Pediatr Surg Int (2013) 29:1047–1051
DOI 10.1007/s00383-013-3405-6

REVIEW ARTICLE

Care of children in a natural disaster: lessons learned from the Great East Japan earthquake and tsunami

Takeo Yonekura · Shigeru Ueno · Tadashi Iwanaka

Published online: 31 August 2013

Abstract The Great East Japan earthquake was one of the most devastating natural disasters ever to hit Japan. We present features of the disaster and the radioactive accident in Fukushima. About 19,000 are dead or remain missing mainly due to the tsunami, but children accounted for only 6.5 % of the deaths. The Japanese Society of Pediatric Surgeons set up the Committee of Aid for Disaster, and collaborated with the Japanese Society of Emergency Pediatrics to share information and provide pediatric medical care in the disaster area. Based on the lessons learned from the experiences, the role of pediatric surgeons and physicians in natural disasters is discussed.

Keywords Earthquake · Tsunami · Nuclear accident · Natural disaster · Children

T. Yonekura
Department of Pediatric Surgery, Nara Hospital, Kinki University School of Medicine, 1248-1 Otuda-Chou, Ikoma, Nara 630-0293, Japan

T. Yonekura (✉)
Chief of Committee of Survey for Pediatric Emergencies of the Japanese Society of Pediatric Surgeons, Department of Pediatric Surgery, Kinki University School of Medicine, 1248-1 Otuda, Ikoma, Nara 630-0293, Japan
e-mail: yonekura@nara.med.kindai.ac.jp

S. Ueno
Immediate Past-Executive Director of Committee of Survey for Pediatric Emergencies of the Japanese Society of Pediatric Surgeons, Department of Pediatric Surgery, Tokai University School of Medicine, 143 Shimokasuya, Isehara, Kanagawa 259-1193, Japan

T. Iwanaka
Immediate Past-President of the Japanese Society of Pediatric Surgeons, Department of Pediatric Surgery, University of Tokyo Hospital, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8655, Japan

Introduction

Over the past two decades, the world has experienced natural disasters of the 2001 Hurricane Katrina, 2004 Indian Ocean earthquake and tsunami, 2005 Pakistan earthquake, 2008 China Sichuan Wenchuan earthquake, 2009 Sumatra earthquake, and 2010 Haitian and Chilean earthquakes. These natural disasters caused considerable mass casualties and devastation.

Japan has been frequently plagued by earthquakes and tsunami. On January 17, 1995, the Hanshin-Awaji epicentral earthquake with a magnitude of 7.3 on the Richter scale struck Kobe [1]. While Japan had comprehensive modern building codes, there were many older residences that were destroyed by the earthquake. A total of 5,502 people died and 41,527 were injured. Most of these disaster victims were crushed under collapsed houses, and the invalid/death ratio was 6.80. As a consequence, nationwide disaster medical assistance teams (DMATs) were developed in Japan.

Children and infants are vulnerable in a disaster [2]. They need to rely on others to take care of their needs, both during and after the disaster. Moreover, pediatric disaster victims often require special care differing from the needs of adult disaster victims [3]. This paper provides an overview of victims in the 2011 East Japan earthquake and tsunami and our aid efforts and the issues raised, and discusses the role of pediatric surgeons and pediatricians in a disaster.

The Great East Japan earthquake

Triple disaster: earthquake and tsunami followed by nuclear accident

The Great East Japan earthquake occurred at 14:46 on March 11, 2011. The epicenter of the earthquake occurred

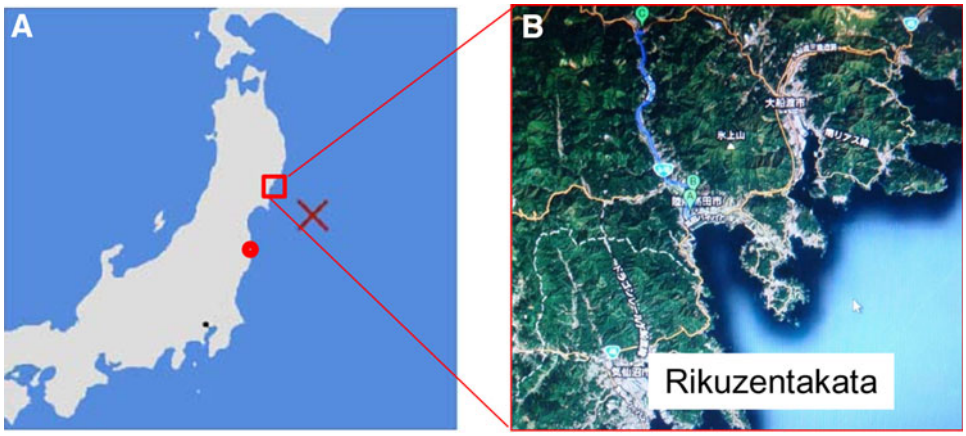

Fig. 1 The Great East Japan earthquake. *X* epicenter of the Great East Japan earthquake. *Open box* Rikuzentakata City. *Filled circle* the nuclear power plant in Fukushima

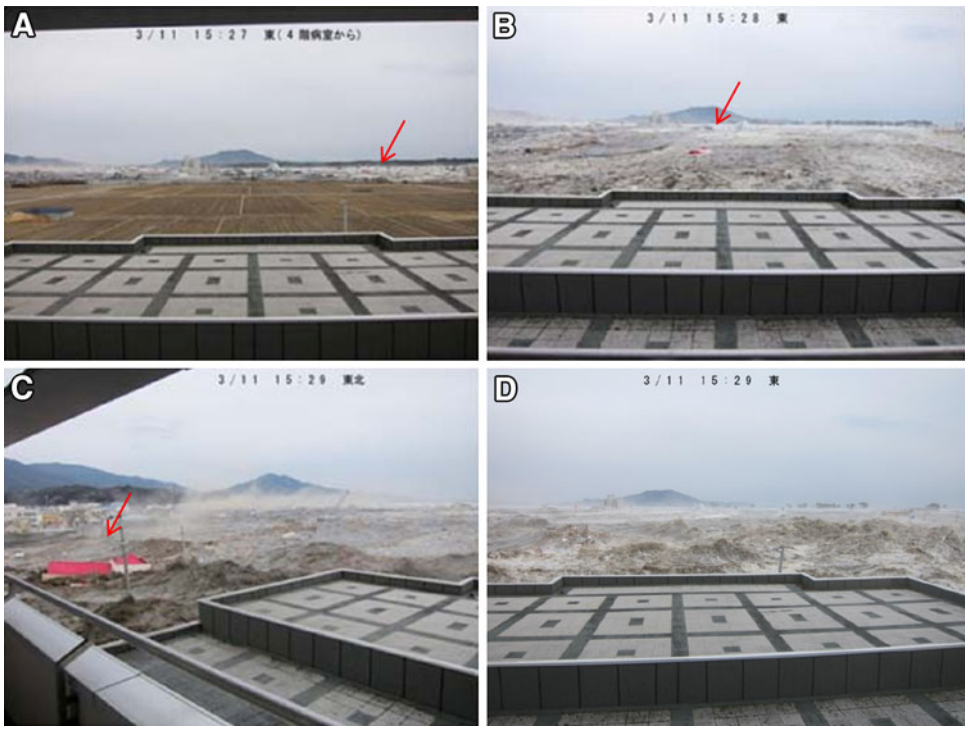

Fig. 2 When the tsunami struck Rikuzentakata City. View from the fourth floor of the Iwate Prefectural Takata Hospital. The tsunami struck the pine grove, and devastated the city within a few minutes. The *red arrow* marks the roof of the Kentucky fried chicken store. The fourth floor of the hospital was under water immediately afterwards. (Photos provided by Dr. Haruo Maeta)

130 km east-southeast of the Ojika Peninsula, with a registered magnitude of 9.2 (Fig. 1). It was an unprecedented triple disaster, with an earthquake and tsunami followed by the destruction of a major nuclear power plant in Fukushima. Three prefectures in the Tohoku region, Miyagi, Iwate, and Fukushima, have been stricken and devastated by the tsunami, of which the maximum vertical height was 40 m above sea level [4]. A large number of rescue teams from emergency-response organizations, the military, and DMATs responded to the disaster immediately after the earthquake. Compared with other types of natural disaster, an earthquake and subsequent tsunami are much more harmful and unpredictable and cause a significant loss of life and property (Fig. 2). Most triage levels of the victims were either black or green. A total of 16,131 people died and 3,240 remain missing, mainly due to the tsunami, and 5,994 were injured. Thirty percent of the population was over 60 years of age in the disaster area, and more than 60 % of the deaths were in this age cohort. Children and adolescents younger than 19 years accounted for 6.5 % of the dead [5]. The invalid/death ratio was 0.30, and there was little need for hyper-acute medical care or wide-area medical evacuation. This is a distinctive feature of a tsunami disaster. The earthquake and tsunami caused the meltdown of the reactors at the Fukushima Daiichi nuclear power plant. A large amount of radioactive material was released into the environment. About 88,000 residents were evacuated from areas within a 20 km radius of the power plant and areas with elevated levels of radiation [6].

Fig. 3 Inside the Iwate Prefectural Takata Hospital after the tsunami. The third and fourth floors of the hospital were devastated by the tsunami. Pine trees were washed into the room. (Photos provided by Dr. Haruo Maeta)

Medical support for pediatric victims in Rikuzentakata

No local information, especially regarding children, was available because communication and traffic networks were shut down over a wide disaster area. We, the Japanese Society of Pediatric Surgeons, set up the Committee of Aid for disaster (CAD) on March 14, and collaborated with the Japanese Society of emergency pediatrics (JSEP) to share information and provide pediatric medical care. The CAD developed a bulletin board system on the JSPS website to share information among the members. The numbers of pediatric patients who needed air transportation were very limited, whereas regionalized systems of care for children who were critically ill were prepared. The advance team of the JSEP gathered information on the medical needs of children in the stricken area. As a result, from March 18 to May 11, 21 doctors, including 4 pediatric surgeons, offered successive pediatric medical care in Rikuzentakata in Iwate, where 90 % of the city was destroyed by the tsunami (Fig. 3). Regional medicine collapsed because regional hospitals were damaged and medical staff were victims of the disaster themselves (Fig. 4). We provided medical care to many children who evacuated to the largest shelter in the city. There were many children who suffered from the common cold and enterocolitis due to poor sanitary conditions in the shelter. Continuing mental health interventions should be allocated to children at risk of symptoms of posttraumatic stress disorder and depression. The loss of parents was particularly devastating for children. There were 229 children and adolescents younger than 18 years who lost both their parents and 1,295 who lost one of their parents in the disaster [7]. Children who had lost their parents needed long-term social and mental health support.

Pediatric surgeons and pediatricians should proceed onsite to understand the medical needs of affected children who are in a minority in large disasters. Careful evaluation of the local conditions can help reduce associated risks to children by assessing the security situation, determining the availability and accessibility of food and clean water, and assessing sanitary conditions, the status of transportation and infrastructure, and the availability of emergency evacuation [8]. A lack of logistics, however, is a problem in a large disaster. It took about half a day to reach Rikuzentakata from Osaka because the transport network had been severely disrupted by the earthquake even 1 month after the disaster.

Survey of radiation exposure in Fukushima

Several surveys were reported to estimate adverse effects on children due to internal and external radiation. The Fukushima health management survey provided a basic survey to estimate levels of external radiation exposure among all 2.05 million residents and four detailed surveys that comprised thyroid ultrasound examination for all children in Fukushima aged 18 years or younger, a comprehensive health check, mental health and lifestyle survey, and pregnancy and birth survey [9]. Low levels of internal cesium radiation ranging from 2.8 to 57.9 Bq/kg (median 11.9 Bq/kg) were detected in 235 children aged 6–15 years [10]. The median thyroid equivalent dose was estimated to be 4.2 and 3.5 mSv for children and adults, respectively, much smaller than the mean thyroid dose in the Chernobyl accident (490 mSv in evacuees) [11]. The Fukushima Daiichi nuclear power plant is now under control; however, it will take more than 40 years to decommission the plant [12]. Longitudinal cohort studies are needed to reveal the long-term effects of the Fukushima nuclear accident on children [6].

Care and preparedness for children in disasters

The number of pediatric deaths was small in the Great East Japan earthquake because the earthquake and tsunami occurred in the daytime. Moreover, schoolchildren and

Fig. 4 Devastation of Rikuzentakata City and the shelter. The tsunami destroyed almost the entire city of Rikuzentakata (**a–c**). A total of 1,850 victims sought refuse in one of the largest shelter in the city (**d**)

even kindergarteners in the Tohoku region had periodically practiced rapid evacuation from a tsunami.

The critical functions of DMATs are triage, stabilization (medical/surgical resuscitation), definitive medical/surgical care, and evacuation. An analysis of four disasters noted that 29.5 % of disaster victims at DMAT field clinics were pediatric patients [13]. Pediatric disaster victims often require special care and considerations that differ from those of adult disaster victims [3, 14, 15]. DMATs, however, often lack pediatric equipment, protocols, and personnel trained to care for children. Pediatric disaster victims have unique physiological characteristics, patterns of injury, and psychosocial needs in such settings [16]. Therefore, pediatric healthcare professionals have a critical role to play in treating diseases and injuries in a disaster. Essential aspects of preparation include pediatric-specific clinical skills, supplies and equipment, operational disaster plans, and interagency practice [17]. The task force for pediatric emergency mass critical care stated that supplies and equipment must be available for a tripling of capacity above the usual peak pediatric intensive care unit capacity for at least 10 days [18].

Regional systems for responding to public health emergencies should be established with close cooperation of public–private partnerships [19]. The military could play an important role due to their ability to respond in a timely fashion and logistic capabilities in a catastrophe caused by a large earthquake and tsunami. Japan's self-defense forces conducted disaster support in an operation named "From the Sea".

Pediatric surgeons and pediatricians should proceed on-site to the disaster area. Careful evaluation of the local conditions while identifying and defining the "on the ground" needs can reduce risks to children from a disaster. A regionalized system for transportation is mandatory. The most severely injured children should be transported from the affected area after initial stabilization to pediatric trauma centers that include pediatric surgeons, pediatric-trained orthopedists, neurosurgeons, and emergency physicians. The availability of a pediatric trauma center would result in a relative mortality risk reduction of 37 % [20].

During the sheltering and recovery phases, medical support teams should be prepared to treat acute illness and prevent a pandemic, but they also need to provide care for chronic illnesses and primary care including vaccinations. Health care providers must also pay attention to children with special healthcare needs and disabilities [21]. They often depend on medication, medical equipment (e.g., ventilators, suctioning devices, and infusion pumps), and complex management plans of care, formulas, and dietary supplements, which frequently depend on local gas, water, and electric companies for support [22]. Continuing attention should be paid to the mental health of children because the psychological impact may last for many years

after the event [23]. Family centered care is recommended to be practical in most disasters [24]. Preventing separation when possible and reuniting families as soon as possible during disaster recovery is critical for the well-being of children. A web-based data system using centralized tracking systems should be instituted.

Summary

The 2011 Great East Japan earthquake was a triple disaster, involving an earthquake, tsunami, and nuclear accident that the world had never previously experienced. The tsunami resulted in the deaths of many residents, and devastated local societies including regional medicine over a wide area. A lack of logistics was a major problem in such a large disaster. Pediatric surgeons, who are generalist and also specialists for pediatric trauma, should proceed on-site to understand and serve the medical needs of affected children who are in a minority in large disasters. The long-term effects of the Fukushima nuclear accident on child and adolescent health remain uncertain.

Acknowledgments Successive pediatric medical care in Rikuzentakata was carried out through the efforts of Drs. Naoki Shimizu, Osamu Saito, and Koutarou Ichikawa of the Japanese Society of Emergency Pediatrics. The pediatric surgeons Mitsugu Owari, Katsuji Yamauchi, and Takuya Kosumi of Nara Hospital, Kinki University School of Medicine also involved. We are particularly grateful to Dr. and Director Mikihito Ishii and members of Iwate Prefectural Takata Hospital for their hospitality in Rikuzentakata. Finally, we would like to express our sincere appreciation and respect to all the people of the world who prayed for and donated to the victims.

References

1. Nakamura H (1995) Overview of the Hanshin-Awaji earthquake disaster. Acta Paediatr Jpn 37:713–716
2. Weiner DL, Manzi SF, Waltzman ML, Morin M, Meginniss A, Fleisher GR (2006) FEMA's organized response with a pediatric subspecialty team: the national disaster medical system response: a pediatric perspective. Pediatrics 117:S405–S411
3. Gnauck KA, Nufer NE, LaValley JM, Crandall CS, Craig FW, Wilson-Ramirez GB (2007) Do pediatric and adult disaster victims differ? A descriptive analysis of clinical encounters from four natural disaster DMAT deployments. Prehosp Disas Med 22:67–73
4. Fire and Disaster Management Agency of the Ministry of Internal Affairs and Communication (2012) Touhokuchihou Taiheiyouoki Jishin, Dai 143 Hou [Report on the Great East Japan Earthquake, No 143]. http://www.fdma.go.jp/bn/higaihou/pdf/jishin/143.pdf (Accessed Feb 6 2012)
5. Higashi Nihon Daishinsai Giseisya no Danjyo, Nenrei Kousei [Age and sex composition of mortality in the Great East Japan Earthquake] (2012) http://www2.ttcn.ne.jp/honkawa/4363f.html (Accessed Feb 6 2012)
6. Hayashi K, Tomita N (2012) Lessons learned from the Great East Japan earthquake: impact on child and adolescent health. Asia Pac J Public Health 24:681–688
7. Ministry of Health, Labour and Welfare (2011) Background paper prepared for the upper house Tohoku reconstruction committee on 1st Aug 2011
8. Murray JS, Monteiro S (2012) Disaster risk and children. Part I: why poverty-stricken populations are impacted most. J Spec Pediatr Nurs 17:168–170
9. Yasumura S, Hosoya M, Yamashita S, Kamiya K, Abe M, Akashi M, Kodama K, Ozasa K, Fukushima Health Management Survey Group (2012) Study protocol for the Fukushima health management survey. J Epidemiol 22:375–383
10. Tsubokura M, Gilmour S, Takahashi K, Oikawa T, Kanazawa Y (2012) Internal radiation exposure after the Fukushima nuclear power plant disaster. JAMA 308:669–670
11. Tokonami S, Hosoda M, Akiba S, Sorimachi A, Kashiwakura I, Balonov M (2012) Thyroid doses for evacuees from the Fukushima nuclear accident. Sci Rep 2:507
12. IAEA (2013) Fukushima nuclear plant cleanup may take more than 40 years. http://hardware.slashdot.org/story/13/04/23/2139218/fukushima-nuclear-plant-cleanup-may-take-more-than-40-years (Accessed Apr 24 2013)
13. Markenson D, Redlener I (2004) Pediatric terrorism preparedness national guidelines and recommendations: findings of an evidence-based consensus process. Biosec Bioterror 2:301–319
14. Mace SE, Bern AI (2007) Needs assessment: are DMAT's up for the challenge of a pediatric disaster? Am Emerg Med 25:762–769
15. Murray JS (2010) Responding to the psychosocial needs of children and families in disasters. Crit Care Nurs 22:481–491
16. Burke RV, Iverson E, Goodhue CJ, Neches RN, Upperman JS (2010) Disaster and mass casualty events in the pediatric population. Sem Pediatr Surg 19:265–270
17. Kanter RK (2012) Regional variation in critical care evacuation needs for children after a mass casualty incident. Disaster Med Public Health Prep 6:146–149
18. Bohn D, Kanter RK, Burns J, Barfield WD, Kissoon N, Task Force for Pediatric Emergency Mass Critical Care (2011) Supplies and equipment for pediatric emergency mass critical care. Pediatr Crit Care Med 12:S120–S127
19. Barfield WD, Krug SE, Kanter RK, Gausche-Hill M, Brantley MD, Chung S, Kissoon N (2011) Neonatal and pediatric regionalized systems in pediatric emergency mass critical care. Pediatr Crit Care Med 12:S128–S134
20. Barthel ER, Pierce JR, Goodhue CJ, Ford HR, Grikscheit TC, Upperman JS (2011) Availability of a pediatric trauma center in a disaster surge decreases triage time of the pediatric surge population: a population kinetics model. Theor Biol Med Model 8:38
21. Takada S, Shintani Y, Sohma O, Tsuneishi S, Uetani Y, Nakamura H (1995) Difficulties of families with handicapped children after the Hanshin-Awaji earthquake. Acta Paediatr Jpn 37:735–740
22. Peek L, Stough L (2010) Children with disabilities in the context of disaster: a social vulnerability perspective. Child Develop 81:1260–1270
23. Jia Z, Shi L, Duan G, Liu W, Pan X, Chen Y, Tian W (2013) Traumatic experiences and mental health consequences among child survivors of the 2008 Sichuan earthquake: a community-based follow-up study. BMC Public Health 13:104
24. Mason KE, Urbansky H, Crocker L, Connor M, Anderson, Kissoon N, Task Force for Pediatric Emergency Mass Critical Care (2011) Pediatric emergency mass critical care: focus on family-centered care. Pediatr Crit Care Med 12:S157–S162