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Original Article

# *Characters of Mortality and Time Series Analysis in Thoracic Injury Before and After Rapid Response Trauma Team Establishment*

**Kaweesak Chittawatanarat, MD, FRCST[1]**
**Chagkrit Ditsatham, MD[1]**
**Narain Chotirosniramit, MD, FRCST[1]**
**Kamtone Chandacham, MD, FRCST[1]**
**Tidarat Jirapongcharoenlap, MD, FRCS[1]**
**Patrinee Traisathit, PhD. (Biomathematics)[2]**

[1]*Department of Surgery, Faculty of Medicine, Chiang Mai University*
[2]*Department of Statistics, Faculty of Science, Chiang Mai University*

***Abstract***

***Background:*** **Severe thoracic injury is a life threatening condition and needs prompt as well as proper treatment. The Department of Surgery, Faculty of Medicine, Chiang Mai University has established the Rapid Response Trauma Team (RRTT) in July 2006. The aim of this study was to verify mortality rate alteration after setting up the RRTT.**

***Methods:*** **We performed a retrospective "before and after" designed study between January 2004 and September 2009. The month before July 2006 was defined as "before RRTT" and after was "after RRTT". Monthly mortality rate, severity injury score (ISS) and demographic data were collected.**

***Results:*** **A total of 951 patients were included [427 (30 months) in before RRTT and 524 (39 months) in after RRTT]. Of these, 83 patients (8.8%) died after admission and were analyzed for characteristics of mortality. The average age of mortality cases was 38.7 ± 16.3 years. Male was a predominant gender. The most common mechanism of injury was motor cycle accident. Although there were no difference of characters and mechanisms of injuries between two periods but patients associated with maxillofacial injury had significant lower mortality in after RRTT (28.5% vs. 10.5%; p = 0.04). The after RRTT group had a significantly higher occurrence of urinary complication and acute renal failure. The average adjusted monthly mortality rate was lower in after RRTT (9.0 ± 6.1 vs. 6.9 ± 4.0%). Time series analysis between two periods demonstrated a trend towards decrease in monthly mortality after RRTT [coefficient(95% CI) = -0.61(-1.13 to -0.23); p<0.01)].**

***Conclusion:*** **The RRTT establishment could decrease mortality rate. The protective effect was predominant in patients associated with maxillofacial injuries.**

***Key words:*** **maxillofacial injury, mortality, multiple injuries, rapid response trauma team, time series analysis, thoracic injury**

***Correspondence address :*** *Kaweesak Chittawatanarat, MD, Department of Surgery, Faculty of Medicine, Chiang Mai University, Thailand; Telephone: +66 5394 5533; Fax: +66 5394 6139; E-mail: kchittaw@gmail.com*

## Introduction

Thoracic trauma is a life threatening condition and considered as the first priority management in initial assessment period[1]. Lack of medical personnel and organized trauma system in Thailand is the important factor[2]. At midyear 2006, the authors organized the Rapid Response Trauma Team (RRTT) which featured only trauma surgical residences and trauma attending to service all admitted and poly-trauma patients. The authors hypothesized that organization team might improve patient mortality especially promptly needed injury of thoracic trauma. Therefore, the purpose of this study was to compare mortality trend and patients' characteristics between before and after RRTT settlement.

## Materials and Methods

In 2003, the Royal College Surgeons of Thailand in cooperation with the American College Surgeons initiated the first Advance Traumatic Life Support (ATLS®) course in Thailand and this was the beginning point of trauma team development at our hospital. In 2004 the authors organized a regional health care system to develop pre-hospital health care system. In hospital organization, the authors started RRTT in July 2006. The authors set the criteria for team activation which consisted of 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 injury of abdomen, chest, neck and vascular injury, electrical injury, pediatric injury, pregnancy, severe soft tissue injury and multiple or poly injuries.

The authors performed retrospective observation study of admitted trauma patients at the Maharaj Nakorn Chiang Mai Hospital, a tertiary university based level I trauma center in northern region of Thailand, between January 2004 and September 2009. The study was divided into "before" and "after" establishment of RRTT. Period of before established RRTT (before RRTT group) was from January 2004 to end of June 2006 while after rapid response trauma team setting (after RRTT group) was from July 2006 to end of September 2009. All thoracic injured patients who were admitted to hospital during January 2004 to September 2009 were reviewed from hospital data bank by International Classification of Diseases (ICD 10) with diagnostic trauma code of S20-S29. The authors excluded patients who were admitted to hospital without thoracic injury, iatrogenic chest injury and patients who re-admitted for other reasons with previous thoracic injury as well as repeated count in different code at the same admission. This study was approved by the Chiang Mai University Ethic Committee.

The authors collected age, gender, date of admission and discharge, mechanisms of injuries, characteristics of injuries, associated organ injuries and admission severity of disease which was measured by Injury Severity Score (ISS) mechanism of injuries and all procedures during admission. The primary outcome was in-hospital mortality and secondary outcomes were in-hospital complications. Poly trauma or multiple trauma patients were defined by ISS score >15.3-5. Data was analyzed by the STATA software (version 11.0, STATA Inc., College Station, TX). All continuous variable data differences were tested using Student's t test for parametric distribution data and reported as mean ± SD or median (25-75 inter-quartile range [IQR]) for non parametric distribution and tested with Mann-Whitney U test. For categorical variables, Pearson's chi-square was used except when small size required the use of Fisher's exact test. Time series analyses of monthly mortality was performed by exploring autocorrelation firstly and lag time was selected by Schwarz's Bayesian (SBIC), the Akaike's (AIC) and the Hannan and Quinn information criterion (HQIC) as well as likelihood ratio.[6-7] Interval selection was tested for stationary by Dickey-Fuller test.[8] Alteration of trend between before and after RRTT was analyzed by Chow test. Differences were considered to be statistically significant when $p < 0.05$.

## Results

Total of 951 admitted patients were collected during the 39-month period. They were divided into two groups, 427 patients of 30 months in before RRTT group and 524 patients in 39 months after RRTT group. Of these, 83 patients (8.8%) died after admission [45 (10.6%) vs. 38 (7.3%) in before and after RRTT respectively]. The mortality patient characteristics were analyzed.

Average age of mortality patient was nearly forty years (All, before, after : 38.7 ± 16.3, 37.7 ± 15.5 and 39.7 ± 17.4 year respectively). Male was the predominant gender. Tendency of severity injury score in mortality patient was higher score in after RRTT (30.2 ± 11.5 vs. 35.0 ± 14.1; p = 0.06). Even though there was no statistical difference demonstrated in group of minor and poly-trauma which was stratified by ISS but three patients died in ISS ≤15. The causes were delayed detection of tension pneumothorax, progression of intracranial lesion and myocardial infarction (Table 1). Motor cycle accident was predominant mechanism of injury. However, there was no statistical difference in characters and mechanisms of injuries in mortality patients between two periods except hemothorax (Table 1). While there was no difference in all number of maxillofacial injury in both periods [44 (10.3%) vs. 46 (8.8%); p = 0.42] the mortality patient had lower occurrence in after RRTT [17 (20.5%) vs. 4 (10.5); p = 0.04]. Overall associated abdominal injury in after RRTT group had higher incidence than before group [73 (17.1%) vs. 144 (27.5%); p <0.01] and these led to effect transmission in higher occurrence in mortality of these kind associated injuries (Table 1).

**Table 1** Patient mortality characteristics of before and after RRTT establisment

| | All (n = 83) | Before (n = 45) | After (n = 38) | P value |
|---|---|---|---|---|
| **General aspect** | | | | |
| Age[mean (SD)] | 38.7 (16.3) | 37.7 (15.5) | 39.7 (17.4) | 0.59 |
| Gender (Male:Female) | 72:11 | 40:5 | 32:6 | 0.53 |
| Injury severity score [ISS (SD)] | 32.7 (13.0) | 30.2 (11.5) | 35.0 (14.1) | 0.06 |
| ISS _ 15 (%) | 3 (3.6) | 3 (6.7) | 0 (0) | 0.11 |
| ISS > 15 (%) | 80 (96.4) | 42 (93.3) | 38 (100) | |
| **Mechanism of injuries** | | | | |
| Pedestrian | 5 (6.0) | 2 (4.4) | 3 (7.9) | 0.51 |
| Motor cycle accidence | 42 (50.6) | 24 (53.3) | 18 (47.4) | 0.58 |
| Car accidence | 4 (4.8) | 2 (4.4) | 2 (5.3) | 0.85 |
| Occupant | 1 (1.2) | 0 (0) | 1 (2.6) | 0.27 |
| Self harm | 1 (1.2) | 0 (0) | 1 (2.6) | 0.27 |
| Body assault | 8 (9.6) | 4 (8.9) | 4 (10.5) | 0.80 |
| Fall | 13 (15.7) | 6 (13.3) | 7 (18.4) | 0.53 |
| Other | 3 (3.6) | 2 (4.4) | 1 (2.6) | 0.66 |
| **Character of injuries** | | | | |
| Thoracic soft tissue injuries | 10 (12.1) | 6 (13.3) | 4 (10.5) | 0.70 |
| Thoracic vertebral and cord injuries | 5 (6.0) | 2 (4.4) | 3 (7.9) | 0.51 |
| Rib (s) and sterna fracture | 27 (32.5) | 14 (31.1) | 13 (34.2) | 0.76 |
| Flail chest | 10 (12.1) | 6 (13.3) | 4 (10.5) | 0.70 |
| Thoracic great vessels injury | 8 (9.6) | 4 (8.9) | 4 (10.5) | 0.80 |
| Other thoracic vessels injury | 1 (1.2) | 0 (0) | 1 (2.6) | 0.27 |
| Heart injury | 9 (10.8) | 5 (11.1) | 4 (10.5) | 0.93 |
| Pneumothorax | 10 (12.1) | 7 (15.6) | 3 (7.9) | 0.29 |
| Hemothorax | 25 (30.1) | 9 (20.0) | 16 (42.1) | 0.03 |
| Pneumohemothorax | 15 (18.1) | 6 (13.3) | 9 (23.7) | 0.22 |
| Lung contusion | 18 (21.7) | 9 (20.0) | 9 (23.7) | 0.69 |
| Large airway injury | 1 (1.2) | 1 (2.2) | 0 (0) | 0.36 |
| Multiple thoracic organ injury | 9 (10.8) | 5 (11.1) | 4 (10.5) | 0.93 |
| Other thoracic injury | 1 (1.2) | 1 (2.2) | 0 (0) | 0.36 |
| **Associated organ injury** | | | | |
| Maxillofacial injury | 17 (20.5) | 13 (28.9) | 4 (10.5) | 0.04 |
| Head injury | 29 (34.9) | 15 (33.3) | 14 (36.8) | 0.74 |
| Neck injury | 6 (7.2) | 4 (8.9) | 2 (5.3) | 0.53 |
| Abdominal injury | 38 (45.8) | 15 (33.3) | 23 (60.5) | 0.01 |
| Orthopedics upper extremity injury | 17 (20.5) | 11 (24.4) | 6 (15.8) | 0.33 |
| Orthopedics lower extremity injury (include pelvis) | 19 (22.9) | 13 (28.9) | 6 (15.8) | 0.16 |

The most common procedure was intercostal drainage (ICD) and one third of mortality patients had ICD inserted. No mortality occurrences were found in patients who underwent trapdoor, video assisted thoracotomy (VAT), tracheostomy, bronchoscopy, thoracic vascular stent and angiogram embolization. Although total number of craniotomy was not different in both periods [10 (2.3%) vs. 9 (1.7%); p = 0.49] the craniotomy associated thoracic injury in before RRTT group had higher mortality [6 (13.3%) vs. 0 (0%); p = 0.03] (Table 2). Overall complications in mortality patient were no difference except urinary complication and acute renal failure which had higher tendency in after RRTT group (Table 2).

With monthly interval in time series analysis of adjusted mortality by severity injury score during 69-month period, the authors found that association of data had autocorrelation (coefficient 0.36; p <0.01). Selection of lag time period was tested by AIC, HQIC and SBIC as well as likelihood ratio (LR). The appropriated lag selection with these methods were monthly interval (lag 1) which had highest significantly likelihood ratio (AIC: -4.45, HQIC: -4.36, SBIC: -4.23 and LR = 146.3; p <0.01). Unit root was tested by Dickey Fuller test which demonstrated yearly trend (lag 12) had acceptable stationary of model. Overall average monthly adjusted mortality in before RRTT had higher percentage than after RRTT (9.0 ± 6.1 % vs.6.1 ± 4.0% in Figure 1). Analysis of monthly trend with regression coefficients before and after RRTT had significant lower tendency coefficient alteration in after RRTT and time [Coefficient = -0.61 (95% confidence interval -1.13 to -0.23); p <0.01) and time trend curve was lower and demonstrated in Figure 1.

## Discussion

In 2003, the first leading cause of death in Thailand was accident, accounting for 20% (73 per 100000)[9]. This occurrence was higher than average world

**Table 2** Procedures and complications in mortality patients of before and after RRTT establisment

| | All (n = 83) | Before (n = 45) | After (n = 38) | P value |
|---|---|---|---|---|
| **Procedure** | | | | |
| ICD | 29 (34.9) | 13 (28.9) | 16 (42.1) | 0.21 |
| ER thoracotomy | 4 (4.8) | 1 (2.2) | 3 (7.9) | 0.23 |
| Thoracotomy | 8 (9.6) | 5 (11.1) | 3 (7.9) | 0.62 |
| Clampshell | 4 (4.8) | 1 (2.2) | 3 (7.9) | 0.23 |
| Sternotomy | 4 (4.8) | 3 (6.7) | 1 (2.6) | 0.39 |
| Pericardial window | 1 (1.2) | 0 (0) | 1 (2.6) | 0.27 |
| Trap-door | 2 (0.2) | 1 (0.2) | 1 (0.2) | 1.00 |
| Exploratory laparotomy | 23 (27.7) | 11 (24.4) | 12 (31.6) | 0.47 |
| Laparoscopic examination | 6 (7.2) | 2 (4.4) | 4 (10.5) | 0.28 |
| Craniotomy | 6 (7.2) | 6 (13.3) | 0 (0) | 0.03 |
| Unexpected cardiopulmonary resuscitation (CPR) | 2 (2.4) | 2 (4.4) | 0 (0) | 0.50 |
| **Complications** | | | | |
| Pulmonary complication | 4 (4.8) | 3 (6.7) | 1 (2.6) | 0.39 |
| Hospital acquired pneumonia | 2 (2.4) | 1 (2.2) | 1 (2.6) | 0.90 |
| Acute respiratory distress syndrome | 3 (3.6) | 2 (4.4) | 1 (2.6) | 0.66 |
| Clot hemothorax | 2 (2.4) | 1 (2.2) | 1 (2.6) | 0.90 |
| Urinary tract complication | 7 (8.4) | 1 (2.2) | 6 (15.8) | 0.03 |
| Acute renal failure | 6 (7.2) | 1 (2.2) | 5 (13.2) | 0.06 |
| Urinary tract infection | 1 (1.2) | 0 (0) | 1 (2.6) | 0.27 |
| Hematologic complication | 55 (66.3) | 29 (64.4) | 26 (68.4) | 0.70 |
| Massive hemorrhage | 51 (61.5) | 27 (60.0) | 24 (63.2) | 0.77 |
| Coagulopathy | 20 (24.1) | 12 (26.7) | 8 (21.1) | 0.55 |
| Hepatic failure | 1 (1.2) | 0 (0) | 1 (2.6) | 0.23 |
| Cardiac complication | 4 (4.8) | 1 (2.2) | 3 (7.9) | 0.22 |
| Neurological complication | 11 (13.3) | 6 (13.3) | 5 (13.2) | 0.98 |
| Other sepsis | 4 (4.8) | 2 (4.4) | 2 (5.3) | 0.86 |

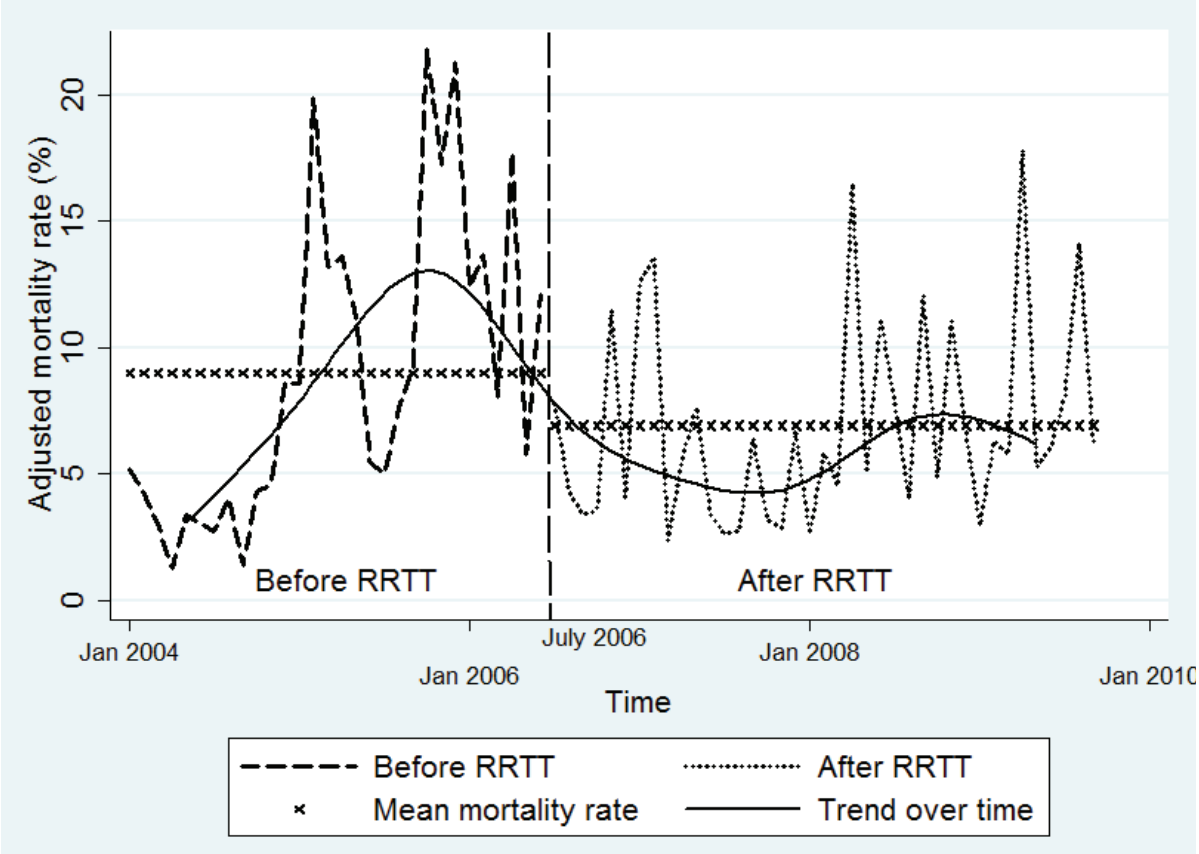


**Figure 1** Time series of monthly adjusted mortality before and after RRTT

incidence which accounted for 10% of global mortality.[10] Multi-level population health impact model demonstrated stream line approach involved four main aspects that are downstream, midstream, upstream and external factors[9]. Public health system, social organization and community resources were provided as midstream factors and could be developed in level of regional health services and hospital providers. Health care outcomes improvement need well-organized communication and available experienced teams to solve patient emergency problems[11]. With these beliefs, the authors initiated system communication from the scene and pre-hospital care to hospital care setting in 2004. At hospital level, RRTT were organized and have serviced all of poly trauma and high risk injured patients since mid 2006.

Emergency and precise management in patients who have thoracic injuries are an important factor and are regarded as first priority concern at initial management after patients arrived at the hospital[1]. The authors hypothesized that the impact of RRTT on these types of injuries might alter monthly trend of mortality as well as characters of mortality patients during observation periods.

As shown in Table 1, tendency of mortality patient had higher ISS in later period. Although no statistical difference of mortality was found in stratified ISS but three patients died in before RRTT in spite of no mortality in after RRTT. These might be due to careful and early detection after systemic organization. After RRTT mortality patients had more hemothorax than previous period and these correlated with higher ISS as in previous discussion and these could explain higher urinary complication and acute renal failure (Table 2).

Maxillofacial trauma had significant lower mortality after RRTT. This phenomenon confirmed the authors' hypothesis that prompt treatment to time dependence injury of airway and ventilation would improve patient outcomes. However, RRTT could not significantly decrease patient with associated abdominal injury. These might occur from higher ISS after

RRTT.

Even though fluctuation of monthly adjusted mortality was observed at study period in Figure 1 the time series analysis after autocorrelation testing and time interval selection demonstrated significant decrease of mortality trend after RRTT. However, these might show only global causal relationship between two periods which could be confounded by unexpected simultaneous factors association.

There were many limitations in this study. First, retrospective nature could not control patients' baseline characteristics. Comparing outcomes might be subject to selection bias. Second, reviewed data had some missing value and was excluded especially at the first inclusion year which might result in lower measured mortality rate than the actual one. Third, the authors could not adjust and measure experiences which increase over time and brought about maturation bias. Finally, the authors included only admitted patients and therefore might not be valid for the outpatient setting.

## Conclusion

RRTT decreases trend of mortality over observation period and the effect was predominant in patients who had associated maxillofacial injuries.

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