BATTERY OF LIFE (BOL) ASSESSMENT IN CRITICALLY ILL PATIENTS

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BATTERY OF LIFE (BOL) ASSESSMENT IN CRITICALLY ILL PATIENTS

ABSTRACT

This was a prospective observational study conducted in University Malaya Medical Centre (UMMC) from November 2017 until May 2018. The objective of this study was to check the association between parameters of Battery of Life (BOL) with the primary outcome (Death/Functional decline) at 30 days. The study population were adult patients aged more than 16 years old referred to crash team UMMC during the period of time. Paediatric patients and pregnant women were excluded. A total of 313 patients were recruited and followed up daily up until 30 days or until discharge and their daily BOL score were recorded. The 6 parameters of BOL concerned with the delivery of oxygen and energy at the tissue level, namely airway, breathing, circulation, haemoglobin, microcirculation and glucose levels, with each parameter having 4 grades of severity (25%; 50%; 75%; 100%) were determined. The daily BOL score is taken as the lowest of all these 6 parameters. The patients would then be followed up at 30 days to determine their primary outcome (death, functional decline, no functional decline). It was concluded that the day 1 BOL score does affect the primary outcome of patient at 30 day. Those scoring 25% had a higher relative risk of mortality of 1.54 times ($p<0.001$) and a higher relative risk of functional decline/mortality of 1.45 times ($P<0.001$) at 30 days. Minimum BOL also does affect the outcome of patient at 30 day with those scoring 25% had a higher relative risk of mortality 5.04 times ($p<0.005$) and a higher relative risk of functional decline/mortality of 2.71 times ($p<0.005$).

Key words: Battery of Life, Death, Functional Decline

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ABSTRAK

Ini adalah satu kajian prospektif yang dijalankan di Pusat Perubatan Universiti Malaya (PPUM) dari November 2017 hingga Mei 2018. Objektif kajian ini adalah untuk mengkaji hubungan antara parameter “Battery of Life” (BOL) dengan status pesakit selapas 30 hari. Populasi kajian adalah pesakit dewasa berusia lebih dari 16 tahun yang dirujuk kepada p”Crash Tea” PPUM sepanjang tempoh waktu kajian. Pesakit pediatrik dan wanita hamil dikecualikan. Sejumlah 313 pesakit direkrut dan disusuli setiap hari sehingga 30 hari atau sehingga discaj dari hospital dan skor BOL harian mereka direkodkan. 6 parameter BOL adalah berkaitan dengan penghantaran oksigen dan tenaga sehingga peringkat tisu, iaitu saluran udara, pernafasan, circulasi, hemoglobin, mikrocirculasi dan tahap glukosa, dengan setiap parameter mempunyai 4 peringkat (25%; 50%; 75%; 100%) telah ditentukan. Skor BOL harian diambil sebagai skor terendah daripada semua 6 parameter ini. Pesakit akan dihubungi pada hari ke-30 untuk menentukan status mereka (kematian, penurunan fungsi, tiada penurunan fungsi). Dalam kajian ini, kami telah mendapati bahawa skor BOL hari pertama memberi kesan kepada status pesakit pada 30 hari. Mereka yang mencatatkan 25% mempunyai risiko relatif kematian yang lebih tinggi iaitu 1.54 kali ($p < 0.001$) dan risiko relatif penurunan fungsi / kematian yang lebih tinggi sebanyak 1.45 kali ($P < 0.001$) pada 30 hari. BOL minima juga memberi kesan kepada status pesakit pada 30 hari dengan skor 25% mempunyai risiko kematian relatif yang relatif 5.04 kali ($p < 0.005$) dan risiko relatif penurunan fungsi / kematian sebanyak 2.71 kali ($p < 0.005$).

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CONTENTS

LIST OF FIGURES AND TABLES

LIST OF SYMBOLS AND ABBREVIATIONS

ATP: Adenosine Triphosphate

BOL: Battery of Life

NEWS: New Early Warning System

MEOWS: Maternal Early Obstetric Warning System

UMMC: University Malaya Medical Centre

ASA: American Society of Anaesthesiologists

ADL: Activity of Daily Living

SEM: Standard Error of Mean

ICU: Intensive Care Unit

LIST OF APPENDICES

CHAPTER 1: INTRODUCTION

What is life? The definition of life is controversial. The current definition is that organisms maintain homeostasis, are composed of cells, undergo metabolism, can grow, adapt to their environment, respond to stimuli, and reproduce. All living creatures depend on energy in form of adenosine triphosphate (ATP) to sustain the activities of life. Energy from the sun is required for the process of photosynthesis in plants to produce energy sources like glucose.[1] In order for metabolism of energy sources like glucose to produce energy in the form of ATPs, oxygen is needed and has to be brought to the cells via a patent airway, by the process of breathing, into the lungs, carried in the blood bound to haemoglobin, and pumped by the heart to various tissues and organs in the body.

The development of early warning systems from simple bedside observation charts arose from the knowledge that physiological abnormalities precede critical illness.[2] As oxygen is needed to sustain life, we have selected a few physiological parameters concerned with the delivery of oxygen from the atmosphere to the cells and categorized them into a 5 criteria namely airway, breathing, circulation, haemoglobin and microcirculation. We have also included blood glucose level as the sixth criteria in view that glucose is the main substrate for oxidative phosphorylation to produce ATPs. These 6 criteria are together referred to as the Battery of Life (BOL). The 6 parameters are chosen as they embody the pathway by which oxygen and energy travel down to the cells. Failure along any of these parameters (the level of function of the individual parameters is divided into 4 categories) will place the patient vulnerable to the threat of life or vulnerable to poor oxygen or energy delivery at the tissue level.

CHAPTER 2: LITERATURE REVIEW

A variety of early warning systems, developed in the non-obstetric adult patient population, assign weighted values to a number of physiological parameters according to their degree of deviation from the normal. The National Early Warning Score (NEWS) developed by Royal College of Physician UK in 2012 measures 6 physiological parameters (Respiratory Rate, Oxygen Saturation, Temperature, Systolic BP, Heart Rate and Level of Consciousness).[3] The Maternal Early Obstetric Warning Score (MEOWS) also measures a numbers of physiological parameters (Respiratory Rate, Oxygen Saturation, Systolic and Diastolic Blood Pressures, Heart Rate, Temperature, Pain score and Neurological Response).[2, 4]to assist in identifying the deteriorating parturient. Lactate levels has also been used as increased lactate levels usually reflect increased morbidity and mortality.[5] 2 multicentre trials in the United States and the Netherlands show that lactate-directed resuscitation therapy has clinical benefit for critically ill patients.[6, 7] These findings confirm that lactate monitoring is a valuable parameter in the early resuscitation of critically ill patients. A pilot study titled "Battery of Life – A novel tool in Predicting Outcome in Acutely Hospitalised Older Patients." was conducted in the geriatric medical ward of UMMC in August 2016 involving 50 patients. The results of this study shows significant association of BOL score with death or functional decline at 30 days[8].

The many warning systems highlighted above has one failing. Whilst the system may flag a sick patient, the next provider called to help the critically ill sick patient cannot identify where to start the process of care. The 6 parameters of BOL selected are concerned with the delivery of oxygen from the atmosphere to the cell and the oxidative phosphorylation of glucose to produce ATP – the fundamental energy needed for survival. A provider looking at the integrated score (BOL score) knows at a glance when alerted how sick the patient is. Further the individual parameter score (Airway, Breathing, Circulation,

Haemoglobin, Microcirculation, Glucose) that leads to this integrated score will flag where the limitation of flow of oxygen and energy is at and the provider can the rapidly pay attention to the parameter causing concern to the patient. We are trying to establish a physiological early warning system based on the delivery of oxygen or energy at the tissue level which is required to sustain life – encapsulating a new and rapid way of attending to the patient's needs. The level of function of these physiological parameters has been elucidated by other studies elsewhere.[6, 9-12]

CHAPTER 3: METHODOLOGY

3.1 OBJECTIVES

The objective of this study is to determine the association between the parameters of Battery of Life (Airway, Breathing, Circulation, Haemoglobin, Microcirculation, Sugar level) with the outcome of patients at 30 days.

3.2 STUDY DESIGN

This prospective observational study was conducted in between November 2017 until May 2018 in University Malaya Medical Centre (UMMC) after approval from the Medical Research Ethics Committee (MREC), University Malaya (MREC ID No 201794-5536).

3.3 STUDY POPULATION

Adult patients aged more than 16 years old who were referred to Crash Team UMMC were recruited in this study. Paediatric patients aged less than 16 years old and pregnant women were excluded from this study.

3.4 STUDY PROCEDURE

Information such as patients' demographic (age, gender, ethnicity) and ASA classification were collected and recorded in the data collection sheet (Appendix A). The battery of life (BOL) of the patients was assessed at initial presentation to the crash team. There will be two versions of the battery of life, one for non-intubated patients (Appendix B) and another one for the intubated patients (Appendix C). These patients were then followed up daily and the BOL score was documented in the data collection sheet (follow

up) (Appendix D). The daily BOL score was taken as the lowest value of the 6 individual parameters of BOL.

All patients who were included in this study were followed up until discharge or until 30 days of presentation to the Crash Team. Their outcome (ADL intact, ADL dependent or death) at 30 days were recorded. If patient was discharged before 30 days, they were contacted via phone to determine their outcome. Patients who were uncontactable during the 30-day follow up were excluded from this study.

CHAPTER 4: RESULTS

4.1 DEMOGRAPHIC CHARACTERISTICS

A total of 396 patients referred to crash team during the period of study was recruited for this study. During the follow up, there were missing data in 11 of these patients, which were excluded from this study. Out of the remaining 385 patients, 72 were uncontactable during the 30 day follow up and were deemed to be lost to follow up, making the final number of 313 patients which were included in this study.

The demographic characteristics of the 313 patients was summarised in table 4.1. The mean age is 60.63 years old. There were 178 male patients (56.9%) and 135 female patients (43.1%). The majority of patients were of Chinese ethnicity with a total of 123 patients which made up 39.3% of the total patients, followed by Malays (107 – 34.2%), Indians (72 – 23%) and others (11 – 3.5%). The mean length of stay was 16.53 days. 31 of the patients were classified as ASA 1 (9.9%), 126 as ASA 2 (40.3%), 133 as ASA 3 (42.5%), 19 as ASA 4 (6.1%), 4 as ASA 5 (1.3%), none as ASA 6.

The BOL score on the day of recruitment into the study (Day 1 BOL) and minimum BOL score attained during admission period was also included in table 1. Out of the 313 patients, 135 patients (43.1%) had a day 1 BOL score of 25%, 104 patients (33.2%) had a day 1 BOL score of 50%, 63 patients (20.1%) had a day 1 BOL score of 75% while the remaining 11 (3.5%) had a day 1 BOL score of 100%. During the whole length of hospital stay, 264 patients (84.3%) had a minimum BOL score of 25%, 40 patients (12.8%) had a minimum BOL score of 50%, 9 patients (2.9%) had a minimum BOL score of 75% while none had a minimum BOL score of 100%.

Table 4.1: Demographic Characteristics (n=313)

Variables	Mean	SEM
Age	60.63	0.952
Length of Stay (days)	16.53	0.966
	N	**%**
Gender		
Male	178	56.9
Female	135	43.1
Ethnicity		
Malay	107	34.2
Chinese	123	39.3
Indian	72	23
Others	11	3.5
ASA Classification		
1	31	9.9
2	126	40.3
3	133	42.5
4	19	6.1
5	4	1.3
6	0	0
Day 1 BOL		
25%	135	43.1
50%	104	33.2
75%	63	20.1
100%	11	3.5
minBOL(Minimum BOL attained during admission period)		
25%	264	84.3
50%	40	12.8
75%	9	2.9
100%	0	0

4.2 PRIMARY OUTCOME

The primary outcome at 30 day follow up was summarised in table 4.2. A total of 169 patients died during the 30 day follow up, which make up 54% of the total population. A total number of 213 patients or 68.1% of the total population experienced functional decline or death during the 30 day follow up. The remaining 100 patients or 31.9% of the total population had no functional decline.

Table 4.2: Primary Outcomes at day 30

	N	**%**
Mortality *(included those died in hospital and after discharge at home)*	169	54.0
Functional decline/ Death	213	68.1
No Functional Decline	100	31.9

We divided the patients into 2 groups, namely those who had a functional decline or were dead and those patients who had no functional decline. We then analysed the effect of demographic characteristics on the outcome, the findings of which can be found in table 4.3. Out of the 3 demographic characteristics that we analysed namely age, gender and length of stay, only age shows a statistical importance in influencing the poorer outcome of the patients with a p value of < 0.001 using a t-test analysis.

Table 4.3: Factors That May Influence Poorer Outcomes in Patients

	Outcome		P value
	Worsened	**Did not Worsen**	
Age (Mean ± SEM)	63.08±1.063	55.39±1.839	p < 0.001
Males (n (%))	129 (60.6%)	49 (49.0%)	p = 0.054
Length of stay (Mean ± SEM)	13.63±1.245	14.53±1.458	p = 0.664

We then used a Pearson Chi-squared test to analyse the effect of day 1 BOL on the primary outcomes, namely mortality and functional decline/mortality. The results were summarised in table 4.4 and table 4.5. The relative risk for mortality was 1.54 times higher if the day 1 BOL score was 25% compared to those who scored more than 25%. The relative risk for functional decline/mortality was 1.45 times higher if day 1 BOL was 25% compared to those who scored more than 25%. All of these relative risks values were found out to be statistically significant with a p value of < 0.001.

Table 4.4: Effect of Day 1 BOL on Mortality

Day 1 BOL	**Mortality (%)**	**R.R(95%CI)**	**P value**
BOL25%	91/135 (67.4%)	1.54(1.25-1.89)	p < 0.001
BOL>25%	78/178 (43.8%)		

Table 4.5: Effect of Day 1 BOL on Functional Decline/Mortality

Day 1 BOL	Functional Decline/ Mortality (%)	R.R(95%CI)	P value
BOL25%	111/135 (82.2%)	1.45(1.25-1.68)	p < 0.001
BOL>25%	101/178 (56.7%)		

We then used a Pearson Chi-squared test to analyse the effect of minimum BOL during the admission period on the primary outcomes, namely mortality and functional decline/mortality. The results were summarised in table 4.6 and table 4.7. The relative risk for mortality is 5.04 times higher if the minimum BOL during hospital stay is 25% compared to those who scored a minimum BOL of more than 25%. The relative risk of functional decline/mortality is 2.71 times higher if patients had a minimum BOL score of 25% compared to those who had minimum BOL score of more than 25%.

Table 4.6: Effect of Minimum BOL on Mortality

Minimum BOL	Mortality (%)	R.R(95%CI)	P value
BOL25%	163/264(61.7%)	5.04(2.36-10.73)	<0.005
BOL>25%	6/49(12.2%)		

Table 4.7: Effect of Minimum BOL on Functional Decline/Mortality

Minimum BOL	Functional decline/ Mortality (%)	R.R(95%CI)	P value
BOL25%	190/264(72%)	2.71(1.69-4.34)	<0.005
BOL>25%	13/49(26.5%)		

CHAPTER 5: DISCUSSIONS

There are no other studies on Battery of Life (BOL) to compare with except one with the title of "Physiological Cause of Death in ICU Using the Battery of Life Scoring System (A Novel Tool in Predicting Mortality)" which was done by a fellow anaesthetic provider. This was a retrospective study on mortality in ICU from years 2014-2017. He found out that the three most common physiological cause of death in ICU were: (1) circulation (2) microcirculation and (3) breathing. In his study, he also found out that short stay patients (4 days stay or less) had a significantly lower average BOL score than their long stay counterparts (more than 4 days), both on day 1 of ICU ($p < 0.001$) as well as during the middle of their ICU stay ($p = 0.007$).[13]

In our study, day 1 BOL score appears to be a useful index to predict the patient's outcome at 30 days. Those with a lower day 1 BOL score have a higher risk of mortality and functional decline. We are unable to pinpoint which parameter of the battery of life is the main contributor of death and functional decline as we did not include the individual parameters of the day 1 BOL in our data analysis.

Minimum BOL score is also a useful index to prognosticate the patient's outcome. In our study, we have collected enough numbers of patients to show that minimum BOL does have a statistically significant influence on the patients' outcome. In future we may be able to focus and optimize care on the parameter that is affected so as to improve outcome.

However, there were some limitations to this study. First, most of our patients were from the general ward where some of the individual BOL parameters were not done on a daily basis, namely haemoglobin levels, lactate levels and blood gases. Therefore, only the daily BOL score was used in our analysis but not the individual BOL parameters. Second, most of the patients which were included in our study were monitored in the general wards,

where the level of monitoring is not as high quality as in an ICU. This may lead to a higher mortality rate when compared to patients monitored in ICU as evidenced by another study with the title of "A Tool of Predicting Outcomes of Patients Admitted to ICU – "Battery of Life"" which was conducted by another fellow anaesthetic provider in ICU patients, where the mortality rate was much lower at 26.1%.[14]

Why is it important to look at BOL score? The BOL score provides a novel tool to monitor our patients. The daily score serves as a good predictor of patients' outcome whereas the individual parameters will pinpoint exactly which stage of the oxygen delivery pathway is disturbed, therefore allowing the care provider to take appropriate corrective measures.

CHAPTER 6: CONCLUSION

Battery of Life (BOL) score at day 1 does appear to be a strong predictor of patients' outcome. The minimum BOL score is also a strong predictor of death and poor outcome. BOL score is generally useful as it can prognosticate the outcome of the patients.

As BOL is a new scoring system, further validation studies of this system in different patient population will need to be conducted and for different purposes. Some of these studies may even compare the effectiveness of the BOL scoring system with more established early warning signs such as National Early Warning Score (NEWS) which is now being practiced in University Malaya Medical Centre (UMMC).

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