



**STUDY ON PRACTICE OF
MASSIVE TRANSFUSION PROTOCOL
ACTIVATION IN HOSPITAL UNIVERSITI
SAINS MALAYSIA**

By

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DISCLAIMER

I hereby declare that this research has been sent to Universiti Sains Malaysia for the degree of Master of Medicine in Transfusion Medicine. It is not to be sent to any other universities. With that, this research might be used for consultation and can be photocopied as a reference.

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LIST OF ABBREVIATIONS

D&C	Dilatation and curettage
FBC	Full blood count
FFP	Fresh frozen plasma
HREC	Human Research Ethics Committee
ICU	Intensive care unit
MLR	multiple logistic regression
MTP	Massive transfusion protocol
MVA	Motor vehicle accident
OGDS	Oesophagogastroduodenoscopy
OR	Odd ratio
O&G	Obstetrics and gynaecology
PC	Packed cell
PROPPR	Pragmatic, Randomised, Optimal Platelet and Plasma Ratios
ROC	Receiver Operating Characteristic
SD	Standard deviation
SLR	Simple logistic regression
SPSS	Statistical Package for the Social Sciences
TEG	Thromboelastography
UGIB	Upper gastrointestinal bleeding
UPT	Unit Perubatan Transfusi
USM	Universiti Sains Malaysia

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ABSTRAK

Pengenalan: *Massive transfusion protocol (MTP)* direka untuk meningkatkan hasil pesakit yang berisiko pendarahan yang teruk. Kajian ini memfokuskan pada prevalensi, indikasi, faktor-faktor yang berkaitan terhadap indikasi kes MTP yang diaktifkan dan mortaliti pesakit yang menerima MTP di Hospital USM.

Kaedah: Kajian rentas silang retrospektif dijalankan terhadap 110 pesakit yang MTP diaktifkan di Hospital USM. Data diambil daripada rekod perubatan, dan sistem tabung darah (MyTransfusi). Analisis logistik ringkas dan berganda digunakan untuk analisis statistik dan nilai $p < 0.05$ dianggap signifikan.

Keputusan: Seramai 273, 087 pesakit dimasukkan ke Hospital USM dan 193 pesakit memerlukan pengaktifan MTP sepanjang tempoh kajian. Prevalensi pengaktifan MTP ialah 0.07%. Kajian ini merangkumi 110 kes MTP yang terdiri daripada 62 (56.3%) trauma dan 48 (43.7%) pesakit bukan trauma. Purata umur pesakit ialah 40.0 tahun, dan majoriti adalah lelaki (66.4%). Dua indikasi MTP yang paling kerap adalah kemalangan kenderaan bermotor ($n = 58$) dan pendarahan gastrointestinal ($n = 24$). Perempuan (OR diselaraskan = 20.08, 95% CI 5.76 – 70.00, $p < 0.001$) dan komorbiditi (OR diselaraskan = 13.66, 95% CI 4.21 – 44.39, $p < 0.001$) berkaitan dengan indikasi MTP. Sementara itu, ketiadaan prosedur kecemasan (OR diselaraskan = 12.77, 95% CI 4.22 – 38.61, $p < 0.001$) dan ketidakpatuhan terhadap MTP (OR diselaraskan = 4.30, 95% CI 1.21 – 15.38, $p = 0.024$) berkaitan secara signifikan dengan mortaliti dalam masa 24 jam yang tinggi selepas pengaktifan MTP.

Kesimpulan: Prevalensi MTP adalah rendah. Hasil kajian kami menunjukkan bahawa prosedur kecemasan awal untuk mengawal punca pendarahan harus dilakukan dan kepatuhan terhadap MTP perlu ditingkatkan untuk hasil pesakit yang lebih baik.

Kata kunci: massive transfusion protocol (MTP), mortaliti, indikasi, kepatuhan

ABSTRACT

Introduction: Massive transfusion protocol (MTP) was designed to improve the outcome of patients at risk of massive haemorrhage. This study focused on the prevalence, indications, associated factors toward the indication of MTP cases and 24-hour mortality among who received MTP in Hospital USM.

Methods: A retrospective cross-sectional study was performed on 110 patients for whom MTP was activated in Hospital USM. Data were extracted from the medical records and blood bank system (MyTransfusi). Simple and multiple logistic analysis was used for statistical analysis, and a p-value of < 0.05 was considered significant.

Results: A total of 273,087 patients were admitted to Hospital USM and 193 patients required MTP activation during the study period. The prevalence of MTP activation was only 0.07%. This study included 110 MTP cases which consisted of 62 (56.3%) trauma and 48 (43.7%) non-trauma patients. The mean age of total patients were 40.0 years old, and majority were male (66.4%). The two most common MTP indications were motor vehicle accidents ($n = 58$) and gastrointestinal bleeding ($n = 24$). Female (adjusted OR = 20.08, 95% CI 5.76 – 70.00, $p < 0.001$) and presence of comorbidity (adjusted OR = 13.66, 95% CI 4.21 – 44.39, $p < 0.001$) significantly associated with MTP indication. Meanwhile, no emergency procedure (adjusted OR = 12.77, 95% CI 4.22 – 38.61, $p < 0.001$) and non-compliance to MTP (adjusted OR = 4.30, 95% CI 1.21 – 15.38, $p = 0.024$) were significantly associated with high mortality within 24-hour post MTP activation.

Conclusion: The prevalence of MTP was low. Our result suggested that early emergency procedures to control the haemorrhage source should be done, and compliance towards MTP needs to be improved for better patient outcomes.

Keywords: Massive transfusion protocol (MTP), mortality, indications, compliance

CHAPTER ONE: INTRODUCTION

CHAPTER ONE

INTRODUCTION

1.1 Overview

This chapter covers the outline of the Study on Practice of Massive Transfusion Protocol Activation in Hospital Universiti Sains Malaysia (USM). This chapter also highlights the research justifications and research questions.

1.2 Background of study

Massive blood loss has a significant impact on the survival and prognosis of many patients. About 40% of trauma-related mortality is due to uncontrolled bleeding, and approximately 25% of trauma patients arriving in the emergency department developed early coagulopathy due to massive haemorrhage (1,2). Furthermore, a major cause of maternal mortality and morbidity is due to massive bleeding (3). In the operating theatre, haemorrhagic shock accounts for 80% of deaths, and up to 50% of mortality was in the first 24 hours following injury (4). In order to maintain adequate circulation and haemostasis, patients with severe haemorrhage require massive transfusion.

Effective coordination and communication between transfusion team, other laboratory services, and clinical team are crucial to ensure optimal management of massively bleeding patients. Thus, a proactive standardised protocol, as MTP, is designed to facilitate communication between different services (clinician, laboratory, and blood bank personnel), avoid delay in critical care, laboratory testing, and blood transfusion for

the patients at risk of massive bleeding (5). The goal of MTP is to ensure the delivery of a pre-defined ratio of blood products rapidly and efficiently to critically bleeding patients (6). Furthermore, the protocol enables the release of blood for initial resuscitation at a standardised pre-defined ratio of blood products regardless of the patient's laboratory result. Making MTP effective requires full cooperation and involvement from the treating clinician and blood bank team (6). Good communication between both teams is essential to prevent poor clinical outcomes, suboptimal or inappropriate transfusion practice and component wastage.

In the absence of MTP, transfusion of large amounts and the improper ratio of blood products cause higher mortality in severely bleeding patients since they may quickly enter the lethal triad of hypothermia, metabolic acidosis and coagulopathy (7). Moreover, the complication of massive bleeding may be exacerbated resulting from excessive fluid resuscitation (8,9). A well-established MTP is pivotal to intervene in the severe bleeding and break the triad(10). Thus, the presence of MTP is an important approach to prevent the complication of massive transfusion, particularly dilutional coagulopathy, which may aggravate the patient's condition.

The MTP in Hospital USM dictates a specific standard of procedure. This protocol was applied for all disciplines including paediatric patients even though it mainly design for adult patients. The attending specialist or medical officer will assess and identify the patients at risk of massive bleeding which requiring massive transfusion. The protocol will be activated by the clinicians if indicated. The team leader (most senior clinician at the scene) must assign trained medical personnel to become porter responsible for sending the patient's blood sample to the blood bank and collecting the issued blood products.

Also, a communication leader must be appointed by the team leader to coordinate the communication between the clinical team and the blood bank. The blood products will be released by cycle (Figure 1.1) according to the protocol approved by Hospital Transfusion Committee (HTC). Each cycle must be prepared and issued out within the duration stated in the protocol. Once the cycle is issued out, blood bank staff must prepare the following cycle immediately until the clinical team deactivates the MTP.

MTP has received a lot of attention and was implemented more frequently for the past two decades, especially in trauma-related massive haemorrhage, gastrointestinal or obstetric haemorrhage and bleeding intra-operatively (1,11). However, many literatures previously focused only on patients' outcomes between pre-MTP and post-MTP periods in specific trauma or obstetric centres. Moreover, there is no study on the indication of MTP and compliance towards the established MTP in Malaysia. Therefore, this study focused on the prevalence, indications, associated factors toward the indication of activated MTP cases and 24-hour mortality among those who received MTP in Hospital USM.

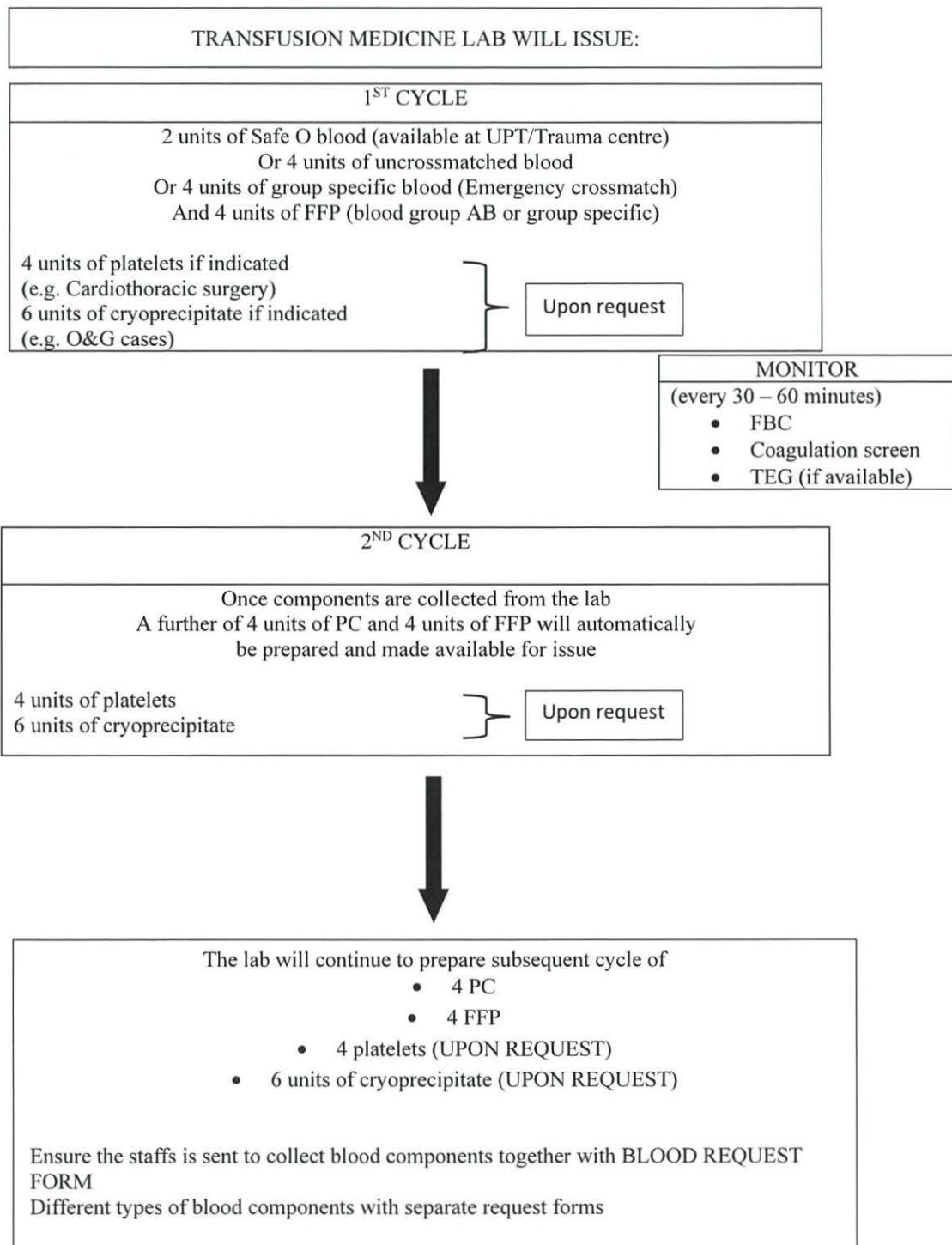


Figure 1.1. MTP flow diagram in Hospital USM (34) (UPT = *Unit Perubatan Transfusi*; PC = packed cells; FFP = fresh frozen plasma; FBC = full blood count; TEG = thromboelastography; O&G = Obstetric and Gynaecology)

1.3 Literature review

MTP was developed previously in the military during war to facilitate and improve the management and outcome of patients with massive bleeding (12). The protocol was implemented for civilian patients in trauma centres after it was proven to give better patient outcomes. MTP occurrence in a few studies done at the obstetric centre was low, which was less than 0.7% only (13,14). In addition, another study done in a level one trauma centre showed a low prevalence of MTP activation, which was 1.6% of total patients admission (15).

Several studies revealed that patients in the trauma group were younger than the non-trauma group (12,16,17). However, gender was not significantly associated with the indication of MTP activation (11,16,18). According to an earlier study done in a trauma centre, only about 26% of patients had comorbidities (18). On the other hand, the study conducted in non-trauma patients discovered that up to 74% of the patients had underlying medical diseases (19). Only one study compared the presence of comorbidities between trauma and non-trauma patients of MTP cases. It was found that comorbidity was significantly lower in trauma patients than in non-trauma patients (16). According to previous studies, gastrointestinal haemorrhage, ruptured abdominal aortic aneurysm, and surgical or obstetric bleeding were the common causes of massive bleeding in non-trauma patients (16,17,20,21). Whereas for trauma patients, research conducted in the United States Of America found that MVA (53%) was the most common indication for MTP activation, followed by gun shot or stabbing (36%) (16). Apart from that, a binational study conducted by Sweden and Denmark found that major surgery (61.2%) and trauma (15.4%) were shown to be the most common causes of MTP activation (22).

A multicentre research that incorporated MTP activation in all departments showed that 50% - 70% of the cases were terminated at the first cycle of MTP (21). On the contrary, a study done in the three level-one trauma centres found that MTP was terminated at the third cycle and beyond (42 – 81%) for most patients (21). There was a literature reported that trauma patients required significantly more PC, FFP, platelet and cryoprecipitate transfusion compared to non-trauma patients ($p < 0.05$) (11). In contrast to the study mentioned above, *Kreuziger et al.* demonstrated that there was no significant difference in term of blood product transfused to the patients in both trauma and non-trauma groups ($p > 0.05$) (16). Many literatures proved that tranexamic acid played an important role as a haemostatic adjunct, which can improve patients' outcomes, especially in trauma and obstetric patients (23,24). *Wijaya et al.* found that majority of their patients were given tranexamic acid (83.3%) as a haemostatic agent. All trauma patients and 57.1% of non-trauma patients received tranexamic acid in the research (12).

A study comparing trauma and non-trauma patients in America showed that trauma patients were more likely to die in the first 24-hour than non-trauma patients (27.4 vs 11.1%, $P=0.02$) (16). Another study with a similar result reported that the 24-hour mortality for trauma and non-trauma patients were 45.5% and 14.3% respectively (12). However, a research published in 2012 revealed that the indication of MTP had no significant difference with the 24-hour mortality of the patient (11). Previous literatures found that the 24-hour and 30-day mortality rate were unaffected by the PC to FFP ratio transfused to the patients during MTP (16,25). However, high FFP to PC ratio contributed to a better haemostatic status of the patient with massive haemorrhage (25). Nevertheless, a previous study showed that only the amount of PC transfused to the patients was

significantly associated with mortality of the patients within 24 hours after MTP activation (26).

Emergency procedures are critical to stopping the source of massive bleeding in the patients that warrant MTP activation. Therefore, the emergency procedure significantly reduces further blood loss and improves patient outcomes in obstetrics cases (27). Besides that, oesophagogastroduodenoscopy (OGDS) intervention significantly reduced recurrent episodes of massive upper gastrointestinal bleeding (UGIB) and the mortality rate (28).

Even though MTP has been associated with improved survival, compliance to the established protocol may affect the outcome of the patients. A study conducted by *Cotton et al.* found that poor compliance towards MTP had higher 24-hour mortality than those who complied with the protocol (38.5% vs 11.8%; $p = 0.004$) (29). Similarly, another study showed that the low compliance group had a higher mortality rate compared to the moderate and high compliance group (62% vs 50% vs 10%; $p = 0.025$) (30).

In term of compliance criteria of the MTP, a previous study found that 53% of patients were transfused with pre-defined MTP-based blood products, and only 11% of patients were compliant to blood investigations criteria (FBC, coagulation profile, ABG, RP, fibrinogen level) during the MTP activation (30). Another literature revealed that 66% of the patients complied with transfusion of pre-defined FFP to PC ratio (29). Besides, most of the cases in the study complied to the criteria of activation by the attending trauma surgeon (92%) (29).

For MTP in paediatric group, dosage of blood products varied from patient to patient based on body weight. For this reason, MTP in paediatric have often supported a variation of specific transfusion ratios and quantities based on patient weight as this correlated with stage of development of the child. According to the systematic review done in 2020, there was no clear data showed improvement of paediatric patient's clinical outcome. This was due to the fact that, the optimum ratio of blood product in paediatric patients was not determined. Secondly, there was no consensus on criteria required for proper activation of paediatric MTP (31).

1.4 Research justification

MTP has been established and implemented in Malaysia for almost a decade currently. However, study on the prevalence and indication of MTP is yet to be carried out in Malaysia tertiary hospitals. Without this data, clinicians have no information on the trend of MTP and the possibility of certain diagnosis that require MTP activation in the local setting. Besides, there is also no published data regarding the practice of MTP in Malaysia. Such data can be the source of local reference to guide the clinicians who are always managing potential MTP cases.

Studies in overseas had shown that lacking of data on MTP practice for non-trauma cases. Most of the previous researches were done in the trauma centre, and the practice of MTP in non-trauma has not been well studied yet (12). Our study focused on the MTP indication and compared the characteristic of both trauma and non-trauma MTP cases to fill the gap in this area. In addition, this will provide a platform to stimulate further study in this field with regard to non-trauma cases.

MTP has been implemented in many clinical settings. In previous studies, the protocol had improved patients' outcomes and optimised the number of blood products transfused (10). However, to achieve the optimal outcome of MTP, the protocol needs to be adhered to accordingly. Currently, there is no study available in Malaysia about the evaluation of compliance with the established MTP protocol. Therefore, it is important to have the data so that compliance toward the MTP can be monitored and audited. Without this data, the improvement of transfusion service in managing massive haemorrhage patients cannot be made optimally.

This study also determined the associated factor toward 24-hour mortality. As different strategies were used by clinicians on top of MTP, such as haemostatic agent and emergency procedure, this study aims to analyse the selected factor that can improve patient mortality. With this valuable data, the current MTP also can be enhanced according to the result of this study

This study was conducted at Hospital USM. With 723 beds, it was one of the tertiary referral hospitals in east coast Malaysia. A large number of patients with different kinds of diseases came to this hospital to seek treatment due to Hospital USM's availability of complete medical facilities and various subspecialty treatments offered. Therefore, it was expected that it has different demographic characteristics of patients. This made Hospital USM an appropriate place for this study to be conducted. Besides that, MTP was well developed and has been implemented in this hospital since 2014. Moreover, the Department of Haematology and Transfusion Medicine Unit in Hospital USM was

capable of supplying blood products for MTP cases once activated because of adequate blood stock and competent staff in the department.

1.5 Research questions

- What are the prevalence and indications of MTP activation in Hospital USM?
- Is there any significant relationship between the indication of activated MTP cases (trauma and non-trauma) with selected factors (age, gender, presence of comorbidity, number of blood product cycles transfused, number of blood components transfused, ratio of blood product, use of haemostatic agent, any emergency procedure done and 24-hour mortality)?
- Is there any significant relationship between 24-hours mortality with selected factors (age, gender, presence of comorbidity, number of blood product cycles transfused, number of blood components transfused, ratio of blood product, use of haemostatic agent, any emergency procedure done and compliance of selected MTP criteria)?

CHAPTER TWO:

OBJECTIVE

CHAPTER TWO

2.1 General objective

To study the practice of MTP activation in Hospital USM

2.2 Specific objective

1. To determine the prevalence and indications of MTP activation in Hospital USM
2. To determine the association between indication of MTP with selected factors (age, gender, presence of comorbidity, number of blood product cycles transfused, number of blood components transfused, ratio of blood product, use of haemostatic agent, any emergency procedure done, 24-hour mortality)
3. To determine the association between 24-hours mortality with selected factors (age, gender, presence of comorbidity, number of blood product cycles transfused, number of blood components transfused, ratio of blood product, use of haemostatic agent, any emergency procedure done and compliance of selected MTP criteria)

2.3 Alternative Hypotheses

- There is association between indication of MTP with selected factors
- There is association between 24-hours mortality with selected factors

2.4 Null hypothesis

- There is no association between indication of MTP with selected factors
- There is no association between 24-hours mortality with selected factors

CHAPTER THREE:

METHODOLOGY

CHAPTER THREE

METHODOLOGY

3.1 Study background

This study focused on prevalence, indication of activated MTP cases in Hospital USM and evaluate the compliance of the clinician towards the established protocol. This study also predicted the associated factor with the indication of MTP activation and 24-hour mortality.

3.2 Study design

This was a retrospective cross-sectional study using medical records, and blood bank system (MyTransfusi).

3.3 Study area

This study was conducted at Hospital USM. MTP was well developed and has been implemented in this hospital since 2014.

3.4 Study population

All patients whose MTP was activated from 1st January 2014 until 30th May 2020. The list of the patients was obtained from the census of MTP activation cases recorded in the Department of Haematology and Transfusion Medicine Unit.

3.5 Subject criteria

3.5.1. Inclusion criteria

- Age above 18 years old
- Patients who received transfusion after MTP activation

3.5.2. Exclusion criteria

- Missing data
- Patients who did not receive blood transfusion after MTP activation

3.6 Sample size

Specific objective 1: To determine the prevalence and indications of MTP activation in Hospital USM

To estimate the prevalence of MTP activation in Hospital USM, single proportion formula as the following was used to calculate the sample size:

$$n = \left(\frac{z}{\Delta} \right)^2 (P(1 - P))$$

where n = sample size

z = the value to estimate the 95% confidence interval (1.96)

P = true population proportion

Δ = precision or detectable difference of expected population proportion and true population proportion

Based on previous studies, the proportion of MTP activation was between 1.6% (15). This study wished to estimate proportion of patients in Malaysia with MTP activation within 2.5% from true proportion with 95% confidence interval. The minimum sample size required with an additional 20% drop out rate was:

$$n = (1.96/0.025)^2 (0.016(1-0.016))$$

$$= 97 + 20\% \text{ drop out rate}$$

$$= \mathbf{116 \text{ patients}}$$

Specific objective 2: To determine the association between indication of MTP with selected factors (age, gender, presence of comorbidity, number of blood product cycles transfused, number of blood components transfused, ratio of blood product, use of haemostatic agent, any emergency procedure done, 24-hour mortality)

Two proportion formula was used to calculate the sample size required for association of indication of MTP activation with 24-hour mortality:

$$n = \frac{P_1(1 - P_1) + P_2(1 - P_2)}{(P_1 - P_2)^2} (Z_\alpha + Z_\beta)^2$$

Where P_1 = proportion of exposure in cases

P_2 = proportion of exposure in controls

Z_α = Level of significance

Z_β = Power of study to demonstrate association if one does exist

Based on *Wijaya et al.*, the 24-hour mortality rate of both trauma and non-trauma patients were 45.5% and 14.3% (12). Using a significance level of 0.05 and a power of 80%, the minimum required sample size to determine relationship of indication of MTP activation and 24-hour mortality was:

$$n = \frac{0.455 (1 - 0.455) + 0.143 (1 - 0.143)}{(0.455 - 0.143)^2} (1.96 + 0.8)^2$$

$$= 33 \text{ per group}$$

Hence, the sample size required was $(33 \times 2) + 20\% \text{ drop out rate} = \mathbf{82 \text{ patients}}$

Specific objective 3: To determine the association between 24-hours mortality with selected factors (age, gender, presence of comorbidity, number of blood product cycles transfused, number of blood components transfused, ratio of blood product, use of haemostatic agent, surgical intervention and compliance of selected MTP criteria)

Two proportion formula was used to calculate the sample size required for association of compliance of MTP activation with 24-hour mortality:

$$n = \frac{P_1(1 - P_1) + P_2(1 - P_2)}{(P_1 - P_2)^2} (Z_\alpha + Z_\beta)^2$$

Where P_1 = proportion of exposure in cases

P_2 = proportion of exposure in controls

Z_α = Level of significance

Z_β = Power of study to demonstrate association if one does exist

Based on Cotton *et al.*, the 24-hour survival of both compliant and non-compliant TEP (MTP) were 88% and 61% (29). Using a significance level of 0.05 and a power of 80%, the minimum required sample size to determine relationship of compliance of MTP activation with 24-hour mortality was:

$$n = \frac{0.88(1 - 0.88) + 0.61(1 - 0.61)}{(0.88 - 0.61)^2} (1.96 + 0.8)^2$$

$$= 40 \text{ per group}$$

Hence, the sample size required was $(40 \times 2) + 20\% \text{ drop out rate} = \mathbf{102 \text{ patients}}$

Conclusion

The highest sample size was from objective 1 = 116 patients

3.7 Sampling method and subject recruitment

3.7.1. Sampling method

Purposive sampling method

All patients whose MTP activated within the study period were traced.

Purposive sampling method was performed and patients who fulfil inclusion and exclusion criterias were recruited in the study.

3.7.2. Subject recruitment

Target population: Patients whose MTP was activated in Hospital USM

Sampling frame: Taken from the census of MTP activation cases in blood bank and patient's medical record from hospital record registry

3.8 Research tool

a) Patient's PROFORMA was prepared to ensure the data collection was complete and easy to be reviewed. The data included were:

- Reference number
- Age
- Gender
- Date of admission
- Date of discharge

- Underlying disease
- Personnel who activated MTP
- Department
- Diagnosis
- Indication of MTP
- Total number of MTP cycle(s) released
- Total number of blood products transfused:
 - Packed red blood cells
 - Fresh frozen plasma
 - Platelet concentrate/ apheresis
 - Cryoprecipitate
- Use of additional haemostatic agents
- Emergency procedure
- 24-hour mortality
- Blood investigation

b) Patient's medical record

c) Census of MTP activation cases

3.9 Data collection method

Hospital director was approached to get approval and written consent to conduct this research in Hospital USM. First, the patients were identified using the census of MTP activation cases in the blood bank. The patient's clinical notes were then traced manually from the Medical Record Department, while laboratory results and transfusion history were traced in the respective laboratory. Data were extracted

from the medical record and blood bank information system (MyTransfusi). All the information and parameters were recorded in the patient's proforma form by the main researcher (registered medical officer). The patient's records were returned to Medical Record Department immediately once the data collection was completed.

3.10 Statistical analysis

Statistical analysis was performed using IBM SPSS version 27 for window-software. For specific objective 1 which was to determine the prevalence and indications of MTP activation in Hospital USM, descriptive statistics were used. Meanwhile, for specific objective 2 which was to determine the association between indication of MTP with selected factor (age, gender, presence of comorbidity, number of blood product cycles transfused, number of blood components transfused, ratio of blood product, use of haemostatic agent, any emergency procedure done, 24-hour mortality), simple and multiple logistic regression was used. The level of significance was set at p-value less than 0.05. As for specific objective 3 which was to determine the association between 24-hours mortality with selected factors (age, gender, presence of comorbidity, number of blood product cycles transfused, number of blood components transfused, ratio of blood product, use of haemostatic agent, surgical intervention and compliance of selected MTP criteria), simple and multiple logistic regression was used. The level of significance was set at p-value less than 0.05.

3.11 List of variables

- Age
- Gender
- Underlying disease
- Personnel who activated MTP
- Indication of MTP
- Total number of MTP cycle released
- Total number of blood products transfused:
 - Packed red blood cells (PC)
 - Fresh frozen plasma (FFP)
 - Platelet concentrate/ apheresis
 - Cryoprecipitate
- Use of additional haemostatic agents
- Emergency procedure
- 24-hour mortality
- Blood investigation