—Review—

Trauma Systems in Japan : History, Present Status and Future Perspectives

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Abstract

As trauma is the leading cause of death for persons 1 to 24 years in Japan, the trauma system must be established to save lives and to reduce serious sequelae. However, the trauma system has not been evaluated since 2000. In May 2002, it revealed that the deaths of about 40% of expired trauma patients who arrived at emergency centers with some vital signs were probably preventable. This result increased the awareness of the need for establishing the trauma system. Then, the Japan Prehospital Trauma Evaluation and Care program for emergency medical technicians was developed, the doctor helicopter system was promoted, the Japan Advanced Trauma Evaluation and Care program for physicians was developed, and the trauma registry program was started. The extension of the procedures that can be performed by Japanese paramedics should be extended with the establishment of a medical control system. However, the key to securing quality regional trauma care is to designate a trauma care hospital as a trauma center and to transport severely injured patients there as rapidly as possible.
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Key words: trauma system, field triage, helicopter transportation, trauma center, preventable trauma death, medical control

Background

According to the mortality statistics of the Ministry of Health, Labor and Welfare[1], accidents are the fifth most common cause of death after malignant neoplasms, heart failure, cerebrovascular disease, and pneumonia but is the leading cause of death for persons 1 to 24 years. Statistics of the Fire and Disaster Management Agency[2] reveal that the following numbers of patients were transported by ambulance during 2002: traffic accident, 40,359; general injuries, 50,123; and other injuries (assault, suicide attempt, labor accident, and sports trauma), 157,593 persons. More than 1,180,000 people were injured, and more than 10,000 were killed in traffic accidents in Japan, according to the 2003 statistics[3] of the Institute of Traffic Accident Research and Data Analysis. The trauma system must be improved to save lives and to reduce serious sequelae. However, the trauma system of Japan has not been evaluated since 2000.

At the 16th annual meeting of the Japanese Association for the Surgery of Trauma in May 2002,

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it was stressed that the deaths of about 40% of expired patients who arrived at emergency centers with some vital signs were probably preventable[4]. For this reason, the Japan Prehospital Trauma Evaluation and Care (JPTEC) program was developed[5]. In addition, the doctor helicopter system of the Ministry of Health, Labor and Welfare was promoted in seven prefectures[6], and the Japan Advanced Trauma Evaluation and Care (JATEC) program for physicians was developed[7]. The Trauma Registry was started to improve the quality of trauma care in hospitals[8]. After outlining the present situation, I will review the history of the trauma system in Japan and describe future perspectives.

Trauma Systems and Its Evaluation

The trauma system consists of three components: prehospital care, transportation, and hospital care, called "The Right Patient in the Right Time to the Right Place"[9]. In the prehospital phase, important factors are a quick call for an ambulance (dial 119) by a witness, emergency care by a bystander, evaluation of the injury and treatment by emergency medical technicians (EMTs), including paramedics, field activity time, and field triage with selection of the hospital. In the transportation phase, transportation time and the suitability of treatment in the ambulance are important factors. Concerning hospital care, physician response time (time from ambulance arrival to the start of medical examination by a doctor), capabilities of the emergency department physician, time to activation of the trauma team, time to the start of surgery or catheter intervention by a radiologist, time to the start of blood transfusion, and other factors are closely related to outcome. Therefore, it is important that there be no delay between the prehospital phase and the hospital phase.

The trauma system needs to be evaluated from two perspectives. First is the investigation of prehospital care, transportation, and hospital care. The second is to analyze the mortality rate and sequelae for the whole region with a population-based study including total medical costs[4,10,11]. Any analysis that is done with the intent of improving the quality of trauma care is also usually reviewed for cost-effectiveness. However, it is difficult to compare trauma systems of two areas or of one area in two time periods using these evaluation methods.

The preventable trauma death (PTD) rate fulfills these evaluation needs[12].

The probability of survival is calculated on the basis of anatomical severity (Injury Severity Score [ISS]) and physiological seriousness (Revised Trauma Score). All deaths with a probability of survival $\geqq 0.5$ are defined as unexpected deaths and are evaluated by peer review (colleague checking). Then, whether death could have been avoided if appropriate medical care and definitive treatment had been done is determined. In cases classified as PTDs, the reviewers determine in which phase (prehospital care, including the selection of the receiving hospital, transportation, and hospital care) care could have been improved to prevent the traumatic death.

History of the Trauma System and Present Problems

1. Prehospital Care

In Japan, there is no history of a medical control system to ensure the quality of prehospital care. Nor were there standing medical orders or protocols with field triage criteria for EMTs until 2000, with the exception of several Fire-Defense Headquarters.

In the United States, patient care priority is determined in the field according to the severity and urgency of the trauma. This process is called field triage. It is important to develop suitable triage criteria according to the medical evidence. In the 1980s, the Trauma Score (1981), Circulation, Respiration, Abdominal/Thoracic, Motor, Speech scale (1982), and the Revised Trauma Score (1989) were developed. They used physiological criteria, such as respiration, circulation, and central nervous system function, as field triage factors. In the 1990s, the Trauma Triage Rule (1990), the Trauma Triage Score (1994), and the committee on trauma of the American College of Surgeon (ACSCOT) criteria (1999) were developed and added anatomical factors, mechanism of injuries, injury site, and patient

Table 1 Field triage criteria

Name		TS	CRAMS	RTS	TTR	TTS	ACSCOT	Florida	JPTEC
Year		1981	1982	1989	1990	1994	1999	2000	2003
Circulation	Blood Pressure	■		■	■	■	■	■	
	Pulse Rate		■					■	
	Blanch Test	■							Child
Respiration	Respiratory Rate	■		■		■	■	■	
	Respiratory State		■			■		■	■
	Thoracic Cage Motion	■							
CNS	Eye Opening	■		■		■	■		■
	Verbal Response	■	■	■		JCS	■		JCS
	Motor Function	■	■	■	■	■	■	■	■
Anatomical Abnormality							■	■	■
Mechanism of Injury					■	■	■	■	■
Injury Site					■	■			
Background, Past Illness							■	■	
Abdominal Finding			■						

background to physiological factors[13] (**Table 1**). Because field triage criteria are indispensable tools that decrease PTD by evaluating the severity of trauma and the urgency of care, developing field triage criteria that suited Japanese EMTs was necessary[14].

Around 2000, the standard prehospital trauma care program was imported from the United States by several doctors and paramedics. The Basic Trauma Life Support course was introduced[15], and the Prehospital Trauma Care Japan course was developed[16]. In June 2003, these programs were centralized under the Japanese Association for Acute Medicine, and the JPTEC council was established to popularize standard trauma care programs for EMTs[17]. In the JPTEC council, instructors are trained, and standard protocols for prehospital trauma care are developed. Provider courses and instructor courses are held nationally.

The paramedic system of Japan is produced on the paramedic system of the United States, but there are differences between the systems. For example, advanced medical treatments, such as tracheal intubation, defibrillation, intravenous fluid administration, emergency drug use (31 types), crycothyroidotomy, and thoracentesis, may be carried out by paramedics according to the field activity protocol or according to direct orders from an emergency physician in Seattle (**Table 2**). Moreover, these procedures are not limited to patients in cardiopulmonary arrest. There is no difference in prehospital trauma care between Japanese paramedics and EMTs if patients in cardiopulmonary arrest are excluded. That is to say, Japanese paramedics cannot start infusion therapy before cardiac arrest for an injured patient who has massive intrathoracic or intra-abdominal bleeding.

2. Patient Transportation

According to the statistics of the Fire and Disaster Management Agency[2], of 4,575,325 people who were transported by ambulance in 2003, 1,584,789 (34.6%) had a transportation time (from the 119 call to arrival at the hospital) of 30 to 60 minutes, and 178,484 (3.9%) had a transportation time of more than 60 minutes (**Fig. 1**). Critically ill or severely injured patients who need urgent operations or catheter intervention should be treated within 1 hour. Therefore the use of a helicopter must be considered when transportation time by ground transportation is expected to exceed 30 minutes. However, because only 2,087 patients were

Table 2 Comparison of paramedic procedures

Country, State, City	Procedures
Inglewood, USA	Tracheal intubation, Defibrillation, Ⅳ access, Drug Use
Florida, USA	Tracheal intubation, EOA, PTLA, Ⅳ access, MAST, Defibrillation, Drug Use
Louisiana, USA	Tracheal intubation, Defibrillation, Ⅳ access, Drug Use (22), BS check
Ottawa, Canada	Tracheal intubation, Defibrillation, Ⅳ access, Drug Use (8), Thoracentesis, I0 infusion, BS check, Inhalation Tx
Seattle, USA	Tracheal intubation, Defibrillation, Ⅳ access, Drug Use (31) Cryco-thyroidotomy, Thoracentesis
Queensland, Australia	Tracheal intubation, Defibrillation, Ⅳ acess, Drug Use (14)
Germany	Tracheal intubation, Defibrillation, Ⅳ access, Drug Use (3)
Japan	Tracheal intubation, LM, Combitube, EGTA, Ⅳ access (Ringer lactate), Defibrillation

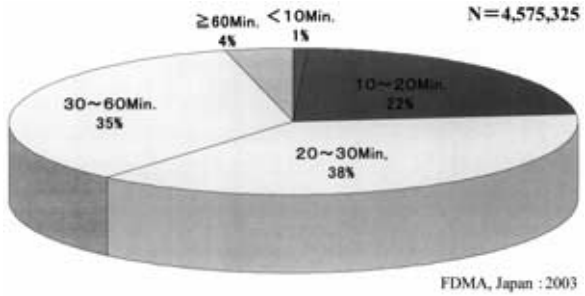

Fig. 1 Ambulance transport time

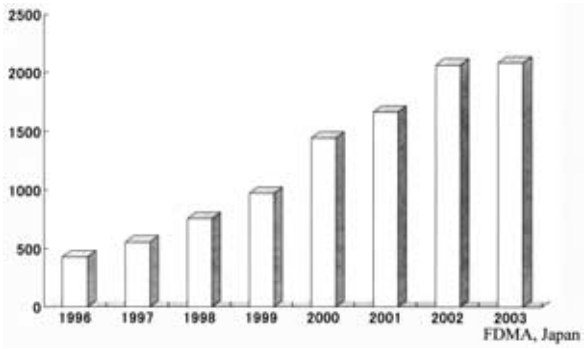

Fig. 2 Total number of emergency missions, fire dept. helicopter

transported by the 68 helicopters of the Fire Department in 2003, critically injured patients cannot be said to be appropriately transported by helicopters in Japan (**Fig. 2**).

In the meantime, the Ministry of Health, Labor and Welfare started the Doctor-Heli (physician-staffed emergency medical service [EMS] helicopter) system in the 2001 fiscal year. This system was extended to nine base hospitals in eight prefectures (Chiba, Kanagawa, Shizuoka, Aichi, Wakayama, Okayama, Fukuoka, and Hokkaido), and the number

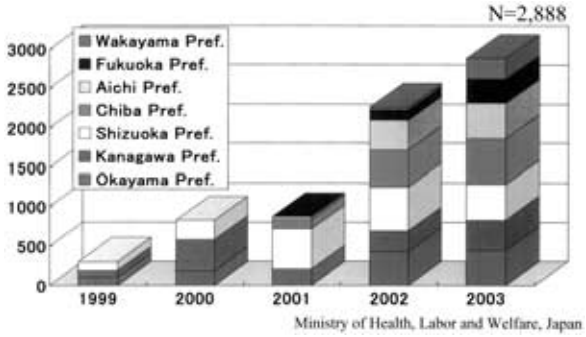

Fig. 3 Total number of missions, Doctor-Heli

of missions in the 2003 fiscal year was 2,888 (**Fig. 3**)[18]. Chiba Doctor-Heli served 1,688 patients from October 2001 through December 2004. Of these patients, 1,513 (90%) were transported directly from the field to the Emergency and Critical Care Center and 168 (10%) were transported between hospitals. The receiving hospitals were base hospitals (Chiba-Hokusoh Hospital, Nippon Medical School) in 1,022 (61%) cases and other hospitals in 615 (36%) cases. Patient disorders were trauma in 840 cases (49.8%), stroke in 275 cases (16.3%), cardiovascular disease in 180 cases (10.7%), and other in 393 cases (23.3%). Thanks to the Doctor-Heli mission, the lives of many critically ill or severely injured patients were saved and functional disability was avoided by start of treatment in the field and transportation to a high-quality emergency hospital[6].

3. Trauma Care Hospital

The three-tiered emergency medical care system was established in Japan in 1977. The system had grown to 174 government-sponsored emergency

care centers by April 2005. However, basic requirements of these centers are to receive every kind of severely ill or injured patient around the clock and not to maintain any special level of treatment for the trauma patient (**Table 3**). The number of lifesaving emergency centers increased according to this requirement, but they were not an improvement in terms of becoming specialized facilities for trauma care.

Around 1990, the interest in PTD increased, although few reports have analyzed the frequency of PTD[19,20]. Volunteers who worked in lifesaving emergency centers gathered, and the Emergency Medical Study Group for Quality (EMSQ) was started to evaluate the emergency medical care system[21]. The rate of PTD was analyzed for trauma patients who were transported to lifesaving emergency centers. The EMSQ research revealed that PTDs accounted for 10.3% of all trauma deaths. Half of these PTDs were due to massive blood loss. Sixty-two percent of the problems were in the initial treatment in the emergency department, such as diagnostic delay and delayed decision-making for surgical intervention[22]. This research increased the awareness of the need for regional and national investigations into the trauma system.

Table 3 Requirements for lifesaving emergency centers

(1) to receive every kind of severely ill or injured patient in 24 hour base
(2) to receive patients from Primary or Secondary Emergency Hospitals or Fire Ambulances in 24 hour base
(3) to keep several vacant beds for the new emergency patients by transferring stable patients to other wards of hospitals
(4) to educate medical students, clinical residents, doctors, nursing students, and paramedics in emergency medicine

As a member of a special group for "the research for the substantiality of the correspondence to the serious trauma patient in the lifesaving emergency center" in 2000 fiscal year funded by Ministry of Health, Labor and Welfare, I investigated the quality of trauma care in lifesaving emergency centers. The investigation revealed that of all trauma deaths of patients who had had any vital signs on hospital admission, 38% were possible PTDs[4]. This research clarified for the first time that large differences exist in the quality of trauma care between regions and between hospitals in Japan. This research continued through fiscal year 2001 and showed that unexpected trauma deaths accouted for 52.1% of all trauma deaths in 2000 and 50.2% in 2001 (**Fig. 4**)[23]. Peer review analysis by EMSQ of cases of unexpected death clarified that it is difficult to save the lives of patients with acute subdural hematoma with Glasgow Coma Scale score 5 or less and of patients older than 80 years. So, we excluded these

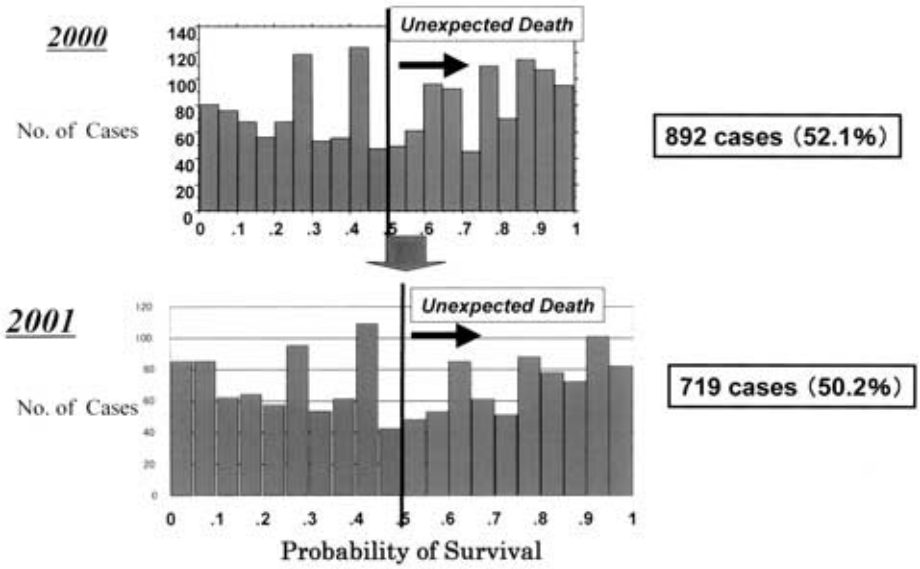

Fig. 4 Distribution of the probability of survival among all trauma deaths

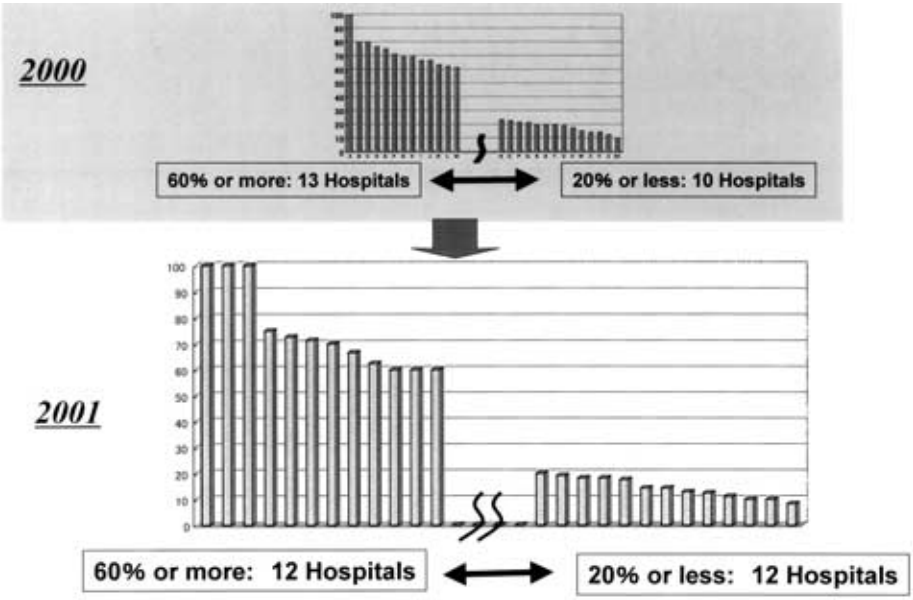

Fig. 5 Ratio of modified unexpected deaths within all trauma deaths

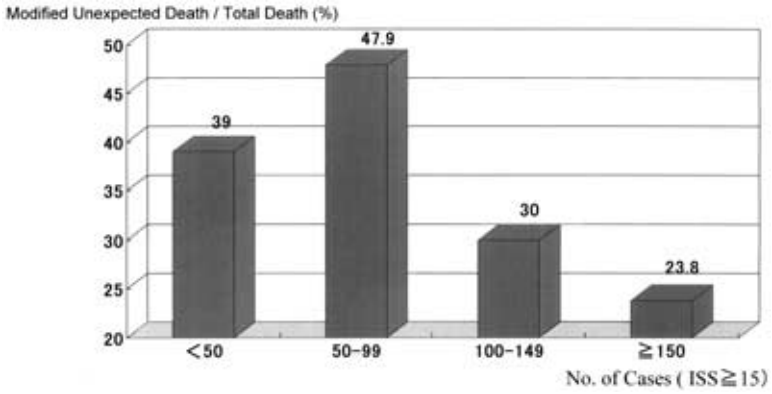

Fig. 6 Relationship between number of severe trauma cases and modified unexpected death ratio

patients from the evaluation of PTD. We then defined the cases that did not meet these exclusion criteria as modified unexpected deaths. The ratio of modified unexpected deaths to all trauma deaths varied greatly from hospital to hospital. Namely, in 2001, 12 hospitals had a ratio of 20% or less (high-quality trauma care), and 12 hospitals had a ratio of more than 60% (low-quality trauma care) (**Fig. 5**). We then studied the relationship between the number of severe injury cases in which the ISS was 15 or more and the percentage of modified unexpected deaths. We found that the modified unexpected death rate in hospitals that treat 50 to 99 cases of severe trauma per year was 47.9% and that of hospitals that treat 150 or more cases was 23.8%. This result shows that the hospitals that treat a larger number of patients with severe trauma have better outcomes (**Fig. 6**).

Trauma System in the United States

In the United States, the need to improve the trauma system was recognized as a national problem after the publication of a report titled "Accidental Death and Sequelae: Neglected disease of modern society"[24] by the National Academy of Sciences-National Research Council in 1966. ACSCOT developed the Advanced Trauma Life

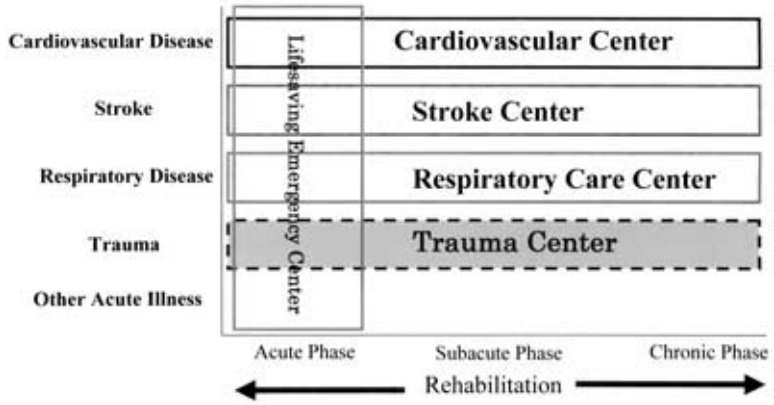

Fig. 7 Lifesaving emergency center/Trauma center

Support course, which became a standard educational program for physicians. The number of instructors increased nationwide[25]. The first trauma center in the United States was established in Illinois in 1971. Subsequently, many trauma centers were established across the country[26]. Trauma centers are required by law to have facilities and equipment for the adequate diagnosis and treatment of trauma, to ensure that the necessary medical staff is available, and to participate in the Trauma Registry to evaluate and improve the quality of trauma care[27].

Trauma centers are designated from level I to level V on the basis of accreditation criteria determined by ACSCOT. Criteria are in proportion to the population and patient volume. They include field triage criteria for bypassing nearby hospitals, the formation of an external quality-assurance committee, and a statewide coverage system[28]. The standards of level I trauma centers are as follows: ensuring the presence of a trauma team and trauma medical director; the ability to gather medical and surgical specialists who can provide advanced trauma life support on a real-time basis when needed; admission of 1,200 or more patients with trauma per year; admissions of 240 or more patients with severe trauma (ISS more than 15) per year or 35 patients per surgeon; a quality assurance/quality improvement program; a trauma registry; trauma education for doctors, nurses, and paramedics; and a trauma-prevention program[29]. Helicopter transport by paramedics or flight nurses or both was started in 1971, and more than 250,000 patients are now transported by 350 helicopters per year. From the 1980s, improvements in the medical control system was also achieved in many places within the United States with the growth of the number of paramedics and improvements in the system in which the medical director has responsibility for the quality of prehospital care[30]. In addition, basic trauma life support and prehospital trauma life support courses were instituted for EMTs by related medical associations, and the quality of prehospital care for the injured patient improved greatly. Because of these various improvements in the trauma system, PTDs markedly decreased from 25.6% to 51.5% of all trauma deaths in the latter half of the 1960s to 0.9% to 20.7% of all trauma deaths in the latter half of the 1980s[31,32].

Future Perspectives of the Trauma System in Japan

JPTEC has developed a standard prehospital trauma care program for EMTs which is being introduced nationwide. Although this program is positioned as part of private learning programs or as lifetime education in many regions, it is expected to be adopted by EMT and paramedic schools and to become a foundation of the medical control system[33]. In March 2003, a committee of the Foundation for Ambulance Service Development proposed a new standard that allows over-triage for emergency patient transport[34]. In the ACSCOT guidelines[28], it is acceptable to increase the over-triage rate to 30% to 50% to limit the under-triage rate to 5% to 10%.

In the transportation system, it is necessary to construct a nationwide EMS helicopter system in which every kind of seriously ill or severely wounded patient can receive appropriate medical care within 15 minutes. This system might include Doctor-Helis, fire department helicopters, Self-Defense Forces helicopters, police helicopters, Coast Guard helicopters, and private helicopters[35]. The appropriate funds should be secured to finance the EMS helicopter program. The JATEC program, which is a standardized trauma training course for physicians, was developed and expanded, and the standard text[7] was issued by a joint committee of the Japanese Association for the Surgery of Trauma and the Japanese Association for Acute Medicine. In the near future, every doctor who treats trauma patients in a lifesaving emergency center should be required to be certified by the JATEC. With the experience in the United States as a reference, Japanese trauma centers should be improved according to suitable domestic standards. Trauma centers are urgently needed nationwide because treatment outcomes for trauma, myocardial infarction, and stroke are excellent in hospitals that treat many cases[36–38]. The trauma center must be positioned as a medical institution including prehospital and lifesaving emergency care and rehabilitation of the trauma patient, as part of a consistent policy (**Fig. 7**). Japan's Trauma Registry was started jointly by the Japanese Association for the Surgery of Trauma and the Japanese Association for Acute Medicine in January 2004, but participation in the registry remains optional[8]. In the future, every hospital that has a responsibility for trauma care should participate in the Trauma Registry, so that the quality of trauma care can be evaluated and be improved. Physicians and other medical workers who are involved need to maintain and improve the quality of trauma care.

Conclusion

We reviewed the history of the trauma system in Japan, its present state and problems, and future perspectives, and compared it with the trauma system in the United States. The extension of the procedures that can be performed by Japanese paramedics and the establishment of a medical control system were discussed as an essential problem of prehospital care. However, the key to securing quality regional trauma care is to designate a trauma care hospital as a trauma center and to transport severely injured patients there as rapidly as possible. That is to say, it is necessary to position the base trauma center as a medical control center that has the responsibility to educate and train EMTs and paramedics. Of course, this center is expected to be a multidisciplinary research and education center for professionals in trauma care.

Although the elimination of PTD is the goal of trauma physicians, this objective must be accomplished in conjunction with multidisciplinary partners. When quality of all phases of trauma care (prehospital, transport, and hospital) is high, the lives of more severely injured patients can be saved and sequelae can be minimized[23]. If the number of traffic-related deaths is to be halved, the trauma system must be given sufficient resources by governments and by private companies, and barriers around ministries and agencies must be removed.

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