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Clinical Paper

Out-of-hospital pediatric airway management in the United States☆

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ABSTRACT

Objective: The objective of this study was to characterize pediatric out-of-hospital airway management interventions, success rates, and complications in the United States using the 2012 National Emergency Medical Services Information System (NEMSIS) dataset.
Methods: In 2012, NEMSIS collected data from Emergency Medical Services (EMS) encounters in 40 states. We included all patients less than 18 years of age and identified all patients who had airway interventions including endotracheal intubation (ETI), bag-valve-mask ventilation (BVM), continuous positive airway pressure/bilevel positive airway pressure (CPAP/BiPAP) and alternate airways (Combitube, King LT, Laryngeal Mask Airway (LMA), esophageal obturator airway, and cricothyroidotomy). Success and complication rates were analyzed and compared across pediatric age groups, by race, ethnicity, clinical condition, and geographic region.
Results: We identified a total of 949,301 pediatric patient care events in the NEMSIS 2012 dataset. 4.5% had airway management procedures (42,936 events). Invasive airway management or ventilation (ETI, cricothyroidotomy, alternate airway, CPAP/BiPAP, BVM and other ventilation) took place in 1.5% of patient care events (14,107). Of those who had invasive airway management, 29.9% were less than 1 year of age, 58.1% were male, 42.3% were white, and 83.6% were in urban areas. ETI occurred in 3124 of patient care events (329 per 100,000; 95% CI 318–341). Overall success of ETI was 81.1% (95% CI 79.7–82.6). Lower success was noted in patients with cardiac arrest (75.5%, 95% CI 72.6–78.3) and those aged 1–12 months (72.1%, 95% CI 68.3–75.6).
Conclusions: Out-of-hospital pediatric advanced airway procedures were infrequently performed. Success rates are lowest in patients aged 1–12 months.

1. Introduction

Emergency Medical Services (EMS) providers care for patients of all ages, including pediatric patients. They see children with a wide variety of critical illnesses including cardiac arrest, respiratory failure, and trauma. Airway management is often one of the initial steps taken in stabilizing a patient with many critical conditions. The purpose of airway management is to achieve adequate tissue oxygenation, ventilation, and limit aspiration of oral and gastric contents. Airway management procedures include suctioning, bag-mask-ventilation (BVM), airway adjuncts (oral and nasal airways), alternative airways (supraglottic devices), and endotracheal intubation (ETI).

Successful airway management requires training, skills and ongoing experience to consistently perform these procedures in an effective, timely, and safe manner. Airway management procedures in children require unique skill sets and equipment due to variations in anatomy based on patient age and size.[1] For example, the pediatric glottis is more superior and anterior than the adult glottis. Previous studies have shown that airway management procedures are rarely performed by individual EMS providers.[2] In addition, airway management skills rapidly deteriorate after training indicating that frequent training is needed to maintain

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airway management skills, which is likely challenging given limited resources and competing needs for training on other topics.[3] Many EMS agencies continue to support ETI as the gold standard for pediatric airway management while others have abandoned ETI due to safety concerns, highlighting the current controversy among experts in out-of-hospital care. There is evidence to suggest that out-of-hospital pediatric airway management may have increased complications compared to hospital-based airway management; a large controlled trial failed to show benefit of ETI and suggested harm in certain subgroups.[4–7]

The National Emergency Medical Services Information System (NEMSIS) is the largest registry of EMS responses in the US. In this report, we sought to describe the characteristics of out-of-hospital pediatric airway management in the United States.

2. Methods

2.1. Study design

The institutional review board of the Oregon Health & Science University reviewed and approved the protocol (IRB00010366). In this descriptive study, we analyzed data from the NEMSIS 2012 Public Release Research Dataset.

2.2. Study setting

The Office of Emergency Medical Services of the National Highway Traffic Safety Administration (NHTSA) funds the NEMSIS project. The goal of NEMSIS is to standardize the data obtained by EMS providers through their patient care reports and aggregate these data for analysis on a local, state, and national level. The NEMSIS, a national EMS dataset, is maintained by the NEMSIS Technical Assistance Center (TAC) housed at the University of Utah School of Medicine.

The NEMSIS TAC promotes the standardized electronic collection of over 400 data elements by encouraging use of electronic patient care report software that is compliant with the NEMSIS system. The lead EMS office in each state coordinates data collection from local EMS agencies then exports the data to the NEMSIS Technical Assistance Center to be placed in the national repository. Of the 400 data elements, only 83 are submitted to the national database with the remainder being housed in individual, local, and state databases. The NEMSIS program does not define inclusion or exclusion criteria of EMS activations to be included in the database, but takes all data meeting the state inclusion criteria. In addition, states can submit data from any number of participating EMS agencies throughout the state, so the data may not represent all EMS agencies in any given participating state.

For this study we identified patients less than 18 years of age from the NEMSIS 2012 Public Release Research Dataset totaling over 1.1 million pediatric EMS activations. Forty states participated in data submission to the 2012 NEMSIS dataset. Among the 40 participating states, 21 reported capture of more than 95% of all 911 ground EMS activations. The remaining states report inclusion of more than 75% of 9-1-1 ground EMS activations. It is estimated that approximately 50% of helicopter based transports in the US states submitting to NEMSIS are captured.

2.3. Selection of participants

This study included all EMS activations for patients less than 18 years of age, including activations where care was provided but the patient was not transported. We excluded EMS activations where EMS responded but there was no patient care. We then identified patients receiving NEMSIS-defined airway interventions or ventilatory support, including endotracheal intubation (ETI), alternate airway insertion, cricothyroidotomy, bag-valve-mask ventilation (BVM), continuous positive airway pressure (CPAP), bilevel positive airway pressure (BiPAP), or other ventilation.

2.4. Outcomes

The primary outcomes were frequency, success and complication rates of pediatric airway management procedures. In this analysis we defined endotracheal intubation (ETI) as direct laryngoscopy, video laryngoscopy, orotracheal intubation, nasotracheal intubation, or rapid sequence intubation (RSI). The alternative airways recorded by NEMSIS include the LMA, the King LT, the Combitube, and the esophageal obturator airway. We included methods of ventilation other than bag-valve-mask as "other ventilation" which includes bag ventilation via endotracheal tube or alternate airway, respirator operation, or ventilator operation. We combined surgical and needle cricothyroidotomy into a single category unless otherwise specified. When patients were ventilated with a bag-valve-mask setup, this was defined as BVM. When patients were ventilated without a mask via a tube, had "respirator operation," or "ventilator operation", they were classified as "other ventilation."

When a procedure appeared more than once for a single patient it was counted only once in the analysis. For example, if a patient had 2 ETIs during their patient care event it would be classified as a single ETI. However, if patients had both BVM and ETI during the same encounter they were classified separately in the analysis. The NEMSIS data also indicated the success of each procedure. In instances where procedures were attempted several times, we considered it a success if any of the attempts were recorded as successful. If two separate intubations took place, and either one or both were successful, this was classified as a successful intubation for that patient care episode. Airway procedural complications included bleeding, bradycardia, esophageal intubation, hypotension, hypoxia, injury, vomiting and other as defined by the paramedic completing the medical record.

Patient level variables included age, gender, race, and ethnicity. Illness specific variables included cardiac arrest, possible injury, provider's primary impression, and cause of injury.

The population setting of the EMS encounter, "urbanicity", is classified in NEMSIS according to the United States Department of Agriculture (USDA) and the Office of Management and Budget (OMB) definitions: urban areas that have large (1+ million residents) or small (less than 1 million residents) metropolitan areas; suburban areas with micropolitan (urban core of at least 10,000 residents) counties adjacent to large or small metropolitan areas; rural areas that have non-urban core counties adjacent to a large or small metropolitan area; and wilderness that are considered non-core counties adjacent to micropolitan counties.

The NEMSIS program has individual data use agreements with each state that preclude release of any state, agency, or provider specific data in the public use dataset. To analyze by region we stratified the data according to the US census regions (Northeast, South, Midwest, and West).

2.5. Primary data analysis

We analyzed the data with descriptive statistics including binomial proportions and exact 95% confidence intervals for those proportions.

We calculated the number and proportion of airway interventions in EMS patient care events for patients less than 18 years. We described demographics of the population receiving airway intervention including age, gender, race, ethnicity, urbanicity of the incident location, and US census region. We also described several illness specific factors such as cardiac arrest status, injury status,