PEDIATRIC TRAUMA

Proceedings of the Third National Conference

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Pediatric Trauma

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PREFACE

This book is a compilation of the major lectures given at the Third National Conference on Pediatric Trauma in Ann Arbor, Michigan, on September 20 to 23, 1989. The authors of these chapters have presented the latest information available in their areas of expertise. This series of lectures is not a comprehensive review of the entire field of pediatric trauma but rather highlights the major clinical and experimental advances. We hope this book will act as a stimulus for future clinical and laboratory research in this rapidly growing field of pediatric care.

Arnold G. Coran, M.D.
Burton H. Harris, M.D.

CONTENTS

CHAPTER 1

Toward a Comprehensive Emergency Medical System for Children

J. Alex Haller, Jr.

Systems management of life-threatening injuries in children and adults is now accepted in the United States and Canada as state of the art care for trauma victims. A few regional trauma systems for adults have had several decades of experience and have served recently as models for inclusion of pediatric trauma.[1] In certain areas, notably Pennsylvania, an emergency medical system with fully integrated adult and children's components has come into being. The National Pediatric Trauma Registry, which includes more than 12,000 children, is indicative of the significant problem of trauma in this age group and offers a base for statistical analysis of injury severity and long-term rehabilitation needs.[2]

Since 1985, several projects under federally funded state demonstration grants for pediatric emergency medical services have attempted to establish guidelines for patient care and to suggest methods for ongoing monitoring of these systems' effectiveness, surveillance of quality, and review of patient outcome.

A statewide, designated pediatric trauma center for Maryland, located in The Johns Hopkins Children's Center, has functioned for 12 years.[3] Data are now available to allow some objective evaluation of the effectiveness and impact of this regional pediatric trauma program.

The level of compliance within Maryland's regionalized pediatric trauma system from 1979 to 1986 was examined recently, using data recorded routinely on all discharges from 58 acute care hospitals in the Maryland.[4] Compliance with regionalization was measured by examining the proportion of patients within each category of injury severity scores (ISS) who were treated at each of three levels of care (statewide pediatric trauma center [SPTC], regional trauma center [RTC], and community hospital [COHO]) and the proportion of in-hospital deaths that occurred at each level of care. During this 8-year period, 30,214 children under 13 years were discharged from a Maryland hospital with the principal diagnosis of trauma. The proportion of patients treated at a SPTC or RTC increased from 32%

in 1979 to 42% in 1986. In the most severely injured group (ISS > 12) the proportion of patients treated at a SPTC increased from 28% to 36%. Overall, 90% of the 174 in-hospital deaths during the study period occurred in designated trauma centers. The percent treatment at SPTC, RTC, and non-RTC for each ISS group for 1986 is presented in Table 1-1 (n = 2937).

The relationship between ISS and level of care indicates good overall compliance with the system; as severity of trauma increased, the child was more likely to be treated at a higher level of care. The younger the child, the more likely the patient was to be admitted to the SPTC. Assessing and monitoring compliance with regionalization is essential in systems management and in evaluation of pediatric trauma care.

The systems approach to trauma management makes it possible to divide a region by geographic area or population composition. Maryland is divided into five EMS regions, based upon geographic and population differences. This allows for statistical evaluation of differences in types of injury (e.g., rural or mountainous areas versus densely populated metropolitan areas).

Several components are intrinsic to such a program. First, a two-way radio communication system between a hospital and emergency medical technicians at the scene of an emergency that will allow for communication with physicians, identification of medical specialists in nearby hospitals, and thus determine the destination of a child patient.

Second, a dependable transport system, preferably tax-supported, which may include several modalities. In Maryland, these components include radio-controlled police helicopter transport, which is initiated through an emergency medical relay center. Transportation to the appropriate specialty facility is arranged through the relay center for each case at the scene. In metropolitan areas of the system, ground transport is by specially equipped, fire-department-staffed ambulances, which operate under the same systems control and communication.

Third, emergency medical technicians must receive specialized training in the care of newborn infants and children from pediatric specialists such as neonatologists, pediatric surgeons, pediatric emergency physicians, and anesthesiologists. Technicians are then qualified to begin IV treatment of small infants, including intraosseous infusions, and to intubate babies and young children. Such training must be a part of the ongoing training program for emergency medical technicians within the regional system. These training programs must be carefully monitored and the technicians must be retested and retrained at appropriate intervals.

Table 1-1.

Level of Care	*ISS 1–4*	*ISS 5–8*	*ISS 9–12*	*ISS > 12*
SPTC	10%	16%	21%	37%
RTC	24%	25%	30%	36%
COHO	66%	59%	49%	27%

Fourth, designated pediatric intensive care units (ICUs) must be centralized within such a system. Within such ICUs, the patient stations must be equipped with multiple-channel monitoring equipment and ventilators, and staffed for immediate detection of cardiopulmonary arrest, for resuscitation, and for continuing post-trauma management. A small, dedicated on-site blood gas laboratory will provide immediate blood gas determination necessary for the moment-to-moment management of these unstable patients.

Fifth, an intermediate care unit is an important component of such a system. It decreases congestion in the pediatric ICU and provides "stepdown" management and continuing care while allowing more family and primary physician input.

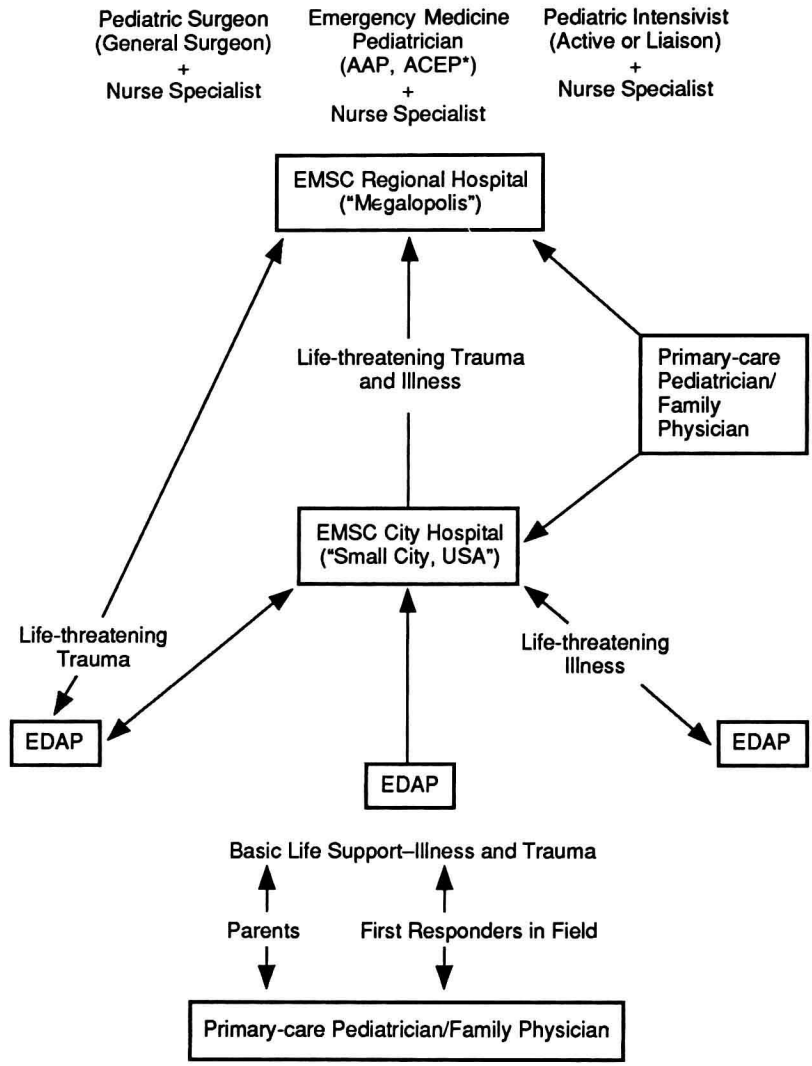
Sixth, a dedicated pediatric rehabilitation unit, under the direction of pediatric physiatrists, neurologists, and other pediatric behavior and learning specialists, provides important support for the eventual recovery of the child trauma patient.

Finally, as asserted by the recent Ross Conference on Emergency Medical Services for Children,[5] the establishment of designated pediatric trauma centers is a natural step toward increasing systems management of life-threatening illnesses as well as injuries. As shown in Figure 1-1, an integrated system emphasizes the close interdependence of primary-care pediatricians, pediatric surgeons, emergency medicine physicians, and critical-care pediatricians in the sequential resuscitation and total management of severely ill and injured children. Within this system, emergency-care nurse specialists work closely with physicians and complete the dedicated and committed basic emergency medical team.

The recently reorganized standing Committee on Emergency Medical Services for Children of the American Academy of Pediatrics, which is composed of pediatricians, emergency physicians, and pediatric surgeons, has been charged with the responsibility of developing national standards of emergency care for children, including both life-threatening illnesses and serious injuries.

Currently, access to such EMSC systems is variable, and a strong educational effort by pediatric health-care providers will be necessary to facilitate entry into the EMSC system. Entry may occur directly from the field by means of paramedics, (e.g., with trauma), by parent transport (e.g., with high fever or seizures), or by primary-care pediatricians (e.g., family physicians) from their offices directly to the regional center or more commonly to "emergency departments appropriate for pediatric care," called EDAPs by Seidel and associates.[6] The whole system is integrated by central EMSC communication, and alarm and transport is controlled on-line by dedicated, experienced pediatric emergency physicians. The major challenge remains of establishing criteria for early detection of childhood illnesses that may rapidly become life-threatening, so that these children can enter the appropriate component of the system before death is impending.

With further integration of such emergency medical services for children and close cooperation among pediatric emergency physicians and pediatric surgeons, such systems management offers an important opportunity to extend modern pediatric critical care to children in the home, in the field, and during transport to designated centers for emergency medical care.



*AAP = American Academy of Pediatrics; ACEP = American College of Emergency Physicians

Figure 1-1. The EMSC is an integrated system for the provision of care.

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CHAPTER 2

The Economics of Pediatric Trauma Care

George D. Zuidema and Peter I. Buerhaus

According to economic theory, the price of a commodity or service and the amount that is sold are determined by the factors affecting its demand and the factors affecting its supply. We do not intend to argue in this chapter that economic theory and its underlying assumptions can or should be applied to an analysis of the price and quantity of pediatric trauma care services that are "consumed." An economic framework is used because it provides a way to organize and discuss issues that affect the delivery of pediatric trauma care and that might not otherwise be described in this book. Furthermore, regardless of one's feelings about the desirability of adapting the principles of economics to the delivery of health care services, the infusion of economic behavior and market competition have become the hallmark of the 1980s, and there is little reason to suggest that this will not continue in the 1990s. It is important, therefore, that physicians and others concerned with developing the nation's pediatric trauma care system become aware of some of the economic forces likely to influence the quantity and quality of pediatric trauma care in the years ahead.

Demand for Pediatric Trauma Care Services

Examining the frequency of injuries provides a number of indicators of the total demand for pediatric trauma care services. The Congressional Office of Technology Assessment (OTA) estimated that each year 353,000 children are hospitalized nationally for traumatic injuries.[22] According to this estimate, each year about 1 in every 130 children is hospitalized because of injury. Expressed differently, before age 15, it can be expected that 1 child in every 9 will be hospitalized for a trauma-related injury. With respect to the number of emergency room visits owing to injuries, the OTA reports that children under age 15 make nearly 10 million emergency room visits each year. Of the total number of emergency room visits, Brill reports that 20 percent to 35 percent are made by children or adolescents; and during weekends and nights, children may comprise up to 40 percent of all emer-

Table 2-1. Percentage of Deaths from Injury and Other Causes

Cause	*Age*		
	1–4 yr	*5–14 yr*	*15–24 yr*
Injuries	46	55	79
Congenital anomalies	13	5	—
Cancer	7	14	5
Pneumonia/Influenza	3	—	—
Heart and liver disease	4	3	3
Other	27	23	13

(National Research Council and the Institute of Medicine: Injury in America: A continuing public health problem, p. 4. Washington, DC, National Academy Press, 1985)

gency room visits.[3] Moreover, Brill estimates that as many as 18 million children receive emergency room care and that 4 million (i.e., 22%) of these take place in rural hospitals with fewer than 100 beds.

Mortality rates for children are another indicator of the demand for pediatric trauma care. Table 2-1 shows that, between age 1 and 4 years, injuries account for nearly half (46%) of all deaths, more than half (55%) of the deaths in children age 5 to 14 years, and nearly four fifths (79%) of the deaths of children aged 15 to 24 years. Injuries account for far more deaths among children than do congenital anomalies, cancer, pneumonia and influenza, and heart disease.[12]

Table 2-2 lists the types of vehicle related and non-vehicle related accidents responsible for child mortality during 1984. Of the total number of fatalities, motor vehicle accidents caused the greatest number of deaths, particularly for ages 5 to 14 years. In addition, more children who were pedestrians were killed than were those who were occupants of a vehicle. With respect to the number of non-vehicle

Table 2-2 Number of Accidental Vehicle Deaths in Children, 1984

Type of Accident	*Number of Fatalities by Age*			
	< 1 yr	*1–4 yr*	*5–14 yr*	*Total*
Motor vehicle	161	977	1138	3401
Person killed:				
Occupant	115	349	420	1173
Pedestrian	14	502	321	1325
Pedal cycle	0	17	218	334
Motorcycle	0	4	98	124
Other	32	105	190	435
Air, rail and water craft	1	31	75	138
Other vehicle	0	9	24	50

(U.S. Congress, Office of Technology Assessment: Healthy children: Investing in the future, OTA-H-345. Washington, DC, U.S. Government Printing Office, 1988)

related fatalities, Table 2-3 shows that fires and burns were the leading cause of death, while other causes clustered into specific age groups: deaths from choking were most common in infancy; deaths from poisoning, falls, and drownings were more common in preschoolers; and deaths from firearms were rare in young children under age 5, but were the third leading cause of death in older children.

An economic approach to health care analysis also attempts to identify sociodemographic and economic characteristics of the population that affect the demand for pediatric trauma care. For example, when comparing accidental death rates by gender, the rate for boys is higher than that for girls.[2] A study on teenage mothers found that infants with very young mothers had significantly higher accident rates than infants with older mothers.[19] With respect to economic influences, persons with low incomes have higher injury-related mortality rates than wealthier persons,[16] which could indicate a lack of either general or health care-focused education or the resources to modify home or neighborhood environments.[22] And it has been shown that while there are more fire-related injuries among low-income urban-dwelling children, among low-income rural children more injuries are caused by farm equipment, poor roads, cars traveling at high speeds, and a lack of quick emergency response and transportation.[12, 16]

Injury prevention strategies are a final but important factor affecting the demand for pediatric trauma care. Three types of strategies to prevent injuries have been identified:[12,17] persuasion through educational programs (e.g., teaching the value of using seatbelts); regulating an individual's behavior (e.g., requiring use of infant car seats or the installation of smoke detectors); and automatic protection devices that help prevent injury through product or environmental design (e.g., equipping automobiles with passive restraints that automatically "seat belt" the occupant, or providing air bag restraints).

In general, education strategies designed to to prevent accidents are the least costly. Typically, they are implemented at the local level and have been shown to

Table 2-3. Non-Vehicle Accidental Deaths of Children, 1984

	Age			
Type of Accident	*< 1 yr*	*1–4 yr*	*5–14 yr*	*Total*
Fires and burns	139	641	508	1288
Drowning	70	556	494	1120
Choking	153	118	45	316
Firearms	0	39	259	298
Falls	28	86	68	182
Poisoning	21	77	56	154
Other	265	280	358	903

(U.S. Congress, Office of Technology Assessment: Healthy children: Investing in the future, OTA-H-345. Washington, DC, U.S. Government Printing Office, 1988)