Original Article

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Impact of Time-to-operation on In-hospital Mortality of Trauma Patients with Abdominal Injury Who Underwent Door-to-door Laparotomy

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Abstract:

Objective: Assessing the impact of time-to-operation, defined as the time from injury to incision, on in-hospital mortality of patients with abdominal injury who underwent door-to-door laparotomy was the primary objective. Other objectives were assessing the impact of time-to-operation on 24-hour mortality, hospital length-of-stay, and intensive-care-unit-free days of this population.

Material and Methods: This retrospective study examined 15-year and older patients with abdominal injuries who underwent door-to-door laparotomy in Songklanagarind Hospital between January 1st, 2015 and December 31st, 2018. Univariable and multivariable statistical analyses of the associations between the variables and in-hospital mortality were done.

Results: Among the 65 patients who met the inclusion criteria, 17 patients died, mostly due to exsanguination. The median time-to-operation was 165 minutes, with a maximum of 480 minutes and a minimum of 55 minutes. There were no statistically significant impacts of time-to-operation on in-hospital and 24-hour mortalities, hospital length-of-stay, or Intensive care unit (ICU)-free days. Multivariable analysis revealed three factors related to in-hospital mortality: Injury Severity Score (ISS) [adjusted odds ratio (OR) 1.09, p-value=0.002, 95% confidence interval (95% CI) 1.022, 1.159], shock [adjusted OR 12.73, p-value=0.008, 95% CI 1.428,113.488], and Glasgow Coma Scale (GCS) score <15 [adjusted OR 15.43, p-value=0.004, 95% CI 1.95, 122.106].

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Conclusion: There were no significant impacts of time-to-operation on in-hospital and 24-hour mortalities of patients with abdominal injury who underwent door-to-door laparotomy. Patients with higher ISS, signs of shock, and/or GCS score lower than 15 had higher in-hospital mortality.

Keywords: abdominal injury, mortality, time-to-operation

Introduction

Road traffic accidents remain one of the leading causes of global death. The incidence is predicted to rise and become the fifth leading cause by 2030[1]. In Thailand, these accidents have been one of the five most common causes of death for decades[2]. Among those trauma deaths, the second peak of the trimodal distribution, mainly due to exsanguination, presents the greatest opportunity for improvement[3]. One earlier study reported that 31% of the victims died of hemorrhage in the chest, abdomen, or both cavities[4]. Another study found that 51% of the deaths that occurred within 48 hours after injury were due to exsanguination of the liver, heart, or major blood vessels[5]. Another study reported that not only a delay or failure of early diagnosis but also non-operative management of abdominal injuries significantly increased morbidity and mortality through causes such as more liver-related complications where the role of repeated imaging was limited[6]. Another research paper indicated that failure of non-operative management led to longer Intensive care unit (ICU) and overall lengths of stay in blunt splenic trauma[7]. Therefore, several studies have been done examining the association between time in the emergency department (ED) before an indicated operation and mortality in various types of trauma patients, especially hypotensive patients. These studies demonstrated that more time before the operation resulted in higher mortality rates, indicating that the number of trauma deaths might have been potentially decreased if the operations had been done sooner[8-11]. This study aimed to examine the impact of time-to-operation, which is defined as the total time from injury time to incision time in the operating room, on in-hospital mortality of patients with an abdominal injury who underwent a door-to-door laparotomy. The expectation was that the findings could be used to reduce preventable mortality and improve the quality of the trauma care system.

Material and Methods

Population

This retrospective study was conducted following the approval of the Human Research Ethics Committee of the Faculty of Medicine, Prince of Songkla University (project number REC. 62-269-10-4). Patients aged at least 15 years old who had an abdominal injury and underwent door-to-door laparotomy (defined as a laparotomy that is immediately performed after a patient is transferred directly from the ED to the operating room) in Songklanagarind Hospital between January 1st, 2015 and December 31st, 2018 were enrolled. The study participants were identified by medical documentation of clinical blunt or penetrating abdominal injuries from the hospital information system (HIS) program and trauma registry. Referred cases, pregnant patients, and patients who died or underwent cardiopulmonary resuscitation upon arrival or received an ED thoracotomy were excluded. Dependent, independent, and potential confounder variables were recorded on a case record form and transferred to a Microsoft Excel file. After double-checking all the data, univariable analysis was done then potential variables from the univariable analysis were selected for multivariable analysis.

Variables

Independent variables: time variables, as shown in Figure 1.

Dependent variables: In-hospital mortality (n, %), 24-hour mortality (n, %), Time to in-hospital mortality (days), Hospital length of stay (days), and intensive-care-unit-free days [ICU-free days] (days) which was listed as 0 for subjects who died at any time.

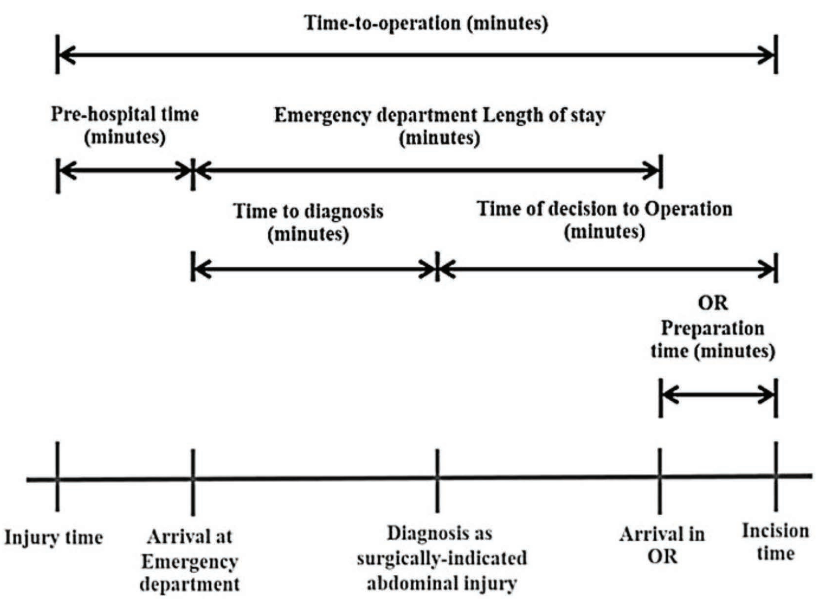
Statistical analysis

The R program version 4.1.2 and Stata18 were used for all analyses. Continuous variables were treated as mean and standard deviation or median and interquartile range (IQR), depending on the data distribution. Discrete variables were analyzed as percentages. Continuous variables were compared with in-hospital mortality using Student's t-test and Wilcoxon rank-sum test. We compared discrete variables with in-hospital mortality using Pearson's Chi-squared test or Fisher's exact test. Univariable and multivariable analyses of the associations between variables and in-hospital mortality were conducted using logistic regression and the two-tailed test, which are presented as p-value, OR, and 95% CI. Differences between groups with a p-value<0.05 were considered significant. Additionally, a confounder summary score was applied to estimate the treatment effects from the coefficients.

Results

Between January 1st, 2015 and December 31st, 2018, 790 patients aged at least 15 years old with abdominal injury in Songklanagarind Hospital were enrolled. Of these, 65 patients (9.0%) met the inclusion criteria and were included, as shown in Figure 2.

Among this population, seventeen patients died, mostly due to exsanguination (10 out of 17 patients). The clinical characteristics of the survival and non-survival groups are shown in Table 1.



OR=operating room

Figure 1 Definition of time variables

Table 1 Clinical characteristics of the study patients

Variables	Survived (n=48)	Non-survived (n=17)	Total (n=65)	p-value
Age–years, median (IQR)	33 (23.8, 52)	27 (20, 44)	32 (23, 51)	0.366
Gender, n (%)				0.348
Male	37 (77.1)	11 (64.7)	48 (73.8)	
Underlying disease, n (%)	10 (20.8)	4 (23.5)	14 (21.5)	1
CVA	1 (2.1)	0 (0.0)	1 (1.5)	1
DLP	0 (0.0)	1 (5.9)	1 (1.5)	0.262
HT	3 (6.2)	3 (17.6)	6 (9.2)	0.179
DM	2 (4.2)	3 (17.6)	5 (7.7)	0.107
Others	8 (16.7)	0 (0.0)	8 (12.3)	0.099
Mechanism of injury, n (%)				0.198
Blunt	33 (68.8)	15 (88.2)	48 (73.8)	
Penetrating	15 (31.2)	2 (11.8)	17 (26.2)	
Cause of injury, n (%)				0.299
MVC	7 (14.6)	3 (17.6)	10 (15.4)	
MCC	23 (47.9)	11 (64.7)	34 (52.3)	
AVP	2 (4.2)	0 (0.0)	2 (3.1)	
GSW	5 (10.4)	1 (5.9)	6 (9.2)	
SW	7 (14.6)	0 (0.0)	7 (10.8)	
Fall	1 (2.1)	2 (11.8)	3 (4.6)	
Assault	3 (6.2)	0 (0.0)	3 (4.6)	
ISS*	20.8 (10.5)	37.8 (16.6)	25.2 (14.4)	<0.001
ISS <25, n (%)	34 (70.8)	4 (23.5)	38 (58.5)	
ISS ≥25, n (%)	14 (29.2)	13 (76.5)	27 (41.5)	
Shock[Ψ], n (%)	21 (43.8)	14 (82.4)	35 (53.8)	0.014
Initial GCS score[†], n (%)				0.002
<15	14 (29.2)	13 (76.5)	27 (41.5)	
15	34 (70.8)	4 (23.5)	38 (58.5)	
TAC activation[‡], n (%)	39 (81.2)	16 (94.1)	55 (84.6)	0.270
Abdominal signs, n (%)	37 (77.1)	12 (70.6)	49 (75.3)	0.517

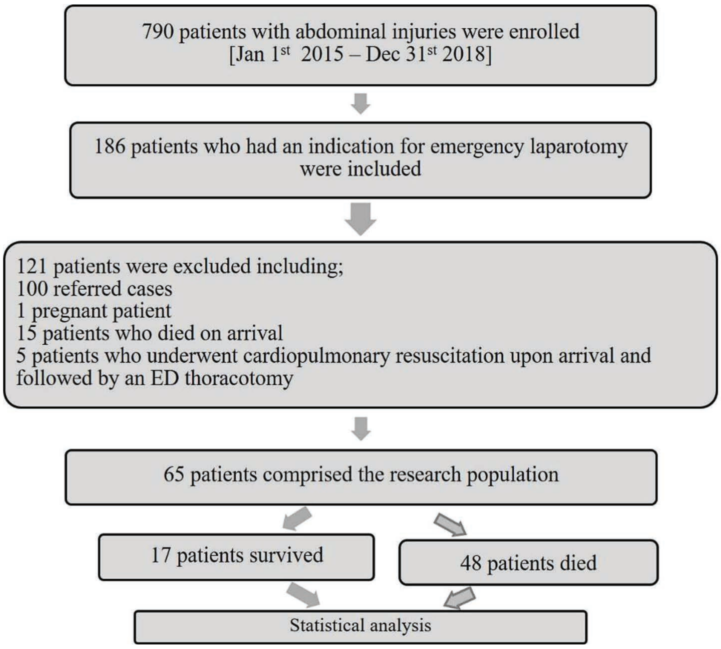
CVA=cerebrovascular accident, DLP=dyslipidemia, HT=hypertension, DM=diabetes mellitus, MVC=motor vehicle crash, MCC=motorcycle crash, AVP=auto versus pedestrian, Fall=fall from height, GSW=gunshot wound, IQR=interquartile range, SW=stab wound, ISS=injury severity score, TAC=trauma team activation criteria

*ISS: the sum of the square of the three maximum AIS scores, with higher scores indicating a higher severity especially when ISS >25

†Initial GCS score: the first Glasgow Coma Scale score recorded at the ED (range from 3 to 15, with lower scores indicating traumatic brain injury)

ΨShock: defined as one or more of the following initial signs recorded at the Emergency department (ED): heart rate (HR) >120/min, systolic blood pressure (SBP) <90mmHg, shock index (SI) ≥0.9, and/or massive transfusion protocol (MTP) activation

‡TAC: systolic blood pressure <90 mmHg, gunshot wound
at chest, abdomen, or back, stab wound at chest or abdomen, arrest, respiratory rate <12/min or >30/min, pulse rate>120/min (post-fluid resuscitation >2L), FAST positive, GCS≤8, and/or evidence of pelvic fracture or long bone fracture with systolic blood pressure <90 mmHg. (all parameters as recorded initially at the ED)



ED=Emergency department

Figure 2 Study flow chart

The median patient age was 32 years, with a range from 15 to 91 years. Abdominal injuries were more common in male patients, with 48 cases (73.8%) vs. 17 cases (26.2%) in female patients, and mostly caused by a blunt mechanism (73.8%). The three most common causes of abdominal injury were motorcycle crashes (52.3%), motor vehicle crashes (15.4%), and stab wounds (10.8%). The baseline clinical characteristics of the survival and non-survival groups were similar, except for ISS, patients with shock, and patients with a GCS score lower than 15. Non-survival patients had a higher average ISS and 76.5 percent of those had an ISS of 25 and higher. Additionally, patients with shock and/or lower GCS scores were more likely to be in the non-survival group.

There were 38 patients (58.4%) who underwent a damage-control laparotomy. Among the 17 non-survival patients, fifteen patients (88.2%) had a solid organ injury which showed a statistically significant difference from the survival group (p-value=0.038). All of the non-survival patients had complications. The two most common and statistically significant complications that led to death were exsanguination (94.1 percent of non-survival patients) and DIC or coagulopathy (82.4 percent of non-survival patients).

The median time-to-operation was 165 minutes, with a maximum of 480 minutes and a minimum of 55 minutes. The time-to-operation consisted of three periods: pre-hospital time (maximum of 88 minutes), time of decision to operation (maximum of 367 minutes), and time to diagnosis (maximum of 224 minutes). Surprisingly, patients who had a longer time of decision to operation had a lower mortality rate with statistical significance (p-value=0.037), but there was no statistically significant correlation between time-to-operation and mortality, as shown in Table 2.

Also, the patients for whom took a longer time of decision to operation had a statistically significantly greater chance of surviving the first 24 hours (p-value=0.006).

However, time-to-operation did not impact the 24-hour mortality, as shown in Table 3.

In univariable analysis, there were statistically significant associations between in-hospital mortality and several factors, as presented in Table 4.

Patients who had in-hospital mortality were more likely to have a higher ISS (OR 1.1, p-value<0.001, 95% CI 1.04, 1.16), especially an ISS of 25 and above (OR 6.59, p-value=0.031, 95% CI 0.8, 54.56). Patients with a GCS score lower than 15 were more likely to be in the non-survival group (OR 7.89, p-value<0.001, 95% CI 2.19, 28.44). Patients with shock had a higher in-hospital mortality rate (OR 6, p-value=0.004, 95% CI 1.52, 23.64). The preoperative laboratory investigations showed that acidosis, defined as arterial pH <7.35, arterial bicarbonate (AHCO3) <20 mEq/L, or venous bicarbonate (VHCO3) <20 mEq/L had statistically significant associations with in-hospital mortality (OR 14.72, p-value<0.001, 95% CI 1.81, 119.94). Intraoperative factors that had a statistically significant impact on in-hospital mortality were the lowest intraoperative SBP <90mmHg, the highest intraoperative HR >120/min, and higher estimated blood loss. Each additional 500mL of intraoperative blood loss was associated with a 17% increase in the in-hospital mortality rate. Non-survival patients were more likely to have undergone a damage control laparotomy and have had excessive fluid resuscitation and blood transfusion at the ED.

After designating the preoperative variables affecting in-hospital mortality, multivariable analysis was performed and revealed 3 factors that were associated with in-hospital mortality: ISS (adjusted OR 1.09, p-value=0.002, 95% CI 1.02, 1.16), patients with shock (adjusted OR 12.73, p-value=0.008, 95% CI 1.43, 113.49), and patients with a GCS score <15 (adjusted OR 15.43, p-value=0.004, 95% CI

Table 2 Effect of time on in-hospital mortality

Time variables	Survival (n=48)	Non-survival (n=17)	p-value
Time-to-operation (minutes), median (IQR)	172.5 (109.2, 202.8)	145 (90, 172)	0.139
Pre-hospital time (minutes), median (IQR)	30 (25, 38)	30 (18, 30)	0.162
Time to diagnosis (minutes), median (IQR)	56 (15.8, 101.5)	51 (40, 85)	0.777
Time of decision to Operation (minutes), median (IQR)	62 (41.5, 97.2)	46 (25, 60)	0.037
Emergency department Length of stay, median (IQR)	144 (71, 172.8)	113 (65, 140)	0.256
OR preparation time (minutes), median (IQR)	4 (2, 5)	5 (2, 5)	0.757

OR=operating room, IQR=interquartile range

Table 3 Effect of time on 24-hour mortality

Time variables	Survival within first 24 hours (n=53)	Non-survival (n=12)	p-value
Time-to-operation (minutes), median (IQR)	175 (110, 202)	140 (85.5, 165)	0.067
Pre-hospital time (minutes), median (IQR)	30 (25, 38)	25 (19.5, 30)	0.192
Time to diagnosis (minutes), median (IQR)	52 (18, 93)	57 (34.5, 87.2)	0.612
Time of decision to Operation (minutes), median (IQR)	64 (42, 104)	37 (24.8, 54.8)	0.006
Emergency department Length of stay, median (IQR)	145 (73, 175)	108.5 (53.2, 139.2)	0.096
OR preparation time (minutes), median (IQR)	4 (2, 5)	5 (2, 5)	0.596

OR=operating room, IQR=interquartile range

1.95, 122.11). Time-to-operation did not impact in-hospital mortality, as shown in Table 5.

For the secondary outcomes, Spearman's rank correlation test was used to evaluate the relations between time-to-operation and hospital length of stay (days) and ICU-free days (days). The results showed no statistically significant impact of time-to-operation on hospital length of stay (S=37894, p-value=0.1709) or ICU-free days (S=37054, p-value=0.129). Furthermore, subgroup analysis found no statistically significant relations between time-to-operation and hospital length of stay (days) (S=17307, p-value=0.6823, rho=0.06) or complications (p-value=0.477).

Table 4 Univariable analysis of variables affecting in-hospital mortality

Variables	OR	95% CI	p-value
Time to operation (minutes)	0.993	0.99, 1.00	0.079
Time to diagnosis (minutes)	0.998	0.99, 1.01	0.706
ISS	1.1	1.04, 1.16	<0.001
ISS ≥25	6.59	0.8, 54.56	0.031
GCS score <15[†]	7.89	2.19, 28.44	<0.001
TAC activation, n (%)	3.69	0.43, 31.58	0.171
Tachycardia (initial HR>120/min), n (%)	3.03	0.91, 10.15	0.074
Hypotension (initial SBP<90mmHg), n (%)	0.5	0.08, 3.28	0.482
MTP activation, n (%)	20.17	4.84, 84.04	<0.001
SI* ≥0.9, n (%)	2.86	0.92, 8.91	0.067
Shock[‡], n (%)	6	1.52, 23.64	0.004
Presence of abdominal signs, n (%)	1.08	0.25, 4.56	0.919
Presence of blood adjunct to the primary survey (NG/Foley/DRE), n (%)	1.7	0.54, 5.36	0.369
Excessive fluid resuscitation and blood transfusion at ED[¶], n (%)	38.86	4.69, 321.78	<0.001
Intraoperative vital signs			
Lowest SBP <90mmHg, n (%)	11.43	1.4, 93.33	0.003
Highest HR >120/min, n (%)	14	3.43, 57.21	<0.001
Estimated blood loss (mL)	1.17	1.07, 1.27	<0.001
Chest tube placement, n (%)	2.99	0.93, 9.60	0.067
Pelvic fracture stabilization, n (%)	4.93	0.75, 32.51	0.095
Anemia (Hb <10 or Hct <30), n (%)	6.27	0.53, 74.07	0.131
Coagulopathy (aPTT ratio ≥3.3 or INR ≥1.5), n (%)	0.34	0.02, 5.76	0.465
Acidosis (pH<7.35, $AHCO_3$ or $VHCO_3$<20), n (%)	14.72	1.81, 119.94	<0.001
Base deficit, n (%)	2.33	0.22, 24.92	0.461
Hemoperitoneum (presence of blood in abdominal/pelvic cavity), n (%)	0.87	0.15, 4.98	0.879
FAST (reference=negative)			0.003
Positive, n (%)	0.33	0.09, 1.25	
Equivocal, n (%)	9.17	0.86, 97.69	
Pelvic fracture, n (%)	3.38	0.74, 15.44	0.121
Intraoperative cardiac arrest, n (%)	3.21	0.58, 17.75	0.188
Damage control laparotomy, n (%)	4.67	1.19, 18.35	0.016

OR=odds ratio, CI=confidence interval, ISS=injury severity score, AHCO3=arterial bicarbonate, GCS score=glasgow coma scale score, VHCO3=venous bicarbonate, FAST=focused assessment with sonography in trauma, TAC=trauma team activation criteria, HR=heart rate, SBP=systolic blood pressure, MTP=massive blood transfusion protocol, NG=nasogastric catheter, DRE=digital rectal exam, Hb=hemoglobin, Hct=hematocrit, aPTT=activated partial thromboplastin time, INR=international normalized ratio, SI=shock index

[¶]Excessive fluid resuscitation and blood transfusion at ED defined as crystalloids ≥2000mL, packed red cells ≥2 units, fresh frozen plasma ≥2 units, platelet concentration ≥6 units, or cryoprecipitate ≥10 units

[†]GCS score=glasgow coma scale score, *shock index is initial HR divided by initial SBP

[‡]Shock: patients with tachycardia, hypotension, needed MTP activation

Table 5 Multivariable analysis of the preoperative variables affecting in-hospital mortality

Preoperative variables	Adjusted OR	95% CI	p-value
Time to operation (minutes)	0.99	0.97, 1.00	0.081
ISS	1.09	1.02, 1.16	0.002
Shock‡	12.73	1.43, 113.49	0.008
Age-years, median (IQR)	1.02	0.97, 1.07	0.510
Gender, n (%)	5.67	0.66, 49.00	0.095
GCS score† <15, n (%)	15.43	1.95, 122.11	0.004

OR=odds ratio, 95% CI=95% confidence interval, ISS=injury severity score, IQR=interquartile range, †GCS score=Glasgow Coma Scale scores ranged from 3 to 15, lower scores indicating traumatic brain injury, ‡Shock=patients with tachycardia, hypotension, needed MTP activation

Discussion

It is not controversial to assume that trauma patients who receive a door-to-door laparotomy should have better outcomes and lower mortality. However, a direct correlation between time-to-operation and mortality is difficult to demonstrate. According to the previous study, among patients with a positive Focused Assessment with Sonography in Trauma (FAST) requiring an emergent laparotomy, delays in operations were associated with increased early (in the first 24 hours) and late (within 30 days) in-hospital mortality (HR for every 10 minutes increase 1.50, CI 1.14-1.97, p-value=0.003), as shown by Barbosa et al[12]. Also, increased time from a FAST examination to the operation had a statistically significant impact on increased in-hospital mortality. In another study, Clarke et al.[10] showed that increased total time (to the ED and in the ED) was significantly associated with higher mortality for the interval 61 to 90 minutes in hypotensive trauma patients who underwent laparotomy. Unexpectedly, Nayduch D et al.[13] reported that four of the audit filters, without intubation, laparotomy >2 hours, transfer >6 hours, and admission to non-surgical service, had significantly better outcomes and lower mortality than their non-indicator counterparts. In other studies on penetrating injuries, Hoyt et al.[9] and Meizoso et al.[8] found increased mortality in patients with delayed operations.

In this study, the most common mechanism and cause of injury were blunt abdominal injury (73.8%) and motorcycle crash (52.3%), respectively. Distinct from previous studies, our study intentionally collected more than 120 variables to control for confounders that are known to affect mortality. The results indicated that patients who did not survive had a higher ISS, lower GCS score, and signs of shock which included initial SBP <90mmHg, initial HR >120/min, initial SI ≤0.9, and/or need of MTP activation with statistically significant differences.

Contrary to previous studies, time-to-operation did not significantly impact in-hospital mortality, even in the multivariable analysis. Then, subgroup analysis was conducted on the patients with shock, as other studies have shown an interest in hypotensive trauma patients, but found no significant impact on in-hospital mortality. These results could be attributed to the small number of patients in our study and the fact that all of these patients were less severely injured and responded well to resuscitation. In our study, various factors, such as HR and SBP were not continuously recorded after resuscitation, which could predict the responsiveness of the population. The patients who had a longer time of decision to operation were more likely to survive and survive for 24 hours with statistically significant differences. This could be explained by an indication bias, meaning that trauma surgeons tend to rapidly decide to start an operation sooner in patients with more severe injuries who are more likely to die. To overcome this problem, we suggest a randomized controlled trial to eliminate this indication or selection bias. The notable limitation of this study was the small sample size, which may have led to non-significant results regarding mortality.

Conclusion

There were no statistically significant impacts on time-to-operation on in-hospital and 24-hour mortalities of patients with abdominal injury who underwent door-to-door laparotomy. Patients with higher ISS, signs of shock, and/or GCS scores lower than 15 had higher in-hospital mortality. Trauma patients with those three factors should be deliberately resuscitated and treated to decrease in-hospital mortality from abdominal injuries.

Conflict of interest

The authors declare no conflicts of interest and no financial support in this study.

References

1. World Health Organization (WHO). Injuries and violence. [monograph on the Internet]. Geneva: WHO Agency; 2018 [cited 2020 Jan 15]. Available from: https://www.who.int/violence_injury_prevention/key_facts/en/
2. Office of the National Economic and Social Development Council (NESDC). Number and death rate per 100,000 population [homepage on Internet]. Coventry: NESDC; 2020 [cited 2020 Jan 15]. Available from: http://social.nesdc.go.th/SocialStat/StatReport_Final.aspx?reportid=367&template=1R2C&yeartype=M&subcatid=15
3. American College of Surgeons. Advanced trauma life support: student course manual. 10th ed. Chicago: Illinoids; 2018.
4. Shackford SR, Mackersie RC, Holbrook TL, Davis JW, Hollingsworth-Fridlund P, Hoyt DB, et al. The epidemiology of traumatic death. A population-based analysis. Arch Surg 1993;128:571-5.
5. Jencks SF, Williams MV, Coleman EA. Rehospitalizations among patients in the Medicare fee-for-service program. N Engl J Med 2009;360:1418-28.
6. Sharma OP, Oswanski MF, Singer D. Role of repeat computerized tomography in nonoperative management of solid organ trauma. Am Surg 2005;71:244-9.
7. Bhangu A, Nepogodiev D, Lal N, Bowley DM. Meta-analysis of predictive factors and outcomes for failure of non-operative management of blunt splenic trauma. Injury 2012;43:1337-46.
8. Meizoso JP, Ray JJ, Karcutskie CAt, Allen CJ, Zakrison TL, Pust GD, et al. Effect of time to operation on mortality for hypotensive patients with gunshot wounds to the torso: The golden 10 minutes. J Trauma Acute Care Surg 2016;81:685-91.
9. Hoyt DB, Shackford SR, McGill T, Mackersie R, Davis J, Hansbrough J. The impact of in-house surgeons and operating room resuscitation on outcome of traumatic injuries. Arch Surg 1989;124:906-9.
10. Clarke JR, Trooskin SZ, Doshi PJ, Greenwald L, Mode CJ. Time to laparotomy for intra-abdominal bleeding from trauma does affect survival for delays up to 90 minutes. J Trauma 2002;52:420-5.
11. Remick KN, Schwab CW, Smith BP, Monshizadeh A, Kim PK, Reilly PM. Defining the optimal time to the operating room may salvage early trauma deaths. J Trauma Acute Care Surg 2014;76:1251-8.
12. Barbosa RR, Rowell SE, Fox EE, Holcomb JB, Bulger EM, Phelan HA, et al. Increasing time to operation is associated with decreased survival in patients with a positive FAST examination requiring emergent laparotomy. J Trauma Acute Care Surg 2013;75:S48-52.
13. Nayduch D, Moylan J, Snyder BL, Andrews L, Rutledge R, Cunningham P. American College of Surgeons trauma quality indicators: an analysis of outcome in a statewide trauma registry. J Trauma 1994;37:565-73.