Pediatric 9-1-1: Show Me the Evidence!

Toni Gross, MD, MPH
Phoenix Children’s Hospital
Division of Emergency Medicine
National Association of EMS Physicians, Pediatric Committee Chair
Overview

- EMS history
- EMSC
- Epidemiology
- Current evidence for “hot” topics
  - Airway
  - Seizures
  - Pain management
What is EMS?

- **Emergency Medical Services**
  - Initial component in the continuum of emergency care
  - Types of agencies (*municipal, private, volunteer*)
  - Types of providers (*ALS, BLS*)
  - Function via delegated practice
    - Physicians establish the standard of care for prehospital providers
    - Care is delivered through medical command
      - protocols (*offline*)
      - direct communication (*online*)
Dead Antilochus carried in the chariot of Nestor
Dead Antilochus carried in the chariot of Nestor

Jean Dominique Larrey: ambulances for Napoleon’s army

Ambulance Volante
Dead Antilochus carried in the chariot of Nestor

Jean Dominique Larrey – ambulances for Napoleon’s army

Ambulance Volante

1864

Congress passes Ambulance Corps Act

Dr. Jonathan Letterman

Wagons of the 57th New York's ambulance corps remove wounded from the field after the Battle of Fredericksburg.
Dead Antilochus carried in the chariot of Nestor

Jean Dominique Larrey – ambulances for Napoleon’s army

Congress passes Ambulance Corps Act

Ambulance Voilante

First Geneva Convention

THE GENEVA CONVENTION

THE GENEVA CONVENTION
EMS History

Dead Antilochus carried in the chariot of Nestor

Jean Dominique Larrey – ambulances for Napoleon’s army

Congress passes Ambulance Corps Act

Ambulance Volante

Cincinnati: 1st civilian-run, hospital-based ambulance service

NYC: 1st municipal-based EMS

1865 - 1869

EMS History

Dead Antilochus carried in the chariot of Nestor

Jean Dominique Larrey – ambulances for Napoleon’s army

Congress passes Ambulance Corps Act

Cincinnati

NYC

1928

Roanoke Life Saving and First Aid Crew: 1st EMS agency trained for on-scene care

Julian Stanley Wise
Dead Antilochus carried in the chariot of Nestor

Jean Dominique Larrey – ambulances for Napoleon’s army

Congress passes Ambulance Corps Act

Roanoke Life Saving and First Aid Crew

Cincinnati

NYC

Dead Antilochus carried in the chariot of Nestor

Jean Dominique Larrey – ambulances for Napoleon’s army

Congress passes Ambulance Corps Act

Roanoke Life Saving and First Aid Crew

Cincinnati

NYC

1860’s: Traffic accidents and cardiovascular disease recognized as major health problems
Dead Antilochus carried in the chariot of Nestor

Congress passes Ambulance Corps Act

Roanoke Life Saving and First Aid Crew

1960’s: Traffic accidents and cardiovascular disease recognized as major health problems

Jean Dominique Larrey – ambulances for Napoleon’s army

Cincinnati

NYC

1966: White Paper, National Highway Safety Act

1960's: Traffic accidents and cardiovascular disease recognized as major health problems

National Traffic and Motor Vehicle Safety Act of 1966

Accidental Death and Disability: The Neglected Disease of Modern Society

United States Congress

White Paper, National Highway Safety Act
Dead Antilochus carried in the chariot of Nestor

Congress passes Ambulance Corps Act

Traffic accidents and cardiovascular disease recognized as major health problems
White Paper, National Highway Safety Act

Jean Dominique Larrey – ambulances for Napoleon’s army

Roanoke Life Saving and First Aid Crew

Wedworth Townsend Act, Dept of Health, Education, Welfare, RWJ Foundation funding, EMS Systems Act

Robert Wood Johnson Foundation
EMS History

Dead Antilochus carried in the chariot of Nestor

Congress passes Ambulance Corps Act

Jean Dominique Larrey – ambulances for Napoleon’s army

Roanoke Life Saving and First Aid Crew

Traffic accidents and cardiovascular disease recognized as major health problems

White Paper, National Highway Safety Act

Cincinnati

NYC

Ambulance Volante

RWJ Foundation funding

EMS Systems Act

1864

1865 - 1869

1928

1966

1970 - 1973

1984

2013

EMSC Authorization

EMSC

White Paper, National Highway Safety Act

National Traffic and Motor Vehicle Safety Act of 1966

EMS History

BC 1793

1864

1865 - 1869

1928

1966

1970 - 1973

1984

2013

EMSC Authorization

EMSC
EMS History

Dead Antilochus carried in the chariot of Nestor

1793

Congress passes Ambulance Corps Act

1845 - 1869

Roanoke Life Saving and First Aid Crew

1928

Traffic accidents and cardiovascular disease recognized as major health problems

1966

White Paper, National Highway Safety Act

1970-1973

Cincinnati

NYC

Jean Dominique Larrey – ambulances for Napoleon’s army

Ambulance Volante

RWJ Foundation funding

EMS Systems Act

EMSC Authorization

EMS Subspecialty
EMS Oversight and Funding
EMS Oversight and Funding

Logos of various organizations involved in EMS oversight and funding.
EMS Funding

- Federal funding = a small percentage of funds devoted to larger programs
  - DHHS: trauma, rural grants, hospital grants, poison control, EMSC, bioterrorism
  - CDC: preventive health grant, injury prevention
  - DHS: firefighter assistance

- Federal reimbursement
  - EMS billing based upon level of service and distance traveled
EMSC

- Emergency Medical Services for Children
- Government agency authorized in 1984
- Supported by DHHS and NHTSA
- Provides funding to state EMS agencies
- Created the Pediatric Emergency Care Applied Research Network (PECARN)
Evidence Deficiency

“Many of the treatments and management strategies that are widely practiced today are not supported by scientific evidence.”

“The lack of available data on prehospital care not only discourages research on the effectiveness of prehospital interventions, but also hinders the development of process and outcome measures for evaluating the performance of the system.”
Evidence Deficiency

- What is the structure of the system?
- Who uses the system?
- For what is the system used?
- What services or procedures are provided to patients?
- What are the outcomes of using the system?
- How well does the system perform?
Epidemiology

• Who uses the system?
  - Pediatric patients account for 5 - 15% of all prehospital transports
  - 7% of ED patients under age 19 arrive by ambulance

Epidemiology

• For what is the system used?
  - About half are for injury
    • 94% of trauma is blunt
    • Motor vehicle crashes and falls most common
  - < 5 years of age: medical complaints predominate
    • Respiratory distress and seizures most common
  - Patients are transported in 89% of calls
  - Approximately 20% admitted to hospital

Epidemiology

• What services or procedures are provided to patients?
  - ALS intervention 14-38%
    • Medications 13%
    • IV access 12%
    • Airway management 2.5%
  - BLS intervention 43%
    • Oxygen administration 27%
    • Spinal immobilization 18%

• < 5 years of age: fewer interventions

Prehospital Education

- PEPP (AAP)
- EPC (NAEMT)
- PALS (AHA)
- BLS (AHA)
- Modular Online CME
  - Emergency Medicine Learning and Resource Center
The Evidence

- Airway
- Seizures
- Pain management
An 8-year-old boy is brought to the emergency department by ambulance after being struck by a motor vehicle while crossing the street
- Unconscious at scene
- Prehospital notification: ETA 12 minutes
- Arrives boarded and collared
- GCS = 8 (M^4V^2E^2)
- Receiving bag-valve-mask (BVM) ventilation
- HR 100, RR 16, SaO_2 96%, BP 92/P
Prehospital Airway Management

- Assumption: ALS skills performed in-hospital can be performed safely and effectively out-of-hospital
  - Endotracheal intubation (ETI) accepted in prehospital practice for more than 20 years
  - Pediatric ETI taught in 97% of paramedic training schools
  - Pediatric ETI success rates: 50% - 100%
  - Major complications in 2% - 23%

Wang 2006, Gauche-Hill 2000
Prehospital Airway Management

Losek 1999 - Milwaukee EMS database

- 78% ETI success rate
  • 93% success in pulseless, nonbreathing patients
  • 48% success rate in impending respiratory failure patients
Vilke 2002 - San Diego EMS database

- ETI attempted in 0.7% of all pediatric calls
  - Median age 2 years
  - 264/324 (82%) had tube secured
  - 3/264 (1%) esophageal intubation
    - All three patients died; deaths ruled unpreventable
Prehospital Airway Management

Ehrlich 2004 - West Virginia single center pediatric trauma registry

- 57% of intubated patients had prehospital ETI
  - 20% by paramedics, 80% by flight nurses
  - 45% success rate for paramedics
  - 70% success rate for flight nurses
  - 27% had complication; 7% had major complication

- >90% of intubated patients had adequate oxygenation/ventilation via BVM documented
Gauche-Hill 2000 - Los Angeles and Orange Counties prospective controlled trial

- Direct comparison of BVM to ETI
  - 830 patients enrolled over 3 years
  - Outcomes analyzed by intention-to-treat

- Overall ETI success rate 58%

- No difference between groups in mortality or neurologic outcome
  - 3 subgroups showed worse outcomes with ETI:
    - Respiratory arrest, foreign body aspiration, child maltreatment
Prehospital Airway Management

DiRusso 2005 -
National Pediatric Trauma Registry

- Intubated patients under age 20 years
  • 5,460/49,747 (11%) of registry intubated
- Risk stratified by injury severity scores
- Patients intubated in prehospital setting had worse outcomes across all injury severity levels
  • Increased mortality
  • More likely to have abnormal functional outcome score
Prehospital Airway Management

Murray 2000 - Los Angeles trauma registry

- Limited to patients with severe head injury, age 11-20 years
  - 32/137 (23%) ETI attempted
  - 22/32 (69%) attempts successful
- Mortality increased in patients receiving ETI and ETI attempt vs. BVM
- No risk stratification based on injury severity
Burton 2003 - Maine EMS database
- Measured EMS provider mean annual exposure to ETI
  • 41% attempted ≥ 1 ETI
  • 1.3% attempted ≥ 5 ETIs
  • 2% attempted pediatric ETI
  • None documented > 2 pediatric ETIs in a year
Wang 2005 - Multicenter paramedic training program data

- Attempted to define learning curve for ETI
  - n = 802
  - Median 7 attempts (IQR 4-12)
    - 89 students reported no attempts
    - 12% performed in prehospital setting
  - Predicted that paramedic students require 15-20 ETI encounters to attain baseline proficiency
    - Implies need for 80,000 OR cases annually in U.S.
Prehospital Airway Management

• Current literature highlights shortcomings associated with prehospital ETI
  - Few studies show improved outcome; several studies describe worsened outcomes
  - Adverse events and errors are frequent
  - May inadvertently interact with other physiologic processes key to resuscitation
  - Significant system-level barriers limit training and clinical experience
Prehospital Airway Management

• Summary
  - Few situations necessitate prehospital ETI
  - ETI is complex procedure
    • Significant amount of training to learn and maintain proficiency
    • C-spine immobilization makes procedure even more demanding
  - Paramedics need to be skilled at BVM ventilation
A 12-year-old female is waiting in the clinic for a scheduled health maintenance visit. She is on Keppra for seizure disorder. A nurse is called to the waiting room to find the patient having a generalized tonic-clonic seizure.
A 12-year-old female is waiting in the clinic for a scheduled health maintenance visit. She is on Keppra for seizure disorder. A nurse is called to the waiting room to find the patient having a generalized tonic-clonic seizure.

- HR 96, RR 10, SaO₂ 95%
A 12-year-old female is waiting in the clinic for a scheduled health maintenance visit. She is on Keppra for seizure disorder. A nurse is called to the waiting room to find the patient having a generalized tonic-clonic seizure.

- HR 96, RR 10, SaO₂ 95%
- Supplemental O₂
- Receptionist calls 9-1-1
- Seizure persists > 5 minutes
A 12-year-old female is waiting in the clinic for a scheduled health maintenance visit. She is on Keppra for seizure disorder. A nurse is called to the waiting room to find the patient having a generalized tonic-clonic seizure.

- HR 96, RR 10, SaO₂ 95%
- Supplemental O₂
- Receptionist calls 9-1-1
- Seizure persists > 5 minutes
- Paramedics arrive, SaO₂ now 90%
Seizure Management

- 10% of all pediatric ambulance calls
- Prehospital management focused on
  - Maintaining airway
  - Adequate oxygenation
  - Establishing IV access
  - Protecting patient from injury
- Most protocols provide for administration of benzodiazepine after 5 minutes
Seizure Management

• Controversial issues
  - Indications for anticonvulsant therapy
  - Choice of anticonvulsant
  - Dose and route of administration
Seizure Management

Alldredge 2001 - San Francisco randomized double-blind placebo-controlled trial

- Lorazepam vs. diazepam vs. placebo
- 205 adults with seizure > 5 minutes
- Seizure terminated by arrival at ED
  - Lorazepam 39/66 (59%)
  - Diazepam 29/68 (43%)
  - Placebo 15/71 (21%)
- No complication difference between groups
Seizure Management

Rainbow 2002 - Australia children’s hospital ED records

- Evaluated safety and efficacy of EMS protocol change from diazepam to midazolam
- n = 107
- Equal efficacy for terminating seizure in 5 min.
- No difference in rates of apnea or ETI
Seizure Management

Vilke 2002 - San Diego EMS database

- Evaluated safety and efficacy of EMS protocol change from diazepam to midazolam
- n = 86; post-Rx assessment in 74 (86%)
- Therapeutic improvement in 67/74 (91%)
  • IV doses more likely to show improvement than IM doses
- Respiratory compromise in 4/86 (5%)
  • All 4 had respiratory compromise before administration of midazolam
Seizure Management

Warden 2006 - Oregon county EMS and ED chart review

- Evaluated safety and efficacy of EMS protocol change from diazepam to midazolam
- n = 93
- Non-significant differences
  - Seizure on arrival to ED
  - Recurrence of seizure in ED
  - Airway maneuvers
  - Admission to hospital
Galustyan 2003 - Milwaukee EMS database

- Evaluated impact of EMS protocol change to decreased dose of diazepam
  - Old dose = 0.25 mg/kg IV or 0.5 mg/kg PR
  - New dose = 0.05 mg/kg IV or 0.1 mg/kg PR
- n = 1,516
- Lower dose had no increase in requirement for additional anticonvulsants in ED
- Lower dose had significantly lower rate of ETI and hospital admission
Seizure Management

Holsti 2007 - Salt Lake City children’s hospital ED and county EMS record review
- Intranasal midazolam vs. rectal diazepam
- n = 124 {57/124 (46%) benzodiazepine-treated}
- IN midazolam
  • Total seizure time 20 minutes shorter
  • Lower rates of
    - Seizure in ED, ETI in ED, additional anticonvulsant in ED, status epilepticus, hospital admission, ICU admission
  • Non-significant difference
    - EMS BVM and ETI
Seizure Management

Silbergleit 2012 - RAMPART Trial, nationwide

- IM midazolam vs. IV lorazepam
- Randomized, double-blind trial
- 33 EMS agencies, 79 receiving hospitals
- Exception from informed consent
- n = 893 (145 under age 21)
- Seizure cessation better with IM midazolam
  - 73% vs. 63% by arrival to ED
  - 2 minutes faster
- Equivalent rates of ETI and seizure recurrence
Seizure Management

• **Summary**
  - Midazolam and diazepam are equally effective for prehospital management of seizures; IM midazolam is more effective than IV lorazepam.
  - Benefits and risks for all.
  - Choice of protocol medication influenced by:
    • Efficacy
    • Safety
    • Route of administration
    • Storage concerns
A 4-year-old boy fell from a swing at the playground. He is tearful but quiet, and has a visible left forearm deformity.
Pain In the Prehospital Setting

EMSOP I 1999
- Pain relief
  • Most relevant outcome parameter for majority of pediatric and adult prehospital conditions
  • Most potential impact on majority of common EMS conditions

EMSOP IV 2002
- Recommendation: all EMS systems should measure severity of pain in all patients
Pain In the Prehospital Setting

NAEMSP position paper 2003

- Pain relief priority for every EMS system
- Every EMS system should have a protocol
  - Mandatory assessment
  - Reliable assessment tools
  - Pharmacologic and non-pharmacologic treatments
  - Mandatory patient monitoring
  - Indications and contraindications
  - Transfer of information
  - Close medical oversight
Pain In the Prehospital Setting

• Challenges
  - Effective but safe techniques
  - Avoid physiologic compromise
  - Do not delay definitive care
  - Do not interfere with ED diagnostic workup

• Barriers
  - Lack of pain assessment tools for different age groups
  - Routes of administration and drug dosing
# Pain In the Prehospital Setting

## Pain Rating Scales

<table>
<thead>
<tr>
<th>Pain Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No pain</td>
</tr>
<tr>
<td>1</td>
<td>Light touch, no apparent distress</td>
</tr>
<tr>
<td>2</td>
<td>Moderate pain</td>
</tr>
<tr>
<td>3</td>
<td>Severe pain</td>
</tr>
<tr>
<td>4</td>
<td>Very severe pain</td>
</tr>
<tr>
<td>5</td>
<td>Worst possible pain</td>
</tr>
</tbody>
</table>

## Pain Scale

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No particular expression or smile</td>
</tr>
<tr>
<td>1</td>
<td>Occasional grimace or frown, withdrawn, disinterested</td>
</tr>
<tr>
<td>2</td>
<td>Frequent to constant frown, sulking, chin tucked, clenched jaw</td>
</tr>
</tbody>
</table>

## FPS-R

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Happy</td>
</tr>
<tr>
<td>2</td>
<td>Sad</td>
</tr>
<tr>
<td>4</td>
<td>Angry</td>
</tr>
<tr>
<td>6</td>
<td>Scared</td>
</tr>
<tr>
<td>8</td>
<td>Painful</td>
</tr>
<tr>
<td>10</td>
<td>Worst possible pain</td>
</tr>
</tbody>
</table>

## Note

- Each of the five categories (Face, Legs, Activity, Cry, and Consolability) is scored from 0-2, which results in a total score between 0 and 10.

Pain In the Prehospital Setting

McLean 2002 - NHAMCS analysis

- Attempt to define epidemiology of pain in patients < 18 years arriving in ED via EMS
- Presenting level of pain

![Pie chart showing pain levels: 52% None, 20% Moderate or Severe, 14% Mild, 14% Unknown]
Pain In the Prehospital Setting

Swor 2005 - Michigan suburban ED

- Patients < 21 years old with extremity fracture or burn
  - n = 73
  - 16/73 (22%) received prehospital analgesia
  - 58/73 (79%) received ED analgesia
  - Prehospital analgesia decreased time to analgesics by 60 minutes
Pain In the Prehospital Setting

McLean 2004 - Michigan county EMS record review
- Assessing feasibility of pain assessment during initiation of pain protocol
- 1,227 patients ≥ 13 years of age
  - 40 patients 13 - 17 years
- 1,002/1,227 (93%) assessment performed
  - Severity
    - Severe 13%
    - Moderate 18%
    - Mild 21%
    - None 48%
Pain In the Prehospital Setting

Hennes 2005 – Milwaukee EMS survey and record review

• Responder estimate
  - Pain assessment
    • Adult  91%
    • Adolescent  31%
    • Child  6%
  - Pain treatment
    • Adult  24%
    • Adolescent/Child  4%

• EMS record
  - Pain assessment
    • Adult  23%-71%
    • Adolescent/Child  4%-13%
  - Pain treatment
    • Adult  4%-14%
    • Adolescent/Child  1%-3%
Pain In the Prehospital Setting

• Summary
  - Pain assessment and treatment varies
  - Pain assessment tools for children exist, but have not been validated in prehospital setting
  - Non-pharmacologic interventions are preferred when transport times are short
  - Chart design important in aiding pain assessment
Conclusions

• Pediatric emergency care is a young field
• Continued research is necessary, despite significant barriers
• What works in the hospital doesn’t always work out of the hospital
• Find your role in the EMS-C system
Thank you