—Original—

Preventable Trauma Deaths after Traffic Accidents in Chiba Prefecture, Japan, 2011: Problems and Solutions

Tomokazu Motomura[1], Kunihiro Mashiko[1], Hisashi Matsumoto[1], Ayumi Motomura[2], Hirotaro Iwase[2], Shigeto Oda[3], Fumihiko Shimamura[4], Tomohisa Shoko[5], Nobuya Kitamura[6], Koji Sakaida[7], Yuichi Fukumoto[8], Miyuki Kasuya[9], Tsutomu Koyama[10] and Hiroyuki Yokota[11]

[1]Shock and Trauma Center, Nippon Medical School Chiba Hokusoh Hospital
[2]Department of Legal Medicine, Graduate School of Medicine, Chiba University
[3]Department of Emergency and Critical Care Medicine, Graduate School of Medicine, Chiba University
[4]Chiba Emergency Medical Center
[5]Trauma and Critical Care Center, Matsudo City Hospital
[6]Department of Emergency and Critical Care Medicine, Kimitsu Chuo Hospital
[7]Funabashi Municipal Medical Center
[8]Juntendo University Urayasu Hospital
[9]Asahi General Hospital
[10]Department of Emergency Medicine, Kashiwa Hospital, the Jikei University School of Medicine
[11]Department of Emergency and Critical Care Medicine, Nippon Medical School

Abstract

Introduction: The incidence of preventable trauma death in the current Japanese emergency medical system remains high. The present study aimed to determine rates of clearly preventable and possibly preventable trauma deaths due to traffic accidents in Chiba Prefecture, Japan, and to consider associated problems and solutions.

Materials and Methods: During 2011, 175 victims died after traffic accidents in Chiba Prefecture. Of these, the deaths of 69 persons who had vital signs at the time of emergency medical service contact were classified as clearly preventable, possibly preventable, or not preventable through the peer review discussion. We also examined problems associated with deaths that were clearly preventable or possibly preventable.

Results: Of the 69 deaths, 9 (13%) were classified as clearly preventable, 11 (16%) as possibly preventable, and 49 (71%) as not preventable. Of the 20 clearly or possibly preventable deaths (each death potentially comprising multiple problems), 5 were related to selection of the hospital before hospital arrival, 4 to problems with regional emergency medical systems, and 15 to inappropriate hemodynamic management, including transfusion and delayed (or not attempted) hemostasis in the hospital.

Discussion: Problems of these 20 deaths showed that appropriate triage at the scene, centralization of patients with severe trauma, and trauma centers are necessary in Japan. Under-triage before arrival at the hospital was related to clearly and possibly preventable deaths. Upgrading the triage category for victims with torso injury must be considered. Not all emergency critical care centers in Japan are able to provide severe trauma care. Preventable trauma deaths occur even in some emergency critical care centers; therefore, we need centralization of severe trauma patients from wider area to reduce the incidence of preventable trauma death.
(J Nippon Med Sch 2014; 81: 320–327)

Key words: preventable trauma death, traffic accident, peer review, trauma center

Correspondence to Tomokazu Motomura, MD, Shock and Trauma Center, Nippon Medical School Chiba Hokusoh Hospital, 1715 Kamagari, Inzai, Chiba 270–1694, Japan
E-mail: xcjwg823@yahoo.co.jp
Journal Website (http://www.nms.ac.jp/jnms/)

Introduction

The incidence of preventable trauma death (PTD) in the Japanese emergency medical system remains high. Evaluation of the quality of emergency prehospital and in-hospital medical care is extremely important for identifying problems and solutions in the system[1]. To perform research on fatal accidents, we established a traffic accident investigation committee and a peer-review group. This committee examined the records of prehospital and in-hospital emergency medical activities on the basis of police department, fire department, hospital, and forensic reports and evaluated the quality of emergency medical activities[2]. The present study aimed to determine rates of clearly preventable and possibly preventable deaths in the course of medical care for patients who had suffered trauma in traffic accidents in Chiba Prefecture, and to consider related problems and solutions.

Materials and Methods

All 175 deaths within 24 hours of traffic accidents in Chiba Prefecture from January 1 through December 31, 2011, were reviewed, based on the information obtained from police department, fire department, hospital, and forensic medicine (**Table 1**).

Of these 175 deaths, 69 deaths, in which the victim had at least one vital sign as below: pulse rate, Glasgow Coma Scale ≥4, spontaneous breathing at the time of emergency medical service (EMS) contact, were investigated. We created a timeline in each case with information from police department, fire department, and hospital records after each accident, and peer-reviewed the deaths with 11 emergency medical physicians from 9 emergency and critical care centers (ECCCs) in Chiba Prefecture and 2 forensic scientists. The 69 deaths were classified as clearly, possibly, or not preventable through the peer review discussion. The probability of survival (Ps) calculated based on revised trauma scores (RTS) at physician contact[3] and vital signs at EMS contact (PsE) were considered. A case was classified as clearly preventable when the PsE was ≥0.5, and when all verification staff agreed that survival would have been possible if prehospital care or in-hospital care or both had been more appropriate. A case was classified as possibly preventable if their discussion regarding the possibility of survival was divided. "Appropriate" means that evaluation and triage of the patient were correct; airway, breathing and circulation were stabilized in the prehospital setting; the air or ground ambulances were alerted immediately; the patient was transported to the correct hospital for the treatment; and the airway (tracheal intubation, surgical airway management), breathing (chest drainage, positive pressure ventilation with intubation for flail chest), and circulation (transfusion, hemostasis surgery for hemothorax, intra-abdominal bleeding, pelvic fracture) were stabilized in the hospital. Deaths in patients with severe brain injuries or PsE <0.5 were classified as not preventable. We then identified problems associated with clearly preventable and possibly preventable deaths.

Results

Survey compliance by police and fire departments was 100%, and that from hospitals was 99%. The mean age of the 69 victims was 64±18.5 years, and 65% of victims were male. Pedestrians, passengers of vehicle, bicyclists, motorcycle riders, others, and unknown accounted for 28 (40%), 17 (25%), 11 (16%), 8 (12%), 3 (4%), and 2 (3%) of the deaths, respectively. Cardiopulmonary arrest occurred in 19 (28%) victims during transport to hospital, and 50 (72%) victims died after arrival at the hospital. The mean intervals between each event were as follows: from the accident to EMS call (119 call), 3 minutes 46 seconds; from EMS call to EMS contact, 9 minutes 2 seconds; from EMS contact to EMS departure from the scene, 18 minutes 21 seconds; and from EMS departure to physician contact, 16 minutes 12 seconds. Therefore, the mean interval between an accident and physician contact was 47 minutes 21

Table 1 Data collected from police, fire department (emergency medical service), hospital, and autopsy

	Police	Fire department (emergency medical service)	Hospital	Autopsy
Timeline Information	Time of accident Time of call to police Time of death	Time of call to fire department Time of dispatch of emergency medical service Time of arrival at scene Time of contact with patient Time of leaving the scene Time of arrival at hospital	Time of physician contact Time of focused assessment with sonography for trauma Time of chest drainage Time of computed tomography scan Time of start of transfusion Time of entering the operation room Time of start of operation Time of other medical interventions Time of death	
Traffic accident information	Exact location of accident	Summary of accident Type of accident (pedestrian, bicycle, motor-bike, 4-wheel vehicle)		Detailed information of accident found at a later date
Medical information		Contents of 119 call Vital signs (blood pressure, heart rate, respiratory rate, Glasgow Coma Scale) at emergency medical service contact Presence or absence of call for doctor delivery system (ambulance, air ambulance) Observation information during transport (transition of vital signs, detailed evaluation of whole body) The destination hospital Reason of hospital selection	Vital signs when doctor contact Detailed information of surgery operative procedure Detailed summary of between doctor contact and death Diagnosis and Abbreviated Injury Scale code Cause of death	Result of computed tomography scan after death Detailed results (diagnosis) of autopsy Cause of death

All 175 deaths within 24 hours of traffic accidents in Chiba Prefecture in 2011 were reviewed with detailed information including information of time passage, traffic accident, and medical activity.

Table 2 Mean timeline for the 69 victims

Event	Interval (min.)	Interval (min.)
Traffic accident		
	3.8	
EMS call		
	9.0	
EMS contact		47.4
	18.4	
Departure from scene		31.3
	16.2	
Doctor contact		

The mean interval from accident to physician contact was 47 minutes 21 seconds, and that from EMS contact to physician contact was 31 minutes 17 seconds. (Modified with permission from Fig. 21 in "Peer Review of Traffic Fatalities in Chiba: Report by the Chiba Traffic Accident Investigating Committee 2011; pp 16 [in Japanese].")

seconds (**Table 2**). The RTS and Ps between EMS contact and physician contact (mean interval, 31 minutes 17 seconds), changed from 4.69±2.18 to 3.24±2.77 (p=0.006) and from 0.46±0.35 to 0.32±0.34 (n.s.), respectively (**Table 3**). Of the 69 deaths, 9 (13%) were classified as clearly preventable (**Table 4a**), 11 (16%) as possibly preventable (**Table 4b**), and 49 (71%) as not preventable.

Of the 20 clearly or possibly preventable deaths, 8 were related to problems of prehospital activity, and 5 of these were associated with problems in hospital selection. Five victims were transported to non-ECCCs, although their conditions were considered unstable at the scene. Four (20%) deaths were related to problems with regional emergency medical systems, as the interval from the accident to physician contact in each case was greater than 60 minutes.

Table 3 Change in RTS (a) and Ps (b) between EMS and physician contact

	EMS contact	Doctor contact	P value
Revised trauma score (RTS)	4.69±2.18	3.24±2.77	<0.006
Provability of survival (Ps)	0.46±0.35	0.32±0.34	n.s.

Between EMS contact and physician contact (mean elapsed time, 31 minutes 17 seconds), RTS decreased from 4.69±2.18 to 3.24±2.77 (p=0.006), and Ps decreased from 0.46±0.35 to 0.32±0.34 (n.s.) (Modified with permission from Fig. 26 and Fig. 29 in "Peer Review of Traffic Fatalities in Chiba: Report by the Chiba Traffic Accident Investigating Committee 2011; pp 18-20 [in Japanese].")

Eighteen of the 20 clearly or possibly preventable deaths were related to problems of in-hospital treatment. Of these 18 deaths, 15 were associated with problems of management for hemodynamic stabilization and delayed (or not attempted) hemostasis for chest, abdominal, or pelvic bleeding (5, 4, and 8 cases, respectively); 2 were associated with craniotomy for intracranial decompression being either delayed or not performed; and 1 was associated with delayed drainage of tension pneumothorax. Five of these 15 patients were transported to ECCCs; PTDs associated with circulation management occurred even in ECCCs.

Overall, the accidents in 12 of 20 cases of clearly or possibly preventable death occurred between 4 p.m. and midnight (**Fig. 1**).

Discussion

The PTD rate of 11% in the present series was higher than rates in other developed countries, where reported rates are less than 1% in urban areas, and 5% to 10% in rural areas[4–8]. Four (20%) of 20 clearly or possibly preventable deaths were associated with problems of regional EMS systems. These traffic accidents occurred far from ECCCs, and more than 60 minutes elapsed between the accident and physician contact. One hour after an accident is referred to as "the golden hour" for victims of severe trauma, and radical surgical approaches should be applied during this time[9,10]. However, in these 4 cases of our series, this opportunity had already been lost by the time of physician contact, and treatment was not able to start until even later. Early contact with trauma physicians can facilitate optimal transport to ECCCs with more advanced triage, stabilization of patients during transport, reduction of the elapsed time between the accident and life-saving surgery based on the transmission of advanced medical information from the scene to the hospital.

The accidents in these 4 cases of preventable death associated with problems of regional EMS systems occurred between 4 p.m. and midnight. Overall, the accidents in 12 of 20 cases of clearly or possibly preventable death occurred during this time. The average time it takes to transport accident victims to medical facilities is longer at night, because air ambulances are not available at this time. A viable night-time emergency vehicle alternative is needed.

Five of 20 clearly or possibly preventable deaths were associated with problems of hospital selection. The patients were transported to non-ECCCs, even if they were considered to be in severe condition by EMS contact at the scene. The patients met the criteria for high-energy trauma criteria (**Table 5**) and were found at the scene to have injuries of the chest, abdomen, and pelvis. The main causes of death among these 5 patients were chest, abdominal, or pelvic bleeding.

The conditions of some patients were stable at EMS contact but worsened during transport. These patients were initially stable physiologically, perhaps because the amount of blood loss might be small at the time of EMS contact. However, the blood loss likely increased as time passed, and the patients went into shock state, hemodynamically.

Important methods for eradicating PTD are appropriate triage in the prehospital and the centralization of severe trauma patients. The 20 patients in the present series whose deaths were

Table 4a Details of 9 clearly preventable deaths due to trauma sustained in motor vehicle accidents

Patient	Age (y), sex	Accident	Accident time	Accident to EMS (min)	Status during transport	PsE	Hospital type	Accident to physician contact (min)	Diagnosis	Ps	Course after physician contact (hours later)	Pre-hospital problem	In-hosptial problem	Cause of death
1	73, M	Bicycle × vehicle	18: 06	7	Stable (chest pain)	0.97	Non-ECCC	50	Rib fracture, hemothorax	0.97	3: 00 shock, 13: 00 dead	—	Delayed (not performed) hemostasis for hemothorax	Bleeding (hemothorax)
2	77, F	Pedestrian × vehicle	17: 40	10	Stable (chest pain)	0.67	Non-ECCC	50	Rib and pelvic fracture hemothorax	0.49	3: 00 dead	—	Delayed (not performed) hemostasis for hemothorax/pelvic fracture	Bleeding (hemothorax, pervic fracture)
3	47, M	Pedestrian × vehicle	13: 15	5	Unstable (disturbance of consciousness, shock)	0.91	Non-ECCC	25	Intra-abdominal bleeding	0.72	2: 00 transfusion, 4: 00 dead	Hospital selection (transported to non-ECCC)	Delayed (not performed) hemostasis for intraabdominal bleeding	Bleeding (intra-abdominal bleeding)
4	91, F	Pedestrian × vehicle	12: 08	7	Unstable (shock) → stable (chest pain)	0.78	Non-ECCC	52	Rib fracture hemothorax	0.92	1: 00 discharged, 4: 00 dead	Hospital selection (transported to non-ECCC)	Missed injury, Delayed (not performed) hemostasis for hemothorax	Bleeding (hemothorax)
5	26, M	Vehicle (driver) single accident	23: 15	16	Unstable (shock), restlessness	0.97	Non-ECCC	41	Pelvic fracture	0.83	3: 30 operation for pelvic fracture, 10: 00 dead	Hospital selection (transported to non-ECCC)	Delayed hemostasis for pelvic fracture	Bleeding (pelvic fracture)
6	79, M	Motor bike × vehicle	16: 20	10	Stable (chest and abdominal pain)	0.96	Non-ECCC	50	Pelvic fracture	0.96	1: 00 CT, 3: 40 transfusion, 6: 00 dead	—	Delayed (not enforced) hemostasis for pelvic fr	Bleeding (pelvic fracture)
7	79, F	Pedestrian × vehicle	19: 08	10	Unstable (shock, disturbance of consciousness)	0.54	Non-ECCC	21	Spleen injury	0.31	0: 50 CT, 2: 30 transcatheter arterial embolization, 6: 30 dead	Hospital selection (transported to non-ECCC)	Delayed hemostasis for abdominal bleeding (spleen injury)	Bleeding (spleen injury)
8	40, M	Pedestrian × vehicle	09: 30	7	Unstable (disturbance of consciousness)	0.80	ECCC	31	epidural hematoma	0.87	5: 30 decreased level of consciousness, 7: 00 craniotomy, 11: 30 dead	—	Delayed craniotomy	Brain injury (epidural hematoma)
9	65, F	Motor bike × vehicle	23: 16	4	Stable-unstable (shock, disturbance of consciousness)	0.93	Non-ECCC	21	Rib fracture hemothorax (lung injury)	0.75	1: 40 transfusion, 2: 00 hemostasis for lung injury, 5: 00 dead	—	Delayed hemostasis for hemothorax	Bleeding (lung injury, hemothorax)

Table 4b Details of 11 probably preventable deaths due to trauma sustained in motor vehicle accidents

Patient	Age (yr), sex	Accident type	Accident time	Accident to EMS (min)	Status during transport	PsE	Hospital type	Accident to physician contact (min)	Diagnosis	Ps	Course after physician contact (hours later)	Pre-hospital problem	In-hosptial problem	Cause of death
10	24, M	Vehicle (passenger) ×vehicle	20: 25	12	Stable (trapped in vehicle, abdominal pain) → cardiopulmonary arrest	0.99	Non-ECCC	68	Pelvic fracture	0.67	No reaction to resuscitation	Regional emergency system (it took 68 min to physician. contact)	−	Bleeding (pelvic fracture)
11	62, M	Bicycle× vehicle	04: 20	21	Stable (chest, abdominal, pelvis pain) → unstable (shock)	0.53	ECCC	54	Liver injury, pelvic fracture	0.40	0: 30 transfusion, 2: 00 dead	−	Delayed (not performed) hemostasis for abdominal bleeding (liver injury), pelvic fracture	Bleeding (liver injury, pelvic fracture)
12	62, M	Vehicle (passenger seat)× vehicle	17: 42	15	Stable → unstable (shock, disturbance of consciousness)	0.93	ECCC	63	Intra-abdominal bleeding	0.33	0: 50 dead	Regional emergency system (it took 63 min to Dr. contact)	Delayed (not performed) hemostasis for intraabdominal bleeding	Bleeding (intra-abdominal bleeding)
13	57, M	Motor bike ×vehicle	15: 27	9	Stable	0.89	ECCC	40 (DH)	Hemothorax (Aortic injury)	0.89	0: 30 cardiopulmonary arrest, 0: 40 operation, 2: 00 dead	−	Delayed hemostasis for Ao injury	Bleeding (Ao injury)
14	28, M	Motor bike ×vehicle	18: 52	16	Unstable (shock) → cardiopulmonary arrest	0.96	ECCC	62	Kidney injury, pelvic fracture	0.09	No reaction for resuscitation	Regional emergency system (It took 62 min to Dr. contact)	−	Bleeding (kidney injury, pelvic fracture)
15	38, F	Vehicle passenger (trapped) ×vehicle	07: 54	14	Unstable (shock, disturbance of consciousness)	0.62	ECCC	34 (DH)	pelvic fracture	0.65	0: 45 transfusion, 2: 30 dead	−	Delayed (not performed) hemostasis for pelvic fracture	Bleeding (pelvic fracture)
16	44, M	Bicycle× vehicle	20: 48	6	Unstable (disturbance of consciousness)	0.80	Non-ECCC	32	Tension pneumothorax	0.35	1: 00 dead	−	Delayed treatment for tension pneumothorax	Tension pneumothorax
17	64, M	Vehicle (emission) ×vehicle	17: 30	18	Stable	0.89	ECCC	64	epidural hematoma	0.89	7: 30 decreased level of consciousness, 19: 00 dead	—	Delayed diagnosis of expanded EDH	Brain injury (epidural hematoma)
18	70, M	Pedestrian ×vehicle	06: 00	9	Stable → unstable (disturbance of consciousness)	0.93	ECCC	55 (DC)	Pelvic fracture	0.93	0: 30 transfusion, 4: 00 dead	—	Delayed (not performed) hemostasis for pelvic fracture	Bleeding (pelvic fracture)
19	86, F	Bicycle× vehicle	16: 40	12	Stable (abdomen, low back pain) → unstable (shock)	0.79	Non-ECCC	97	pelvic fracture	0.62	0: 40 transfusion, 1: 30 transcatheter arterial embolization, 5: 00 death	Hospital selection (transported to N-ECCC), Regional emergency system (it took 97 min)	Delayed hemostasis for pelvic fracture	Bleeding (pelvic fracture)
20	96, M	Pedestrian ×vehicle	14: 22	12	Stable (low back pain)	0.90	Non-ECCC	35	pelvic fracture	0.90	4: 00 dead	—	Delayed hemostasis for pelvic fracture	Bleeding (pelvic fracture)

ECCC, emergency and critical care center; N, nonemergency/critical care center; PsE, probability of survival when EMS contacted; Ps, provability of survival when physician contacted

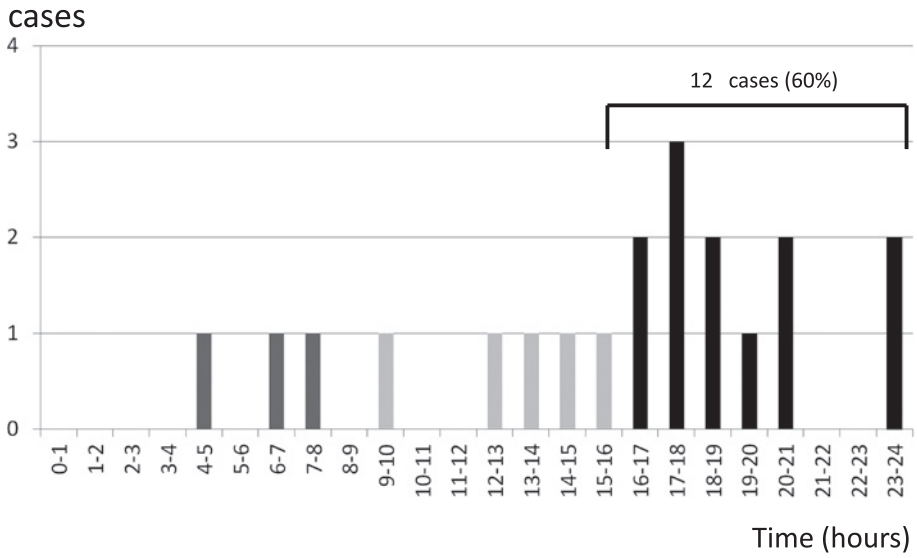

Fig. 1 Time of occurrence of clearly preventable deaths and possibly preventable deaths due to trauma
Twelve (60%) deaths occurred from 4 p.m. to midnight.

Table 5 Criteria for high-energy trauma in Japan

- Death inside vehicle
- Ejection from automobile
- Run over
- Five meters from impact point
- Severe warping of crashed vehicle
- >20 min required to rescue passenger trapped in crashed vehicle
- Automobile rolled over
- Located in different place from fallen motorcycle
- Automobile threw pedestrian/cyclist
- Rear-ended vehicle

clearly or possibly preventable were injured in high-energy accidents, and 7 of 12 patients whose vital signs were stable at initial EMS contact complained of pain of the torso. The category of triage for patients with suspected torso injury should be upgraded in prehospital activity.

Eighteen (90%) of 20 clearly or possibly preventable deaths were related to problems of in-hospital medical care. Fifteen of these 18 deaths were associated with problematic management of chest, abdominal, or pelvic bleeding. The deaths were also related to problems with circulatory management, including delayed (or not performed) blood transfusion and delayed (or not attempted) hemostatic intervention. Five of these 15 victims were transported to ECCCs that are at the highest level of the emergency medical system in Japan. Not all of these ECCCs have a framework capable of treating victims of severe trauma, and this study showed that PTDs occurred even in ECCCs.

The lack of a suitable framework for treating patients with severe trauma is an important problem in Japan. Patients with severe trauma should be treated in a medical system capable of rapid treatment with circulatory management including transfusion, life-saving techniques, hemostasis through thoracotomy, laparotomy and external pelvic fixation, and transcatheter arterial embolization, around the clock, 365 days a year. However, Japan has not yet established the centralization rule of severe trauma patient. Hospitals with an annual volume exceeding 650 patients with severe injuries (Injury Severity Score >15) have significantly lower mortality rates and shorter lengths of stay[11]. The centralization of severe trauma patients in the wider area is necessary to achieve appropriate patient volume for the maturation of hospitals. In addition, the situation in Chiba Prefecture is probably not unique, and the frequency of PTD is probably similar throughout Japan. Therefore a new framework that goes beyond the current emergency medical system for patients with severe trauma, namely “trauma center system” is required as soon as possible in Japan and

the verification meetings are similarly needed throughout the country.

In conclusion, the present study found that of the 175 victims who died within 24 hours after injuries in traffic accident in Chiba Prefecture during 2011, 69 had vital signs at the time of EMS contact, and 20 of these 69 had deaths that were clearly preventable or possibly preventable. The problems associated with these 20 deaths were hospital selection, regional problems (long intervals between accidents and physician contact), and PTD occurring even at ECCCs. The triage category for suspected torso injury should be upgraded, and centralization of both patients with severe trauma and finite medical resources is needed to eradicate PTDs.

Acknowledgements: We would like to thank the Traffic Accident Investigation Committee in Chiba Prefecture for permission to publish details of these cases.

Conflict of Interest: No conflict of interest is declared.

References

1. Takayanagi K, Koseki K, Aruga T: Preventable trauma deaths: evaluation by peer review and a guide for quality improvement. Emergency Medical Study Group for Quality. Clin Perform Qual Healthc 1998; 6: 163–167.
2. Peer Review of Traffic Fatalities in Chiba: In Report by the Chiba Traffic Accident Investigating Committee, 2011; pp 4–42 [in Japanese].
3. Champion HR: Trauma scoring. Scand J Surg 2002; 91: 12–22.
4. Esposito TJ, Sanddal TL, Reynolds SA, et al.: Effect of a voluntary trauma system on preventable death and inappropriate care in a rural state. J Trauma 2003; 54: 663–670.
5. Rogers FB, Shackford SR, et al.: Trauma deaths in a mature urban vs rural trauma system. A comparison. Arch Surg 1997; 132: 376–382.
6. Sanddal TL, Esposito TJ, Whitney JR, et al.: Analysis of preventable trauma deaths and opportunities for trauma care improvement in Utah. J trauma 2011; 70: 970–977.
7. Teixeira PGR, Inaba K, Hadjizacharia P, et al.: Preventable or potentially preventable mortality at a Mature trauma center. J trauma 2007; 63: 1338–1347.
8. Tien HC, Spencer F, Tremblay LN, et al.: Preventable deaths from hemorrhage at a level I Canadian trauma center. J trauma 2007; 62: 142–146.
9. Cowley RA, Hudson F, Scanlan E, et al.: An economical and proved helicopter program for transporting the emergency critically ill and injured patient in Maryland. J Trauma 1973; 13: 1029–1038.
10. Champion HR, Augenstein JS, Blatt AJ, et al.: New tools to reduce deaths and disabilities by improving emergency care. Champion, 05-0191. http://www-nrd.nhtsa.dot.gov/pdf/esv/esv19/05-0191-W.pdf#search='new + tools + to + reduce + deaths + and + disabilities'
11. Nathens AB, Jurkovich GJ, Maier RV, et al.: Relationship between trauma center volume and outcomes. JAMA 2001; 285: 1164–1171.

(Received, August 1, 2013)
(Accepted, May 14, 2014)