Journal of Anesthesia, El-dawlatly and El-Tahan[8] report the results of the first electronic survey exploring the attitude and knowledge of Middle Eastern anesthesiologists with respect to: (1) Their preferences to specific neuromuscular blocking agents, (2) Routine use of anticholinesterases, (3) Awareness about the existence and incidence of PORC, and (4) The use of neuromuscular monitoring. The results of this survey demonstrated that cis-atracurium and rocuronium, as expected, were the two most frequently utilized neuromuscular blockers. Neostigmine was used by 78% of respondents to antagonize residual rocuronium-induced neuromuscular block. The conditions and attitude to antagonize cis-atracurium-induced neuromuscular blockade is not clear. Almost one-third of contributors routinely use neuromuscular monitoring without specifying the subjective or objective nature of the equipment. Some of the results of this Middle Eastern survey are impressive compared to the findings of a similar recent survey in Europe and USA.[6] In Naguib's *et al.* survey,[6] the incidence of PORC was considered to be less than 1% by most of respondents. Additionally, 82% and 65.8% of the European

Access this article online	
Quick Response Code:	Website: www.saudija.org
	DOI: 10.4103/1658-354X.114045

and US contributors respectively reported that they did not routinely administer an anticholinesterase at the end of surgery after non-depolarizing neuromuscular blockers. In contrast, the small sample size of Middle Eastern anesthesiologists seems to more frequently antagonize residual neuromuscular blockade, at least with rocuronium. Further, they are more aware about the existence of PORC.[8] The overall initial impression is that despite the limited resources in the Middle East, anesthesiologists in this region are generally adopting relatively safe strategies to initiate, maintain, and appropriately antagonize the residual effects of neuromuscular blockers. It is to be noted however, that this assumption is based on the contribution of only 71 respondents who might have contributed to the survey primarily due to their special interest and good experience in neuromuscular blockers. A more elaborate wide scale survey covering the diverse anesthesia practice in the Middle East is expected to provide different and probably less optimistic results. An elegant editorial published in the British Medical Journal pointed out that developing countries are replete with high quality medical personnel with excellent academic and clinical experience.[9] The authors literally stated that "We will meet in the developing world a level of will, skill, and constancy that may put ours to shame. We may find ourselves not the teachers we thought we were, but students of those who work under circumstances that would have stopped us long ago."[9]

Pharmacologists, anesthesiologists, and biomedical engineers have done strenuous relentless efforts with impressive outcomes to optimize neuromuscular blockers, antagonists, and monitoring equipments. The armamentarium of neuromuscular blockers now includes several intermediate acting neuromuscular blockers with improved metabolic pathway and minor hemodynamic effects. A new concept of steroid neuromuscular blockers encapsulation using gamma cyclodextrin (sugammadex) appears to be a miraculous milestone in the clinical anesthesia practice.[10] Additionally an objective and affordable acceleromyograph is available for clinical monitoring of neuromuscular transmission. Despite all these favorable effective developments, several related questions remain unanswered: (1) Why PORC continues to be a significant problem in PACU?, (2) Why antagonist agents are underutilized?, and (3) Why anesthesiologists are reluctant to use neuromuscular monitoring?

The most probable answers to the aforementioned questions could be grouped under two main items: First, the false impression that although PORC do occur in clinical practice it is well-tolerated by most of the patients without appreciable serious consequences. This is definitely not true and is a clear misconception. There is a good mounting evidence that PORC is associated with critical respiratory events,[11] extended PACU stay,[12] and impaired post-operative respiratory functions.[13] Second, there is a perceived impression supported by evidence that routine monitoring of neuromuscular transmission with the use of subjective monitors does not eliminate PORC.[4] This is most likely related to the fact that what makes the difference in the incidence of PORC is not the use of neuromuscular monitor but the knowledge and experience of the anesthesiologist using this monitor. Anesthesiologists should realize several important basic principles to use the neuromuscular monitor effectively and reliably: (1) What is the target level of neuromuscular block at the hand muscles compatible with the intraoperative surgical needs and safe adequate recovery of upper airway muscles at the end of surgery? (2) The fact that different muscles have variable response to the effect of neuromuscular blocking drugs,[14] (3) The more the degree of neuromuscular recovery at the conclusion of surgery the more effective will be the antagonism of residual neuromuscular blockade and the target level of adequate recovery will be achieved in a shorter clinically acceptable time frame,[15] (4) It is impossible to reliably quantify the degree of recovery with the use of subjective monitors,[16] and (5) Local cooling of the hand may make adductor pollicis twitch tension monitoring less reliable during clinical anesthesia.[17] Unfortunately, these simple facts are not fully appreciated by most of the practicing anesthesiologists regardless of their location on the Globe.

A crucial element to improve current suboptimal practices is the development and implementation of evidence-based guidelines on how neuromuscular blocking drugs should be administered, monitored, or antagonized by a prominent professional organization e.g., the American society of anesthesiologists (ASA).[18] The report of the ASA task force on post-anesthetic care states that "Assessment of neuromuscular function primarily includes physical examination and "on occasion" may include neuromuscular monitoring."[19] In contrast, the Australian and New Zealand college of anesthetists recommend that the equipment to monitor neuromuscular function must be available for every patient in whom neuromuscular blockade has been induced.[20]

In the Middle East region, the practice of medical profession including anesthesia commonly adopts US standards to optimize patient care and outcome. However, when such guidelines are not yet available, organizational key stakeholders and responsible department directors should take the initiative to develop their own evidence-based guidelines or clinical pathways to optimize patient care and ensure safe outcomes. More than 20 years ago, Professor Mohamed Seraj, the

founder and former Chairman of the Department of Anesthesia, Faculty of Medicine, King Saud University, Riyadh, KSA, realized the importance of the availability of neuromuscular monitoring equipments in all operating theaters at King Khalid University hospital (KKUH). Further, he appointed Professor *Jørgen Viby Mogensen* a well-known leader in neuromuscular monitoring as a visiting professor in the department to ensure adequate expert training of all faculty members and trainees. Professor Seraj is to be commended on his responsible attitude and his vision to improve patient safety and enhance the quality of anesthesia training in KKUH. A 5 year formal training program including education in neuromuscular transmission monitoring, routine use of antagonists, and increased use of objective monitoring reduced the incidence of PORC from 60 to only 3.5% in a reputable French health facility.[21]

In conclusion, regular monitoring of neuromuscular transmission preferably using an objective equipment and routine antagonism of residual neuromuscular block after appreciable degree of spontaneous recovery are the two simple logical clinical recommendations to reduce the incidence of PORC. However, the use of neuromuscular monitors will not be associated with the appropriate target outcome without adequate knowledge and training to ensure that the attending anesthesiologists knows much more beyond the electric shocks and shaking hands.

Mohamed Abdulatif

Department of Anesthesiology and Surgical Intensive Care, Faculty of Medicine, Cairo University, Egypt.
E-mail: abdulatif@hotmail.com

REFERENCES

1. Griffith H, Johnson E. The use of curare in general anesthesia. Anesthesiology 1942;3:418-20.
2. Beecher HK, Todd DP. A study of the deaths associated with anesthesia and surgery: Based on a study of 599, 548 anesthesias in ten institutions 1948-1952, inclusive. Ann Surg 1954;140:2-35.
3. Edwards G, Morton HJ, Pask EA, Wylie WD. Deaths associated with anaesthesia: A report on 1,000 cases. Anaesthesia 1956;11:194-220.
4. Naguib M, Kopman AF, Ensor JE. Neuromuscular monitoring and postoperative residual curarisation: A meta-analysis. Br J Anaesth 2007;98:302-16.
5. Murphy GS, Szokol JW, Avram MJ, Greenberg SB, Marymont JH, Vender JS, *et al*. Intraoperative acceleromyography monitoring reduces symptoms of muscle weakness and improves quality of recovery in the early postoperative period. Anesthesiology 2011;115:946-54.
6. Naguib M, Kopman AF, Lien CA, Hunter JM, Lopez A, Brull SJ. A survey of current management of neuromuscular block in the United States and Europe. Anesth Analg 2010;111:110-9.
7. Dahaba AA. Different conditions that could result in the bispectral index indicating an incorrect hypnotic state. Anesth Analg 2005;101:765-73.
8. El-dawlatly A, El-Tahan MR, MMM-Anaesthesia Group Collaborators. A survey of the current use of neuromuscular blocking drugs among the Middle Eastern anesthesiologists. Saudi J Anaesth 2013;7:146-50.
9. Richards T, Tumwine J. Poor countries make the best teachers: Discuss. BMJ 2004;329:1113-4.
10. Naguib M. Sugammadex: Another milestone in clinical neuromuscular pharmacology. Anesth Analg 2007;104:575-81.
11. Murphy GS, Szokol JW, Marymont JH, Greenberg SB, Avram MJ, Vender JS. Residual neuromuscular blockade and critical respiratory events in the postanesthesia care unit. Anesth Analg 2008;107:130-7.
12. Butterly A, Bittner EA, George E, Sandberg WS, Eikermann M, Schmidt U. Postoperative residual curarization from intermediate-acting neuromuscular blocking agents delays recovery room discharge. Br J Anaesth 2010;105:304-9.
13. Kumar GV, Nair AP, Murthy HS, Jalaja KR, Ramachandra K, Parameshwara G. Residual neuromuscular blockade affects postoperative pulmonary function. Anesthesiology 2012;117:1234-44.
14. Donati F, Bejan DR. Not all muscles are the same. Br J Anaesth 1992;68:235-6.
15. Brull SJ, Murphy GS. Residual neuromuscular block: Lessons unlearned. Part II: Methods to reduce the risk of residual weakness. Anesth Analg 2010;111:129-40.
16. Drenck NE, Ueda N, Olsen NV, Engbaek J, Jensen E, Skovgaard LT, *et al*. Manual evaluation of residual curarization using double burst stimulation: A comparison with train-of-four. Anesthesiology 1989;70:578-81.
17. Heier T, Caldwell JE. Impact of hypothermia on the response to neuromuscular blocking drugs. Anesthesiology 2006;104:1070-80.
18. Kopman AF. Managing neuromuscular block: Where are the guidelines? Anesth Analg 2010;111:9-10.
19. Silverstein JH, Apfelbaum JL, Barlow JC, Chung FF, Connis RT, Fillmore RB, *et al.* Practice guidelines for postanesthetic care. A report of the American society of anesthesiologists task force on postanesthesia care. Anesthesiology 2002;96:742-52.
20. Futter M, Gin T. Neuromuscular block: Views from the Western pacific. Anesth Analg 2010;111:11-2.
21. Baillard C, Clec'h C, Catineau J, Salhi F, Gehan G, Cupa M, *et al*. Postoperative residual neuromuscular block: A survey of management. Br J Anaesth 2005;95:622-6.

How to cite this article: Abdulatif M. Neuromuscular transmission monitoring: Beyond the electric shocks and the shaking hands. Saudi J Anaesth 2013;7:115-7.