Effects of Rapid Response Trauma Team in Thoracic Injuries in Northern Trauma Center Level I

Kaweesak Chittawatanarat MD, PhD, FRCST*,
Chagkrit Ditsatham MD*, Kamtone Chandacham MD, FRCST*,
Tidarat Jirapongcharoenlap MD, FRCST*, Narain Chotirosniramit MD, FRCST*

** Department of Surgery, Faculty of Medicine, Chiang Mai University, Chiang Mai, Thailand*

Background and Objective: *Associated thoracic injury is the first priority at the initial assessment and its outcomes are time-dependent. Faculty of Medicine, Chiang Mai University organized a rapid response trauma team (RRTT) at mid-year 2006. The aims of this present paper were to report the effects of RRTT regarding outcomes of thoracic injury.*
Material and Method: *We performed a retrospective review for admitted thoracic injury patients between January 2004 and September 2009. The interval prior to July 2006 was defined as "before RRTT" and the latter as "after RRTT". The severity-adjusted mortality was calculated.*
Results: *During the 69 months, 951 patients were included (427 in "before RRTT", 524 in "after RRTT"). Although the severity injury score (ISS) was significantly lower before RRTT, the severe trauma patients (ISS >15) had a significantly higher mortality (25.3% vs. 15.3%; p = 0.01). RRTT significantly improved the mortality odds ratio in the overall and severe trauma [0.39 (0.22-0.68); p<0.01 and 0.43 (0.25-0.73); p<0.01]. Subgroup analysis found to have positive effects with the RRTT in maxillofacial, head, and orthopedics associated injuries.*
Conclusion: *RRTT for thoracic injuries in the tertiary level I trauma center could decrease the severity-adjusted mortality, especially in severe trauma patients.*

Keywords: *Rapid response trauma team, Mortality, Thoracic injury, Severe trauma*

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Injury associated with thoracic trauma is an important cause of mortality and is considered as a first priority management in poly-trauma patients. Many patients with thoracic trauma die after reaching the hospital. Many of these deaths could be prevented with prompt diagnosis and treatment[1]. Timing and precise decision-making are key factors for reducing this mortality. In addition, mortality rate could be changed through the trauma center designations, which have better outcomes in specific types of severe injuries in higher trauma levels[2]. Although the activation of a trauma team by a three-tier system with pre-hospital triage criteria have been established in developed countries, there are many limitations in developing countries due to fewer personnel resources[3].

With limitations, our trauma center has developed a rapid response trauma team (RRTT) that featured trauma surgical residents and a trauma-attending physician to facilitate all admitted and severe trauma patients. The authors hypothesized that early and prompt management after team establishment should improve the outcome in highly time dependent injuries especially associated thoracic trauma. Therefore, the purpose of this present paper was to report the effects of a trauma team on these types of injury.

Correspondence to:
Chittawatanarat K, Department of Surgery, Faculty of Medicine, Chiang Mai University, Chiang Mai 50200, Thailand.
Phone: 053-945-533, Fax: 053-946-139
E-mail: kchittaw@gmail.com

Material and Method

Study design and time selection

The authors conducted a retrospective observation study of consecutive trauma patients admitted to a single tertiary university based level I trauma center between January 2004 and September 2009. The study was divided into "before" and "after" the establishment of a rapid response trauma team (RRTT). The period of time before an established RRTT (Before RRTT group) was between January 2004 and the end of June 2006. The rapid response trauma team (After RRTT group) was followed between July 2006 and the end of September 2009. The Chiang Mai University Ethic Committee approved this present.

Our medical institute is a tertiary referral center in the northern region of Thailand that primarily covers nine provinces in the northern region, which includes a population of more than 6 million. The hospital is an academic teaching hospital with 1,375 beds in all specialties and is a level I trauma center in Thailand with more than 2,500 trauma admissions a year and more than 15,000 emergency trauma annual visits.

Development of rapid response trauma team activation (RRTT)

The traditional trauma transferring system at the scene or patient delivery from community hospital to the referral hospital before the establishment of the RRTT was to notify the on-duty general surgical team after the patient arrived at the hospital. This method had a lack of pre-hospital communication. The pre-hospital care personals were not well organized and trained. The hospital administration established and started the RRTT in July 2006. The criteria for team activated RRTT were patients with cardiac arrest or history of cardiopulmonary resuscitation, hypotension or blood pressure drop at the scene, difficult airway management, Glasgow's Coma score <8, suspected cervical spine injury or neurological deficit, pelvic fracture, all blunt or penetrating injuries of the abdomen, chest, and neck and vascular injury, electrical injury, pediatric injury, pregnancy, severe soft tissue injury, and multiple injuries. All trauma patients meeting the criteria were directed to in-house trauma residents and consultation staff from the pre-hospital period or upon the patient's arrival to the hospital by local radio transistor or mobile phone 24-hour services from the calling center. The team would appear at the emergency room within five minutes. In case of severe traumatized patients and pre-hospital notification, the team would wait and be available at the emergency department before the patient's arrival. In addition, the team also evaluated all admitted trauma patients with less severe injuries at the emergency department.

Selection of participants

All of the associated thoracic injured patients who were admitted to the hospital between January 2004 and September 2009 were reviewed from the hospital data bank and trauma registry. The authors collected the age, gender, date of admission and discharge, mechanism of injuries, character of injuries, associated organ injuries, and admission severity of disease, which was measured by the Injury Severity Score (ISS). In addition, the mechanism of injuries and all procedures during the admission were recorded. ISS were collected and verified by one well-trained doctor and uncertain score were discussed. The primary outcome was all causes of in-hospital mortality and secondary outcomes were in-hospital complications. Multiple or severe trauma patients are defined by an ISS score >15[4-6].

Data was analyzed by STATA software (version 11.0, STATA Inc., College Station, TX). All continuing variable data were tested for normal distribution with visual inspection of histogram and Shapiro Wilk W test and reported as mean ± SD if it had normal distribution or median (25-75 inter-quartile range [IQR]) for non-parametric distribution. Group differences were calculated using Student's t-test for normal distributed continuous variables, Mann-Whitney U test for nonparametric continuous variables and Pearson's Chi-square for categorical variables, except when small size required the use of Fisher's exact test. Severity of injury was controlled in the analysis model by binary logistic regression for binary outcome variable.

The authors designed subgroup analysis to compare patients in severe-trauma patient. The groups were based on age, which was divided into three groups (<30, 30-60 and >60 year), mechanism of injury, and associated organ injuries. Differences were considered to be statistically significant when $p<0.05$.

Results

During the 69-months of the study period, 976 patients were admitted with associated thoracic injury and reviewed. The authors excluded 25 patients due to unavailable admission case records. Nine hundred fifty one patients were included and analyzed. These patients were divided into two groups, 427 patients admitted during the 30 months before RRTT group and 524 patients admitted during the 39 months after RRTT group.

During all observation periods, male was the predominant gender (82.6%) with the average age 39.9±17.0 years. The age pattern was similar in both periods (Table 1). The median ISS (IQR) in the after RRTT group was significantly higher than in the before RRTT group [14 (16) vs. 10 (11); $p<0.01$]. Motorcycle accident was the most common mechanism of injuries in our series. The trend of mechanisms of injuries altered overtime. There was a decrease of blunt injury rate due to motorcycle accident (55.0% vs. 43.3%; $p<0.01$) with a significant increase of penetrating

Table 1. General character of thoracic injuries (n = 951)

	All (n = 951)	Before (n = 427)	After (n = 524)	p-value
General aspects				
Age [mean (SD)]	39.9 (17.0)	39.1 (16.7)	40.6 (17.3)	0.18
<30 years (%)	313 (32.9)	151 (35.3)	162 (30.9)	
30-60 years (%)	521 (54.8)	226 (52.8)	295 (56.2)	0.36
>60 years(%)	117 (12.3)	50 (11.9)	67 (12.9)	
Gender (male:female)	786:165	353:74	433:91	<0.01
Injury severity score [median (IQR)]	14 (13.0)	10 (11.0)	14 (16.0)	<0.01
ISS ≤15 (%)	544 (57.8)	267 (63.3)	277 (53.4)	<0.01
ISS >15 (%)	397 (42.2)	155 (36.7)	242 (46.6)	
Character of injury				
Thoracic soft tissue injuries	145 (15.3)	75 (17.6)	70 (13.4)	0.07
Thoracic vertebral and cord injuries	37 (3.9)	13 (3.0)	24 (4.6)	0.22
Rib fracture(s)	591 (62.2)	264 (61.8)	327 (62.4)	0.86
Flail chest	50 (5.1)	21 (4.7)	29 (5.5)	0.53
Thoracic great vessels injury	33 (3.5)	13 (3.4)	20 (3.8)	0.51
Other thoracic vessels injury	11 (1.2)	7 (1.6)	4 (0.8)	0.21
Heart injury	37 (3.9)	17 (4.0)	20 (3.8)	0.90
Pneumothorax	139 (14.6)	53 (12.4)	86 (16.4)	0.08
Hemothorax	193 (20.3)	85 (19.9)	108 (20.6)	0.79
Pneumohemothorax	135 (14.2)	48 (11.2)	87 (16.6)	0.02
Lung contusion	88 (9.3)	33 (7.7)	55 (10.5)	0.14
Large airway injury	6 (0.6)	3 (0.7)	3 (0.6)	0.80
Multiple thoracic organ injury	45 (4.7)	19 (4.5)	26 (5.0)	0.71
Other thoracic injury	13 (1.4)	8 (1.9)	5 (1.0)	0.23
Associated organ injury				
Maxillofacial injury	90 (9.5)	44 (10.3)	46 (8.8)	0.42
Head injury	159 (16.7)	52 (12.2)	107 (20.4)	<0.01
Neck injury	39 (4.1)	16 (3.8)	23 (4.4)	0.62
Abdominal injury	217 (22.8)	73 (17.1)	144 (27.5)	<0.01
Orthopedics upper extremity injury	264 (27.8)	94 (22.0)	170 (32.4)	<0.01
Orthopedics lower extremity injury (include pelvis)	110 (11.6)	48 (11.2)	62 (11.8)	0.77

injuries from firearms (0.4% vs. 3.8%; p<0.01). The first five most common characteristics of injuries were rib(s) fracture, hemothorax, thoracic soft tissue injuries, pneumothorax, and peumohemothorax respectively. These were comparable between before and after RRTT except for a significant increase in pneumohemothorax (Table 1).

The most common organ injuries with associated thoracic injuries in our series were orthopedics upper extremity, abdominal injury, and head injury respectively. These significantly increased over time when compared between the two periods. Maxillofacial injury and lower extremity injury associated with thoracic injury occurred nearly 10%. There was no difference between the groups (Table 1).

Intercostal drainage (ICD) was the most common procedure and had a higher trend in the after RRTT group (156 [36.5%] vs. 221 [42.2%]; p = 0.08). After RRTT, the authors frequently performed clampshell of thoracic procedure (2 [0.2%] vs. 9 [1.7%] p = 0.03; mortality 1/1 in before RRTT, 3/9 in after RRTT; p = 0.22) as well as laparoscopic examination for abdominal associated injury (9 [2.1%] vs. 22 [4.2%]; p = 0.07). Furthermore, frequently, after RRTT had to do bronchoscopic examination (2 [0.5%] vs. 9 [1.7%]; p = 0.07), video-assisted thoracotomy (1 [0.2%] vs. 5 [1.0%]; p = 0.10), and aortic stent graft (0 [0%] vs. 4 [0.8%]; p = 0.13). Over the 39-month period, the authors performed seven ERT (1 in the before and 6 in the after group). All were penetrating injuries. No patient survived in the before group and half of the patients survived in the after RRTT group.

The crude overall mortality is nearly 9%. Although there were comparable ISS in non-surviving patients in our series (Table 2), there was a tendency for a decrease in crude mortality after RRTT

Table 2. Mortality and complications

	All (n = 951)	Before (n = 427)	After (n = 524)	p-value
Mortality				
Crude mortality rate (%)	83 (8.8)	45 (10.6)	38 (7.3)	0.07
Gender (male:female)	72:11	40:5	32:6	0.53
Age [mean (SD)]	38.7 (16.3)	37.7 (15.5)	39.7 (17.4)	0.59
Injury severity score [median (IQR)]	29 (12.0)	29 (13.0)	30 (15.0)	0.10
ISS ≤15 (%)	3 (0.6)	3 (1.1)	0 (0)	0.08
ISS >15 (%)	76 (19.2)	39 (25.3)	37 (15.3)	0.01
Complications				
Pulmonary complications	31 (3.3)	15 (3.5)	16 (3.1)	0.69
Urinary tract complication	18 (1.9)	5 (1.2)	13 (2.5)	0.14
Hematologic complication	59 (6.1)	29 (6.8)	29 (5.5)	0.42
Hepatic failure	3 (0.3)	0 (0)	3 (0.6)	0.12
Cardiac complication	8 (0.8)	3 (0.7)	5 (1.0)	0.68
Neurological complication	14 (1.5)	8 (1.9)	6 (1.2)	0.35
Other sepsis	11 (1.2)	3 (0.7)	8 (1.5)	0.24

ISS = injury severity score

(10.6% vs. 7.3%; p = 0.07). However, the authors found a significant decrease in mortality in the subgroup of severe trauma patient with ISS >15 (25.3% vs. 15.3%; p = 0.01) (Table 2). Even though there was no statistical significance of mortality in patient with ISS ≤15, three patients died in before group while no patient died in the after group. One patient died from delayed detection of occult pneumothorax and developed a tension pneumothorax after admission. The second one died from a progression of intracranial pathology and the last one died from undetected myocardial infarction after injury.

The most common complications that followed thoracic injury were hematologic (including hemorrhage and coagulopathy), pulmonary, and urinary complication respectively (6.1, 3.3, and 1.9% respectively) (Table 2). Although hematologic and neurological complications were slightly higher in before RRTT group, there were no statistically significant differences between groups of these complications.

The authors analyzed the predicted model of mortality probability by logistic regression with increment in ISS and demonstrated in Fig. 1. In our model, the predictability line initially separated about ISS >15 and finally joined together around ISS >60 by visual observation. Of these predicted models, at 50% of mortality, the after RRTT group had a higher ISS than all and before RRTT group (ISS [95% confidence interval; CI] in before, all, and after RRTT: 35.5 [25.9-45.1], 40.2 [30.0-50.4], and 42.9 [31.7-54.1] respectively).

For subgroups analysis, in Fig. 2, odds ratio (OR) of mortality of RRTT in subgroup patients had significant protective effects in overall severity as well as in severe trauma patients [OR 0.39 (0.22-0.68); p<0.01 and 0.43 (0.25-0.73); p<0.01 respectively]. In analysis of RRTT effects after being adjusted by ISS, although significantly lower in the overall age, the effect was significantly different only in the age group between 30 and 60 years (OR 0.33 [0.16-0.68]; p<0.01). The male gender had a lower risk of mortality than females after RRTT in our series (OR 0.35 [0.19-0.64]; p<0.01). The effect of RRTT for types of injuries had beneficial effects only in rib

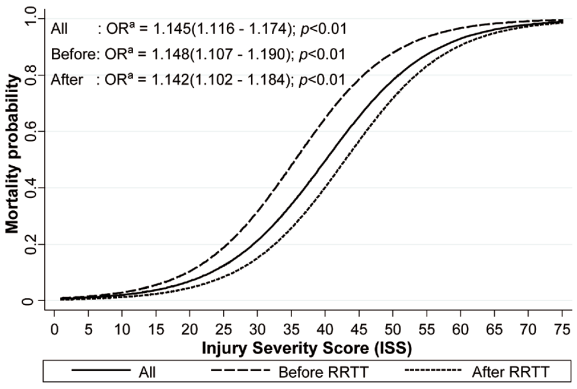

Fig. 1 Mortality probability and injury severity score (ISS) before and after RRTT.
[a] Odds ratio (95% confidence interval) of mortality alteration in each ISS increment of all, before and after RRTT.
OR = odds ratio; RRTT = rapid response trauma team

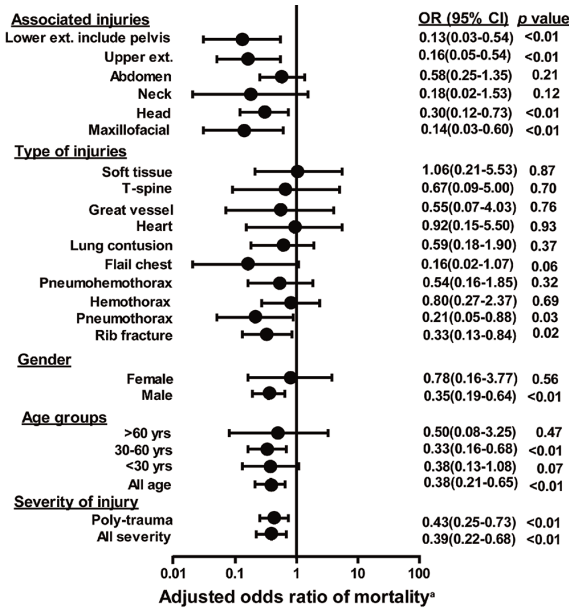

Fig. 2 Adjusted odds ratio of mortality in each subgroup. [a] Odds ratio were adjusted by injury severity score. 95% CI = 95% confidence interval; ext. = extremity(s); T-spine = thoracic spine(s); yrs = years

fracture and pneumothorax. Associated orthopedics injuries (upper and lower extremities), head injury, and maxillofacial injury had improved outcomes after RRTT implementation (Fig. 2).

Discussion

In general aspects of thoracic injury, our study demonstrated a significant proportion mechanisms occurring from blunt injury. These differed from the western series that reported less than 10% in all admitted trauma patients[7]. However, our series showed a significant increase of penetrating injury from firearms between the two periods. This might be explained by the alteration of socioeconomic and life style during rapid growth of our country. Clamshell thoracotomy was performed to access the bilateral thoracic cavity as well as the mediastinum. There was no statistical difference in the mortality in this subgroup. All patients died (1/1) in the before RRTT and only one-third mortality (3/9) in the after RRTT. In addition, there was an increasing tendency to insert intercostal drainage, bronchoscopy, emergency thoracotomy (ERT), sternotomy, tracheostomy, and angio-embolization. A greater number of ERT was performed in the after RRTT group and about half of the patients survived, which is comparable to the ERT of Aihara et al series[8].

The injury severity was assessed by the injury severity score (ISS)[9]. Although there were controversial points to define severe injury that ranged from 12 to 25[10,11]. Most of the studies defined severe-trauma ISS cut-point as more than 15[2,4,12]. At the after RRTT period, the admitted trauma patient had a significantly higher proportion of severe-trauma (ISS median [IQR]: 10 [11] vs. 14 [16]; $p<0.01$). This phenomenon might have occurred by improving the transfer system or high severity injury mechanisms. Although it was hard to compare crude mortality between two periods because the ISS significantly increased in after RRTT, the overall crude mortality tended to decease after RRTT (10.3% vs. 7.3%; $p = 0.07$). These effects showed the difference in severe-trauma patients, which statistically decreased in crude mortality rate after RRTT (25.3% vs. 15.3%; $p = 0.01$). To reduce the injury severity effects on mortality after RRTT, multivariable logistic regression analysis were performed. There were significantly decreased on the adjusted odds ratio of all severity injury as well as poly trauma patients (Fig. 2).The authors also analyzed the mortality probability model (Fig. 1). Of these, the authors found a shift to the right of the probability curve after RRTT that meant less mortality probability at the same ISS after RRTT (Fig. 1). In addition, in each age group, RRTT had a significant protective effect with increasing age, which was predominant in age group between 30 and 60 year-old. Furthermore, it had trends in younger age. However, there was no effect in elderly people (Fig. 2). This finding was similar to a previous study showing high mortality even with minor or moderately severe injuries in elderly patients[13]. For gender subgroup, recent evidence indicated that the female gender might be a factor that plays a significant protective role in the outcome of shock, trauma, and sepsis[14]. However, RRTT had inverse effect in our subgroup analysis. While males showed a protective trend after RRTT, females' results were opposite (Fig. 2). Despite no evidence confirmation, it is probably explained by two following reasons. First, more thickness of chest wall in female might be the cause of delayed detection of thoracic injury. Second, unequal size and smaller number of female to male ratio would decrease power and precision in subgroup analysis.

For each subgroup of type and associated injuries, the authors found that head, maxillofacial, rib fracture, and pneumothorax had a significant protective effect. Furthermore, there was a tendency to decrease in flail chest patients after adjusted injury severity

(Fig. 2). These findings confirmed our hypothesis that RRTT provided a benefit on time dependent-injuries involving airway and ventilation. In addition, the positive outcome of RRTT was significantly revealed in orthopedics patients. There was a tendency in associated abdominal injuries (Fig. 2). These findings might be explained by the prompt resuscitation and management issue.

Although the authors attempted to decrease confounder effects by multivariable analysis with injury severity adjusted parameter and stratification of affected outcome variables in each subgroup, there were some inevitable limitations in this study due to the nature of retrospective before and after intervention study. First, the authors could not control the advance and progression in pharmaceutical aspects and equipment as well as physicians and nurse experiences over time, which might affect better outcomes. However, the authors endeavored to control these effects by using consecutive period and shorted study duration between before and after periods. Second, the authors controlled confounder only by adjusted injury severity. The other important physiologic scores were not completely collected in our data. Therefore, physiologic severity could not be compared between groups. Finally, our study did not collect time usage in each step after patient delivery to hospital and resource consumption. Thus, the authors could not conclude the time difference between group and economic aspect from our study.

Conclusion

RRTT for thoracic injuries in the tertiary level I trauma center could decreased the severity-adjusted mortality especially in severe trauma patients.

Acknowledgement

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Potential conflicts of interest

None.

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ผลของการก่อตั้งทีมตอบสนองต่อผู้ป่วยอุบัติเหตุอย่างรวดเร็วต่อผู้บาดเจ็บของทรวงอกในโรงพยาบาลศูนย์อุบัติเหตุระดับที่ 1 ภาคเหนือ

กวีศักดิ์ จิตตวัฒนรัตน์, จักรกริช ดิษธรรม, กำธน จันทร์แจ่ม, ธิดารัตน์ จิรพงศ์เจริญลาภ, นเรนทร์ โชติรสนิรมิต

ภูมิหลังและวัตถุประสงค์: *เนื่องจากผู้ป่วยที่ได้รับบาดเจ็บของทรวงอกจัดว่ามีความสำคัญในลำดับต้น ในการช่วยเหลือเบื้องต้นและผลการรักษาภาวะดังกล่าวเกี่ยวข้องกับระยะเวลาที่ให้การรักษา คณะแพทยศาสตร์ มหาวิทยาลัยเชียงใหม่ได้ก่อตั้งทีมแพทย์อุบัติเหตุเพื่อตอบสนองต่อผู้ป่วยอุบัติเหตุรุนแรงตั้งแต่กลางปี พ.ศ. 2549 วัตถุประสงค์ของการศึกษานี้เพื่อรายงานผลของทีมแพทย์ที่มีผลต่อการบาดเจ็บของทรวงอก*

วัสดุและวิธีการ: *คณะผู้นิพนธ์ได้ทำการเก็บเวชระเบียนย้อนหลังผู้ป่วยที่ได้รับบาดเจ็บในช่องทรวงอกตั้งแต่ เดือนมกราคม พ.ศ. 2547 ถึง เดือนกันยายน พ.ศ. 2552 ระยะเวลาก่อนเดือนกรกฎาคม พ.ศ. 2549 จัดเป็นกลุ่ม "ก่อนก่อตั้งทีม" และระยะเวลาต่อมาเป็น "หลังก่อตั้งทีม" โดยบันทึกลักษณะความรุนแรงของการบาดเจ็บและการเสียชีวิตผู้ป่วยในช่วงเวลาดังกล่าว*

ผลการศึกษา: *ระยะเวลาการศึกษา 69 เดือน ผู้ป่วยจำนวนทั้งหมด 951 ราย (427 ราย ในกลุ่มก่อนก่อตั้งทีม 524 ราย ในกลุ่มหลังก่อตั้งทีม) แม้ผู้ป่วยในกลุ่มก่อนก่อตั้งทีมมีความรุนแรงของการบาดเจ็บโดยเฉลี่ยน้อยกว่าอย่างมีนัยสำคัญ แต่ผู้ป่วยที่มีการบาดเจ็บหนักที่มีระดับคะแนน ISS มากกว่า 15 มีอัตราการเสียชีวิตสูงขึ้นอย่างมีนัยสำคัญ (25.3% vs. 15.3%; p = 0.01) โดยพบว่าการก่อตั้งทีมดังกล่าวสามารถลดความเสี่ยงต่อการเสียชีวิตลงอย่างมีนัยสำคัญ ทั้งในกลุ่มผู้บาดเจ็บทั้งหมดและกลุ่มที่มีการบาดเจ็บรุนแรง [0.39 (0.22-0.68); p<0.01 และ 0.43 (0.25-0.73); p<0.01 ตามลำดับ] ในการวิเคราะห์กลุ่มย่อยพบว่าผู้ป่วยที่มีบาดเจ็บบริเวณใบหน้า ศีรษะ และผู้ป่วยที่มีกระดูกหัก จะได้ประโยชน์สูงจากทีมดังกล่าว*

สรุป: *ทีมอุบัติเหตุที่ตอบสนองต่อผู้ป่วยบาดเจ็บทรวงอกในโรงพยาบาลศูนย์อุบัติเหตุระดับที่ 1 สามารถลดอัตราการเสียชีวิตได้โดยเฉพาะผู้ป่วยที่มีการบาดเจ็บรุนแรง*