The impact on patients' time-to-theatre following colour coding classification in emergency operation theatre, Sarawak General Hospital

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ABSTRACT

Introduction: A proper prioritisation system of emergency cases allows appropriate timing of surgery and efficient allocation of resources and staff expertise. The aim of this study was to determine the impact of colour coding classification on Time-to- theatre (TTT) of patients in comparison with the normal practice.

Method: Categorisation was a surgical judgment call after thorough clinical assessment. There were 4 levels of urgency with their respective TTT; Red (2 hours), Yellow (8 hours), Green (24 hours), Blue (72 hours). Caesarean cases were excluded in colour coding due to pre - existing classification. The data for mean TTT was collected 4 weeks before the implementation (Stage 1), and another 4 weeks after implementation (Stage II). As there was a violation in the assumption for parametric test, Mann Whitney U test was used to compare the means between these two groups. Using logarithmic (Ln) transformation for TTT, Analysis of Covariance (ANCOVA) was conducted for multivariate analysis to adjust the effect of various departments. The mean TTT for each colour coding classification was also calculated.

Results: The mean TTT was reduced from 13 hours 48 min to 10 hours, although more cases were completed in Stage II (428 vs 481 cases). Based on Mann-Whitney U test, the difference in TTT for Stage I (Median=6.0, /IQR=18.9) and Stage II (Median=4.2, IQR=11.5) was significantly different (p=0.023). The result remained significant (p=0.039) even after controlled for various department in the analysis. The mean/median TTT after colour coding was Red- 2h 24min/1h, Yellow- 8h 26min/3h 45 min, Green- 15h 8min/8h 15min, and Blue- 13h 46min/13h 5min.

Conclusion: Colour coding classification in emergency Operation (OT) was effective in reducing TTT of patients for non-caesarean section cases.

KEY WORDS:
Emergency; operation theatre; colour coding; time-to-theatre

INTRODUCTION

A proper prioritisation system of emergency cases allows appropriate timing of surgery and appropriate and efficient allocation of resources and staff expertise.[1] Apart from that, the implementation of a universal classification of emergency operations will be able to improve the efficiency of operation Theatre (OT) utilisation during daytime, shorten preoperative delay in patients requiring urgent surgery, as well as enable monitoring for providing emergency surgery services.[2,3] Conversely, a lack of a proper prioritisation system and delayed surgical intervention has shown to incur significant costs, including an increase in morbidity rates as well as economic impact.[4]

In the United Kingdom, the National Confidential Enquiry into Patient Outcome and Death (NCEPOD) is the accepted system for surgical scheduling. The NCEPOD classifies interventions as immediate, urgent, expedited and elective. For each of these categories, the respective target times to theatre from decision to operation is within minutes, hours, days or planned.[5] Despite having this classification, this system has not been widely adopted in Malaysia.

Colour coding of cases booked in the OT is another method of classification of urgency. Colour codes provide a common and standardised language among surgical teams and other OT staff.[6] In 2008, Dupuis et al.,[7] conducted a study evaluating the use of a three-colour code as a communication tool, in relation to the degree of urgency for emergency Caesarean sections. Findings from that study suggested that the colour coding system significantly shortened the decision-to-delivery interval, indicating that it was an effective tool for communicating the degree of urgency for caesarean cases. This method of classification could be extended to non-caesarean cases.

Classification of emergency cases has not been implemented for most of the OT in Malaysia. This impedes prioritisation of cases in the emergency OT. Based on the' observations of the authors, several factors that contribute to the poor prioritisation of cases in the emergency OT include 1) a lack of communication between surgeons and anaesthetists regarding the clinical severity of cases. In a normal practice, the anaesthetic team is usually the main personnel calling the cases based on the medical information of the patients (e.g. diagnoses and surgical procedure) written on the OT chit. However, in some instances, the anaesthetists may not have sufficient information to judge the clinical severity of a case that has been posted to the OT due to inadequate or

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inaccurate information on the OT chit. Likewise, information regarding a patient may not be properly communicated due to repeated handovers across several days and several medical personnel. Thus, patients who require earlier attention may not always be called to the OT in a timely manner. 2) Inadequate handover between the surgeon who posted a case and the surgeon who performed on the case, several days after the case has been first posted. 3) A tendency for prioritisation based on preferences of either the surgeon or anaesthetist e.g. a laparotomy over appendicectomy cases, resulting in indefinite waiting of patients with relatively "less urgent" diagnoses written on the list. This may lead to the deterioration of the condition of the patient after waiting beyond the recommended time frame. 4) Semi-urgent cases may be prioritised to be done during office hours for personal convenience.

Although certain cases are posted as non-urgent, prolonged waiting will in turn result in further deterioration of the condition patients.[8,9] As documented in publications, the timing of surgical intervention is critical for outcomes of patients who require emergency surgery.[6]

There is a need for a simplified classification system, thus, a guideline for the classification of emergency cases was drafted and presented at an OT committee meeting in December 2018 (Appendix 1). This guideline defined the procedures for booking emergency OT by all surgical disciplines; no elective cases should be booked in the emergency OT. This guideline also allowed anaesthetists or surgeons to improve patient safety by upgrading the colour code for cases in the event of deteriorating clinical conditions, extreme of ages and prolonged waiting time (e.g. more than twice the recommended waiting time frame).

With the establishment of the guideline, classification of emergency cases was implemented from the 2nd of January 2019 onward. Our aim was to ensure that patients receive the attention required within the recommended time frame.[3,8-11]

The aim of this study was to determine the impact of colour coding of cases in emergency OT on patients' time-to-theatre (TTT) for emergency surgery.

MATERIAL AND METHODS

Methods

A cross sectional study was performed to compare mean TTT of the patients before implementation, Stage I (3rd-30th Dec 2018) and after implementation, Stage II (21st Jan – 17th Feb 2019) of colour coding in Main OT, SGH. This study was registered and approved by the National Medical Research Register (NMRR-19-1344-48077; approved on 15 July 2019).

This study took place in Sarawak General Hospital (SGH) which is a paper based tertiary referral hospital under the Ministry of Health of Malaysia in Sarawak with 1009 beds and 12 operation rooms (OR). Eleven of the ORs are in the Main OT. In 2018, the Main OT managed 8187 emergency cases (including 268 local anaesthesia cases), and 11204 elective cases (including 2067 local anaesthesia cases). There is a dedicated Emergency Maternity OT situated inside the labour ward, which manages most of the emergency caesarean cases. Due to safety of patients of obstetrics, cases after office hours are conducted in the Main OT with a dedicated team.

In December 2018, a guideline for booking cases in the emergency OT was established and finalised by a SGH OT committee meeting which was also attended by all surgical disciplines and OT staff. The guideline was implemented from the 2nd of January 2019 onwards to classify all cases regardless of the disciplines in the Main OT. Non-caesarean cases were classified by the referring surgeon according to urgency of the case based on clinical evaluation using a four-colour code as shown below (Table I)

Guidelines For The Booking Of Cases On The Emergency OT List, And Emergency Case Categorisation

We have prepared this guideline with the following objectives:-

To categorise and prioritise patients for surgery according to their surgical acuity.

- To improve communication and teamwork between anaesthetic, surgical and nursing personnel.
- To improve data capturing and audit capabilities.

Booking a case in Main OT

- Emergency surgical case: An emergency surgical case is admitted to a health institution in an unplanned and unscheduled manner. Patients usually present with acute surgical conditions that require prompt and focused treatment.
- Elective surgical case: An elective surgical case is admitted to the hospital from home for a scheduled surgical procedure.
- Categorisation is a surgical judgement call after thorough assessment and is the responsibility of the surgeon booking the case.
- Caesarean sections will be categorised according to RCOG recommendation, and will be labelled as I, II, III, and IV according to the urgency. Waiting time frame is not applicable for these patients.
- The booking of a blue case for longer than 72 hours is strongly discouraged as this has far reaching implications for the function of emergency theatre as well as patient safety and comfort.
- Elective cases will not be accepted for booking on the emergency slate, particularly if they have "fallen off" the end of an elective slate due to lack of time.
- Arbitration between surgeons with similarly triaged patients regarding priority on the emergency list to be decided by the Department of Anaesthesia consultant on call.
- Surgeons are encouraged to engage with the consultant anaesthetist on call should they feel that their case has been unfairly superseded by another.

Re-categorisation

- When a yellow, green or blue case is due in theatre (8, 24 and 72 hours after booking, respectively), and cannot be done, the case must be "re-categorised." The surgeon should then re-categorise his/her case appropriately.

Table I: Colour coding classification for non-caesarean section

Colour Code	Category, Waiting time	Definitions	Examples
Red	Acute Emergency (within 2 hours)	Patient conditions require immediate operation e.g., life threatening situation failing which life/limb will be lost.	Embolectomy for Acute ischaemic limb. Bleeding GIT. Unstable Trauma patient with abdominal /chest/ neuro injuries (blunt/penetrating) Torsion testis Acute extradural haemorrhage, drop in GCS due to surgical lesion. Compartment syndrome. Threatened airway.
Yellow	Emergency (within 8 hours)	Patient condition which haemodynamically stable that requires operative procedure to be carried out otherwise life is threatened or morbidity increased	Suspected traumatic intrabdominal injury Perforated viscus, intestinal obstruction. Necrotising fasciitis Blocked VP shunt, Cerebral abscess, ruptured meningocele. Compound fracture. Perforating eye injuries Leaking ectopic pregnancy
Green	Urgent (within 24 hours)	Patient conditions which requires operative procedure within 24 hours otherwise there is increased in morbidity	Acute Appendix, Abscess, carbuncle, Cholecystitis/empyema, cholangitis, Laceration wound. Chronic subdural haematoma, aneurysm. Infected wound for debridement.
Blue	Semi-urgent (within 72 hours)	Patient surgical pathology is stable and non-emergent but the patient cannot or should not leave hospital without an operation.	Secondary suturing. Tracheostomy for prolonged ventilation.

Table II: Urgency of caesarean section

Category		Definition
I	Maternal or foetal compromise	Immediate threat to life of women or foetus
II		No Immediate threat to life of women or foetus
III	No maternal or foetal compromise	Requires early delivery
IV		At a time to suit the women and maternity services

Table III: Demographics of patients for Stage I and Stage II (Non colour code vs colour code)

		Stage I (n= 428)	Stage II (n= 481)
Age in years: Mean (SD)		38.4 (20.7)	39.3 (21.2)
Gender: frequency (%)	Male	259 (60.5%)	298 (62%)
	Female	169 (39.5%)	183 (38%)
Specialty	Orthopaedics	148 (34.6%)	195 (40.6%)
Frequency (%)	General Surgery	143 (33.4%)	131 (27.2%)
	Neurosurgery	29 (6.8%)	39 (8.1%)
	O&G	34 (7.9%)	40 (8.3%)
	Plastic Surgery	40 (9.4%)	28 (5.8%)
	ENT	18 (4.2%)	18 (3.7%)
	Paeds Surgery	9 (2.1%)	8 (1.7%)
	Eye	4 (0.9%)	5 (1.0%)
	Urology	1 (0.2%)	9 (1.9%)
	Others	2 (0.5%)	8 (1.7%)

Table IV: TTT (hours) after colour coding

Colour Coding	N	Mean (hours)	Std. Deviation	Median (hours)	Inter quartile range	Kurtosis	Skewness	Minimum	Maximum
Red	98	2.4	4.0	1.0	18.9	10.4	3.0	0.0	24.0
Yellow	179	8.4	11.4	3.8	8.8	5.4	2.2	0.0	59.0
Green	193	15.1	16.9	8.3	19.7	4.1	1.9	0.0	95.5
Blue	11	13.8	11.4	13.1	24.1	-1.8	0.0	0.0	29.4

Table V: Mean/Median TTT (hours) for different Surgical Department

Department	Stage 1				Stage 2			
	Mean (hours)	Median (hours)	SD	IQR	Mean (hours)	Median (hours)	SD	IQR
Orthopaedics	17.9	9.3	23.2	22.9	13.1	7.3	15.9	16.6
General Surgery	15.4	8.0	17.7	22.0	12.4	6.1	14.1	18.8
Neuro Surgery	9.5	1.3	20.9	5.8	3.7	1.8	6.3	3.0
O & G	3.6	0.5	7.7	5.0	4.0	1.1	7.8	5.3
Plastic Surgery	12.9	6.3	16.1	12.4	6.5	1.5	12.0	7.3
ENT	6.2	2.5	8.7	7.4	4.3	0.3	8.2	4.5
Paeds Surgery	2.4	1.8	1.8	3.1	2.0	1.8	1.4	2.3
Eye	1.6	1.7	1.2	2.3	1.7	1.6	1.9	3.5
Urology					3.8	2.4	3.9	3.8
Others					2.4	0.7	4.8	2.1

Footnote:
-The overall Mean/Median TTT before colour coding is 13.8 hours/6.0 hours, and after colour coding 10.0 hours/4.2 hours.
-Comparison of total average time (hrs) between stage I and stage II was statistically significant (p=0.023) and also was significant after controlled for various departments (p=0.039).
-SD refers to standard deviation, IQR refers to interquartile range.

- **Upgrade of category** will be considered by the Anaesthetist/Surgeon on call with the following patient's condition:
  - Significant medical/anaesthetic risk from clinical assessment.
  - Extreme of ages: infants <1year, elderly patient >80yrs old.
  - Waiting time more than double of the recommended time eg. Yellow >16 hours, Green more than 48 hours.

Caesarean cases were classified using pre-existing classification (Category I, II, III, IV) without colour coding.[12] (Table II) A soft copy of the guideline was distributed electronically to all OT staff. Hardcopies of the guideline were also attached to the OT booking forms for reference. Adequate time was given to OT staff to familiarise with the guidelines.

The red code indicated the most urgent type of emergency surgery class: in which case the surgery should be performed as soon as possible or within 2 hours; followed by the yellow code within 8 hours, the green code within 24 hours, and the blue code within 72 hours. A list of the typical cases in each category was also provided in the guidelines. If there was a change in the condition of the patients during the TTT, the colour code could be changed by the surgeon or anaesthetist responsible.

The inclusion criterion was all patients undergoing surgery in the Main OT requiring general anaesthesia or regional anaesthesia. The exclusion criterion was patients undergoing emergency surgery only under local anaesthesia without the need of anaesthetics or emergency scrub staff. Caesarean cases were also excluded in the analysis, as such cases have their own existing classification system.

The following information was extracted from the OT booking forms for this study: age, gender, discipline, diagnosis, type of surgery, time the case was listed in the OT list and the time patient was called to OT. TTT of patients for emergency surgery was calculated based on the difference between time listed and time called to the OT. This information is then listed in the data collection form and analysed.

Statistical Analysis

Descriptive analysis was conducted to describe the variables including the TTT in the two groups (Colour coding versus normal approach).

The assumptions for parametric tests were first assessed based on histogram, skewness and kurtosis values. As there was a serious violation in the assumption for parametric test, the Mann Whitney U test was used to study the impact of the introduction of colour coding on TTT by comparing the TTT before (Stage I) and after (Stage II) introduction of the colour code. However, independent sample t-test was also conducted but after transformed the outcome variable into logarithmic (Ln) transformation. The threshold for statistical significance was set at the 5% level ($p < 0.05$).

We then proceeded with an Analysis of Covariance (ANCOVA), to determine whether or not the difference in TTT between the two stages would still remain significant, even after controlling for different surgical departments. To proceed with (ANCOVA), the variable TTT was transformed to Ln transformation to ensure it fits with parametric assumption. All analyses were performed using SPSS (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.)

RESULTS

There were 530 and 601 cases done under general anaesthesia (GA) /Regional Anaesthesia (RA) respectively during Stage I and Stage II. We excluded caesarean section, 92 cases (GA) and 120 cases (RA) during that period due to different classification methods.

All the patient demographics and also according to specialty are shown in Table III.

Based on Mann Whitney U test, the TTT was significantly different (p=0.023) between Stage I (Median=6.0, /IQR=18.9) and Stage II (Median=4.2, IQR=11.5).

The overall mean TTT had reduced significantly from 13.8 hours to 10.0 hours. Independent sample t-test was conducted using transformed "TTT" based on Ln transformation,

p=0.030. The p-value for the grouping variable (before colour coding vs after colour coding) still remained significant (p=0.039) even after controlling for different surgical department (using ANCOVA). Logarithmic (Ln) transformation was applied for variable TTT so the assumptions for ANCOVA were satisfied.

The mean/median TTT after colour coding was Red- 2h 24min/1h, Yellow- 8h 26min/3h 45 min, Green- 15h 8min/8h 15min, and Blue- 13h 46min/13h 5min.

Table IV shows the mean TTT after colour coding. The target time frame for TTT was 2 hours, 8 hours, 24 hours, and 72 hours for Red, Yellow, Green and Blue respectively. Table V shows the mean and median TTT for different surgical department.

DISCUSSION

Consistent with previous reports, this study agrees that classification of cases by colour coding shortens TTT.[2,7] Several factors may explain this finding. Firstly, coding of procedures or surgeries was standardised e.g., active bleeding is coded Red, bowel obstruction is coded Yellow. This enhanced objectivity of case prioritisation and thus, addressed a few of the factors for poor prioritisation of cases, including the tendency for prioritisation of certain cases based on the preference or convenience of the surgeons and/or anaesthetists. To avoid further deterioration of the condition of patients due to prolonged waiting, the guideline allowed upgrading of a case if the patient had waited more than twice the standard time frame. This helped to avoid certain Green coded cases (e.g., acute appendicitis) that have been on the waiting list for more than 48 hours, from being superseded by Yellow coded cases (e.g., intestinal obstruction).
Implementation of a universal standardised classification of cases also helped to improve the efficiency of operating theatre utilisation. For example, the anaesthetists and scrub team were able to allocate sufficient time to prepare and allocate resources.

Secondly, expanding on the proposal by Dupuis et al[7], we observed that the colour coding classification was a useful communication tool among surgeons and anaesthetists for non-caesarean cases. As SGH is the main referral hospital in Sarawak, it handles many surgical disciplines. It is not uncommon to have more than 20 patients in the emergency surgery list. With the utilisation of a colour coding classification system, the clinical severity of cases posted on the OT chit can be easily communicated between surgeons and anaesthetists, as well as the OT staff.

Apart from that, colour coding encouraged communication between surgeon and anaesthetists, particularly when there is an atypical colour code (e.g. bowel obstruction with severe sepsis that requires a code Red rather than code Yellow). When a surgeon colour codes a case as red, the OT staff and anaesthetic team would actively seek out the reason for this classification (i.e., if the case was truly an urgent case or it was a misclassification). If it was a true Red code classification, the OT staff including the doctors and nurses would start making arrangements for that case to be prioritised and called to OT in a timely manner.

Colour coding in caesarean cases was a potential communication tool among Obstetrics OT staff and Obstetricians. However caesarean cases were not included in this study because there was a dedicated OT for caesarean cases and main OT manages the smaller fraction of caesarean cases after office hours. Caesarean cases continued to be classified according to Lucas et al.[12] in SGH.

Thirdly, colour coding provided good visual organisation of the proportion of urgent and non-urgent cases in the OT booking list. During the night, this coding system helped anaesthetists and surgeons to prioritize the completion of Red and Yellow coded cases. Green and blue cases were usually considered for surgery the following day or rescheduled into the elective OT list, which also helped prevent prolonged fasting of non-urgent cases. These non-urgent cases were also scrutinised so that the TTT was not prolonged in order to prevent clinical deterioration.[10,11] As described previously, patients who had waited twice the recommended time frame are prioritised accordingly.

While the results from the study were encouraging, the significant impact of the colour coding on TTT may also potentially be due to the Hawthorne effect which refers to a phenomenon which is thought to occur when people observed during a study temporarily change their behaviour or performance. There was an increased attention of team performance during Stage II; OT staff was also constantly reminded of the importance of achieving the stated time frame. In response to this effect, more cases were called to OT during Stage II (Stage I 428 vs. Stage II 481), with a significantly reduced TTT (from 13.8 to 10.0 hour). Nevertheless, it may also suggest an improved use of time where a person is able to do more cases with reduced TTT. In fact, TTT has been proposed as a key performance indicator of theatre efficiency.[4]

LIMITATION

This study has limitations. The cross-sectional design could lead to several biases. SGH is a paper based tertiary hospital. The precision of the time listed, and time called relies on the nurse on duty at the counter who filled up the OT list. Nevertheless, there were no changes in the group of nurses and the process to perform the documentation. These documentations were then used to calculate the TTT. We also assumed that the time listed was the time of decision making. However, if there was a delay in sending the OT chit to the OT counter, there was likely a delay in listing the patient, rendering the TTT inaccurate. Transcriptions of data into statistical software were also subject to human error; in order to reduce error, two persons always counter checked the entry.

CONCLUSION

Our study suggests that the use of a colour coding classification significantly shortens TTT by effectively communicating the degree of urgency in managing emergency cases. Further prospective studies are needed to confirm these results.

CONFLICT OF INTEREST

The authors declare that they have no conflicting interests.

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