Focus on Airway Management

Medical Conditions Associated with Out-of-Hospital Endotracheal Intubation

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Abstract

Background. While prior studies describe the clinical presentation of patients requiring paramedic out-of-hospital endotracheal intubation (ETI), limited data characterize the underlying medical conditions or comorbidities. **Objective.** To characterize the medical conditions and comorbidities of patients receiving successful paramedic out-of-hospital ETI. **Methods.** We used Pennsylvania statewide emergency medical services (EMS) clinical data, including all successful ETIs performed during 2003–2005. Using multiple imputation triple-match algorithms, we probabilistically linked EMS ETI to statewide death and hospital admission data. Each hospitalization record contained one primary and up to eight secondary diagnoses, classified according to the *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM). We determined the proportion of patients in each major ICD-9-CM diagnostic group and subgroup. We calculated the Charlson Comorbidity Index score for each patient. Using binomial proportions with confidence intervals (CIs), we analyzed the data and combined imputed results using Rubin's method. **Results.** Across the imputed sets, we linked 25,733 (77.7% linkage) successful ETIs to death or hospital records; 56.3% patients died before and 43.7% survived to hospital admission. Of the 14,478 patients who died before hospital admission, most (92.7%; 95% CI: 92.5–93.3%) had presented to EMS in cardiac arrest. Of the 11,255 hospitalized patents, the leading primary diagnoses were circulatory diseases (32.0%; 95% CI: 30.2–33.7%), respiratory diseases (22.8%; 95% CI: 21.9–23.7%), and injury or poisoning (25.2%; 95% CI: 22.7–27.8%). Prominent primary diagnosis subgroups included asphyxia and respiratory failure (15.2%), traumatic brain injury and skull fractures (11.3%), acute myocardial infarction and ischemic heart disease (10.9%), poisonings and drug and alcohol disorders (6.7%), dysrhythmias (6.7%), hemorrhagic and nonhemorrhagic stroke (5.9%), acute heart failure and cardiomyopathies (5.6%), pneumonia and aspiration (4.9%), and sepsis, septicemia, and septic shock (3.2%). Most of the admitted ETI patients had a secondary circulatory (70.8%), respiratory (61.4%), or endocrine, nutritional, or metabolic (51.4%) secondary diagnosis. The mean Charlson Index score was 1.6 (95% CI: 1.5–1.7). **Conclusions.** The majority of successful paramedic ETIs occur on patients with cardiac arrest and circulatory and respiratory conditions. Injuries, poisonings, and other conditions compromise smaller but important portions of the paramedic ETI pool. Patients undergoing ETI have multiple comorbidities. These findings may guide the systemic planning of paramedic airway management care and education. **Key words:** emergency medical services; paramedics; intubation, intratracheal; comorbidities

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Introduction

Endotracheal intubation (ETI) is a key intervention performed by paramedics in the United States.[1–9] Prior studies indicate that the most frequent episodes of out-of-hospital ETI occur in patients suffering from cardiac arrest, with the remaining ETIs occurring in patients with a range of undifferentiated nonarrest medical and trauma conditions.[10–12] However, we know little about the medical conditions associated with paramedic ETI. This information is important because different medical conditions may require unique airway management or ventilation strategies. For example, patients with traumatic brain injury may merit drug-facilitated ETI.[13,14] Patients with acute heart failure may respond to noninvasive ventilation with continuous positive airway pressure (CPAP).[15,16] Furthermore, coexisting medical comorbidities may complicate airway management and ventilatory strategies as well as the outcomes of these patients.

An improved systemic understanding of the medical conditions and comorbidities associated with paramedic ETI could aid emergency medical services (EMS) system planning, helping medical directors to identify the range of strategies and training curricula needed for paramedic airway management. We sought to describe the medical conditions and comorbidities of patients receiving successful paramedic out-of-hospital ETI.

METHODS

Study Design

The Institutional Review Boards of the University of Alabama at Birmingham and the University of Pittsburgh approved the study. In this retrospective analysis, we linked Commonwealth of Pennsylvania statewide EMS, hospital discharge, and death data to determine the hospital discharge diagnoses of patients receiving successful out-of-hospital ETI.

Study Setting

This study included patients receiving out-of-hospital care in the Commonwealth of Pennsylvania. Emergency medical services care in Pennsylvania encompasses a range of practice settings including dense urban population centers (for example, Philadelphia and Pittsburgh), extensive suburban areas, and remote rural areas. Care configurations include independent private and municipal agencies providing both local and regional EMS care. There are 11 independent air medical services across the Commonwealth.

Pennsylvania EMS rescuers work in both volunteer and career capacities. The EMS roles in Pennsylvania include first responders, emergency medical technicians, paramedics, prehospital registered nurses, and EMS physicians. Advanced life support (ALS) vehicles may have one or two ALS rescuers. Only EMS paramedics, nurses, and physicians perform out-of-hospital ETI. Paramedics comprise over 90% of Pennsylvania ALS rescuers. All air medical rescuers may use neuromuscular-blockade–assisted (rapid-sequence) ETI. Only select ground EMS units are permitted to use ETI facilitated by sedatives only; ground EMS units are not permitted to perform neuromuscular-blockade–assisted (rapid-sequence) ETI.

Sources of Data

For this study we used three sources of data: 1) Pennsylvania Emergency Medical Service Patient Care Report Data Set (PAEMS) data, 2) the Pennsylvania Health Care Cost Containment Council hospital discharge data set (PHC4), and 3) the Pennsylvania Death Registry (PA Death). We used data for the three-year period January 1, 2003, through December 31, 2005.

The PAEMS database contains information on all Pennsylvania EMS patient care incidents. The EMS agencies in Pennsylvania use electronic medical record systems that transmit patient care data to a central database. Those EMS services without computer access must submit patient care reports using computer scan forms. The PAEMS database follows the National Highway Traffic Safety Administration standards for EMS data collection and reporting. The data describe patient characteristics, nature and severity of illness, injury patterns, administered drugs, procedures and interventions, and information regarding the EMS service and out-of-hospital rescuers delivering care.[17]

The PHC4 database contains demographic, diagnostic, and clinical information for all hospital discharges in the Commonwealth of Pennsylvania.[18] Using standard reporting software, hospitals provide basic demographic (patient age, gender), clinical (the date, time, and location of hospital admission, the discharge status and hospital length of stay), and diagnostic information. The database contains a primary and up to eight secondary discharge diagnoses, defined using the *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM). The PHC4 database does not include patients dying in the emergency department (ED) prior to hospital admission.

The PA Death database contains demographic and clinical information on all deaths in the Commonwealth of Pennsylvania, including the date, time, location, and attributed reason for death.[19]

Linkage of Data Sets

Because the three data sets (PAEMS, PHC4, PA Death) did not have unique patient identifiers (for example, name, Social Security number, date of birth, medical record number), we connected patient records using probabilistic linkage. Probabilistic linkage compares the values from several data fields to estimate the probability that pairs of records represent the same person or event.[20–23] Many medical research studies have used probabilistic linkage.[24–30]

We previously described the details and results of the record linking process.[10] To facilitate linkage, we limited PAEMS to successful ETI cases, and we limited

PHC4 to patients 1) admitted through the ED and 2) admitted to an intensive care unit or discharged with a diagnosis of mechanical ventilation (ICD-9-CM 96.7–96.72), cardiopulmonary arrest (ICD-9-CM 427.4–427.5), or respiratory arrest (ICD-9-CM 799.1).

The probabilistic linking process used combinations of the following variables: date and time of encounter, patient age, patient gender, patient race, receiving hospital facility, EMS agency location, and patient geographic location (minor civil division). Since an EMS patient might appear in both the PHC4 and PA Death data sets, we used a "triple-match" algorithm to resolve these overlapping linkages.[31]

A customary practice in probabilistic linkage is to retain only record pairs with predicted match weights over an a priori fixed threshold (e.g., match probability >0.90).[32] However, this approach often results in low match rates and may inadvertently exclude true matches just below the defined threshold. To avoid this outcome, we used a multiple imputation procedure, creating a series of linked data sets based on the probability distribution of match weights.[31] Using this technique, we created five probability-linked data sets. We conducted separate analyses on each probability-linked data set and combined the estimates using Rubin's method.[33,34]

We linked patient records for the period January 1, 2003, to December 31, 2005. We performed record linkage using LinkSolv, version 6 (Strategic Matching Inc., Morrisonville, NY).

Selection of Patients

We included patients reported as receiving successful out-of-hospital ETI by ALS rescuers. The PAEMS data set does not contain information on unsuccessful ETIs. Rescuers define and report ETI success; there are no statewide protocols for independent confirmation by a second rescuer or physician. The PAEMS cannot identify instances where initial ETI failure was followed by successful supraglottic airway placement.

Outcomes

The outcomes of this study were the patient primary and secondary medical conditions. We determined and classified the outcomes differently for patients dying before hospital admission and those admitted to the hospital (Fig. 1).

We classified patients dying in the field or ED as "death before hospital admission." Patients dying before hospital admission do not appear in the hospital discharge data set and therefore do not have assigned ICD-9-CM discharge diagnosis codes. Because of the inconsistency of death reports and their use of the different ICD-10 classification system, we opted not to use the "reason for death" data appearing in the PA Death data set.

For patients surviving to hospital admission, we determined the primary and secondary medical conditions from ICD-9-CM hospital discharge diagnosis codes appearing in the PHC4 data set. At the completion of a patient's hospital course, hospital personnel typically assign diagnosis codes (ICD-9-CM) reflecting the medical conditions associated with the patient's hospitalization, as well as the patient's comorbidities. Hospitals typically use this information to support billing efforts. The PHC4 data set contains the primary and up to eight secondary ICD-9-CM diagnosis codes for each hospitalization.

To examine the concurrent medical conditions of the study population, we also calculated Charlson Comorbidity Index scores for each hospitalized patient.[35] The Charlson Index is a widely used system for characterizing patient comorbidities, drawing upon information regarding chronic medical conditions (myocardial infarction, congestive heart failure, peripheral vascular disease, cerebrovascular disease, dementia, chronic pulmonary disease, rheumatologic disease, peptic ulcer disease, liver disease, diabetes, hemiplegia or paraplegia, renal disease, cancer, and acquired immunodeficiency syndrome [AIDS]). Each condition receives a different weight (1, 2, or 6 points). The total Charlson score consists of the sum of the individual weighted scores and ranges from 0 to 37, reflecting increasing risks of one-year mortality. For example, a patient with a history of myocardial infarction has a Charlson score of 1, corresponding to 10% probability of death within one year.[36] A patient with a history of myocardial infarction and leukemia has a Charlson score of 2, corresponding to 19% probability of death within one year. In scientific analyses, authors typically categorize the Charlson score as 0, 1, 2, or ≥3. Deyo et al. adapted the Charlson Index for use with ICD-9-CM administrative data sets.[37]

Primary Data Analysis

We grouped the primary and secondary discharge diagnoses of admitted ETI patients according to major ICD-9-CM disease categories (Table 1). We opted to group the cases using the ICD-9-CM system because of the wide recognition of this method.

In addition to the major ICD-9-CM categories, we also highlighted selected disease subgroups with potential relevance to airway management. We defined a subgroup for sepsis, septicemia, bacteremia, and septic shock (ICD-9-CM 003.1, 022.3, 031.2, 038–038.9, 040.82, 422.92, 449, 659.3, 670.20–670.24, 673.3, 771.81, 771.83, 785.52, 790.7, 995.90–995.94). Under endocrine disorders, we identified the subgroup with diabetic, hyperglycemic, and hypoglycemic conditions (ICD-9-CM 250–250.9, 251.0–251.2). Under neurologic disorders, we identified epilepsy, seizures, and convulsions (ICD-9-CM 345–345.91, 649.40–649.44, 779.0, 780.3–780.39)

TABLE 1. Discharge Diagnoses of Patients Receiving Out-of-Hospital Endotracheal Intubation, Commonwealth of Pennsylvania, 2003–2005

	Primary Diagnosis (All ETI Patients, $n = 25{,}733$)		Primary Diagnosis (Admitted Patients Only, $n = 11{,}255$)		Secondary Diagnoses (Admitted Patients Only, $n = 11{,}255$)	
ICD-9-CM Diagnosis Category	*n*	(%; 95% CI)	*n*	(%; 95% CI)	*n*	(%; 95% CI)
Patient not admitted to hospital (died before hospital admission)	**14,478**	**(56.3; 51.3–61.2)**	N/A	(N/A)	N/A	(N/A)
001–139.9 Infectious and parasitic diseases	**389**	**(1.5; 1.2–1.9)**	**394**	**(3.5; 3.0–3.9)**	**1,373**	**(12.2; 11.4–12.9)**
003.1, 022.3, 031.2, 038–038.9, 040.82, 422.92, 449, 659.3, 670.20–670.24, 673.3, 771.81, 771.83, 785.52, 790.7, 995.90–995.94 Sepsis, septicemia, bacteremia, and septic shock	360	(1.4; 1.0–1.8)	360	(3.2; 2.7–3.7)	912	(8.1; 7.2–9.1)
140–239.9 Neoplasms (e.g., cancers, tumors, and malignancies)	**157**	**(0.6; 0.4–0.8)**	**158**	**(1.4; 1.1–1.7)**	**608**	**(5.4; 4.8–6.0)**
240–279.9 Endocrine, nutritional, and metabolic diseases, and immunity disorders	**180**	**(0.7; 0.5–0.8)**	**169**	**(1.5; 1.3–1.7)**	**5,785**	**(51.4; 50.1–52.7)**
250–250.9, 251.0–251.2 Diabetic, hyperglycemic, and hypoglycemic conditions	90	(0.35; 0.28–0.43)	90	(0.8; 0.6–1.0)	2,094	(18.6; 17.9–19.4)
280–289.9 Diseases of the blood and blood-forming organs	**31**	**(0.12; 0.06–0.17)**	**34**	**(0.3; 0.1–0.4)**	**1,801**	**(16.0; 15.3–16.7)**
290–319.9 Mental disorders (including alcohol and drug-related disorders)	**67**	**(0.26; 0.18–0.33)**	**68**	**(0.6; 0.4–0.7)**	**3,084**	**(27.4; 25.6–29.2)**
320–359.9 Diseases of the nervous system	**206**	**(0.8; 0.5–1.1)**	**203**	**(1.8; 1.3–2.3)**	**2,307**	**(20.5; 17.1–24.0)**
345–345.91, 649.40–649.44, 779.0, 780.3–780.39 Epilepsy, seizures, and convulsions	79	(0.7; 0.6–0.8)	169	(1.5; 1.3–1.8)	968	(8.6; 8.0–9.3)
348.1–348.39, 349.82 Anoxic brain injury and encephalopathy	45	(0.4; 0.2–0.7)	113	(1.0; 0.5–1.4)	1,249	(11.1; 7.5–14.7)
360–389.9 Diseases of the sense organs (e.g., eyes, ears)	**10**	**(0.04; 0.01–0.07)**	**11**	**(0.10; 0.03–0.17)**	**315**	**(2.8; 2.5–3.2)**
390–459.9 Diseases of the circulatory system	**3,603**	**(14.0; 11.7–16.3)**	**3,602**	**(32.0; 30.2–33.7)**	**7,969**	**(70.8; 68.2–73.4)**
410–414.9 Acute myocardial infarction and ischemic heart disease	1,235	(4.8; 3.9–5.6)	1,227	(10.9; 10.0–11.8)	2,994	(26.6; 25.6–27.6)
415.1–415.19 Pulmonary embolism	28	(0.25; 0.18–0.33)	68	(0.6; 0.4–0.7)	68	(0.6; 0.4–0.7)
426–427.9 Dysrhythmias	746	(2.9; 2.2–3.6)	754	(6.7; 5.8–7.6)	3,658	(32.5; 29.3–35.7)
425, 425.1–425.2, 425.4–425.9, 428–428.9 Acute heart failure and cardiomyopathies	643	(2.5; 2.2–2.7)	630	(5.6; 5.1–6.1)	2,668	(23.7; 22.6–24.8)
430–432.9 Hemorrhagic stroke	360	(1.4; 1.2–1.7)	371	(3.3; 2.9–3.6)	101	(0.9; 0.7–1.0)
433.0–437.9 Thrombotic and other strokes	124	(1.1; 0.8–1.4)	293	(2.6; 2.1–3.0)	326	(2.9; 2.4–3.3)
460–519.9 Diseases of the respiratory system	**2,573**	**(10.0; 8.7–11.3)**	**2,566**	**(22.8; 21.9–23.7)**	**6,911**	**(61.4; 59.7–63.2)**
464–466.19, 480–488.9, 507–507.8, 510–510.9, 513–513.1 Pneumonia, aspiration pneumonitis, and other infections	540	(2.1; 1.8–2.5)	552	(4.9; 4.4–5.3)	2,364	(21.0; 20.1–22.0)
490–493.92 Asthma, COPD, and chronic bronchitis	257	(1.0; 0.8–1.1)	248	(2.2; 1.9–2.5)	1,317	(11.7; 11.1–12.4)
518.5, 518.81–518.85, 799.0–799.1 Asphyxia and respiratory failure	1,698	(6.6; 5.8–7.5)	1,711	(15.2; 14.5–15.9)	3,928	(34.9; 33.1–36.7)
520–579.9 Diseases of the digestive system	**437**	**(1.7; 1.4–1.9)**	**428**	**(3.8; 3.4–4.2)**	**1,936**	**(17.2; 16.2–18.2)**
580–629.9 Diseases of the genitourinary system	**129**	**(0.5; 0.4–0.6)**	**135**	**(1.2; 1.0–1.4)**	**2,881**	**(25.6; 23.7–27.5)**
584–586 Acute and chronic renal failure	77	(0.3; 0.2–0.4)	79	(0.7; 0.6–0.9)	1,463	(13.0; 10.9–15.1)
680–709.9 Diseases of the skin and subcutaneous tissue (includes cellulitis)	**15**	**(0.06; 0.02–0.09)**	**15**	**(0.13; 0.06–0.21)**	**574**	**(5.1; 4.6–5.5)**
710–739.9 Diseases of the musculoskeletal system and connective tissue	**36**	**(0.14; 0.09–0.19)**	**34**	**(0.3; 0.2–0.4)**	**1,047**	**(9.3; 8.7–10.0)**
740–759.9 Congenital anomalies	**5**	**(0.02; 0.000003–0.03)**	**5**	**(0.04; 0.000004–0.07)**	**79**	**(0.7; 0.6–0.9)**
760–779.9 Certain conditions originating in the perinatal period	**3**	**(0.01; [−0.002]–0.03)**	**3**	**(0.03; [−0.00003]–0.06)**	**10**	**(0.09; 0.04–0.2)**
780–799.9 Symptoms, signs, and ill-defined conditions	**566**	**(2.2; 2.0–2.4)**	**574**	**(5.1; 4.6–5.7)**	**3,433**	**(30.5; 29.2–31.9)**
780.0–780.2, 780.97 Syncope, coma, and altered mental status	51	(0.45; 0.36–0.55)	113	(1.0; 0.8–1.2)	450	(4.0; 3.6–4.4)
786.5–786.59 Chest pain	113	(1.0; 0.8–1.1)	248	(2.2; 1.9–2.5)	1,317	(11.7; 11.1–12.4)
276.5–276.52, 458–458.9, 785.5–785.51, 785.59, 958.4, 995.0, 999.4 Shock, hypovolemia, dehydration, hypotension, and anaphylaxis	77	(0.3; 0.2–0.4)	79	(0.7; 0.5–0.8)	1,576	(14.0; 12.7–15.2)

(Continued on next page)

TABLE 1. Discharge Diagnoses of Patients Receiving Out-of-Hospital Endotracheal Intubation, Commonwealth of Pennsylvania, 2003–2005 (Continued)

ICD-9-CM Diagnosis Category	Primary Diagnosis (All ETI Patients, $n = 25{,}733$) n	(%; 95% CI)	Primary Diagnosis (Admitted Patients Only, $n = 11{,}255$) n	(%; 95% CI)	Secondary Diagnoses (Admitted Patients Only, $n = 11{,}255$) n	(%; 95% CI)
800–999.9 Injury and poisoning	**2,831**	**(11.0; 10.6–11.4)**	**2,836**	**(25.2; 22.7–27.8)**	**3,084**	**(27.4; 25.3–29.4)**
800–804.9, 850–854.9, 959.0–959.09 Skull fractures and traumatic brain injury	1,287	(5.0; 4.7–5.2)	1,272	(11.3; 10.0–12.6)	822	(7.3; 6.2–8.3)
805–806.9, 952–952.9 Fractures of spine and spinal cord injuries	69	(0.27; 0.20–0.33)	68	(0.6; 0.5–0.8)	416	(3.7; 3.1–4.3)
807–839.9, 885–887.7, 895–897.7, 900–904.9, 925–929 Other fractures, islocations, amputations, crush and vascular injuries	232	(0.9; 0.8–1.0)	236	(2.1; 1.7–2.4)	867	(7.7; 6.8–8.6)
860–869.9 Internal injury of chest, abdomen, and pelvis	257	(1.0; 0.8–1.1)	248	(2.2; 1.8–2.6)	754	(6.7; 5.7–7.7)
940–949.9 Burns	49	(0.19; 0.13–0.24)	45	(0.4; 0.3–0.6)	45	(0.4; 0.3–0.6)
291–292.9, 303.0–305.9, 960–989.9 Poisonings, drug and alcohol disorders	746	(2.9; 2.7–3.2)	754	(6.7; 5.9–7.5)	1,891	(16.8; 15.3–18.3)

Percentages reflect estimates for each imputed set, combined by Rubin's method. Each hospital record contained one primary discharge diagnosis and up to eight secondary discharge diagnoses.
CI = confidence interval; COPD = chronic obstructive pulmonary disease; ETI = endotracheal intubation; ICD-9-CM = *International Classification of Diseases, Ninth Revision, Clinical Modification*; N/A = not applicable.

as well as anoxic brain injury and encephalopathy (348.1–348.39, 349.82).

Circulatory system disease subgroups included acute myocardial infarction and ischemic heart disease (ICD-9-CM 410–414.9), pulmonary embolism (415.1–415.19), dysrhythmias (426–427.9), congestive heart failure and cardiomyopathies (425, 425.1–425.2, 425.4–425.9, 428–428.9), hemorrhagic stroke (430–432.9), and thrombotic and other strokes (433–437.9). Respiratory disease subgroups included pneumonia and influenza (ICD-9-CM 480–488.9), chronic obstructive pulmonary disease and allied conditions (490–496.9), and other respiratory diseases (510–519.9). Among genitourinary disorders, we identified acute and chronic renal failure (ICD-9-CM 584–586).

Injury subgroups included skull fractures and traumatic brain injury (ICD-9-CM 800–804.9, 850–854.9, 959.0–959.09), spinal fractures and spinal cord injuries (805–806.9, 952–952.9), other fractures, dislocations, amputations, crush and vascular injuries (807–839.9, 885–887.7, 895–897.7, 900–904.9, 925–929), chest, abdomen, and pelvis internal injuries (860–869.9), and burns (940–949.9). We identified all poisonings and drug and alcohol disorders (ICD-9-CM 291–292.9, 303.0–305.9, 960–989.9).

Under symptoms, signs, and ill-defined conditions, we identified the subgroup syncope, coma, and altered mental status (ICD-9-CM 780.0–780.2, 780.97), chest pain (786.5–786.59), and shock, hypovolemia, dehydration, hypotension, and anaphylaxis (276.5–276.52, 458–458.9, 785.5–785.51, 785.59, 958.4, 995.0, 999.4). We excluded diagnoses related to the complications of complications of pregnancy, childbirth, and the puerperium (ICD-9-CM 630679).

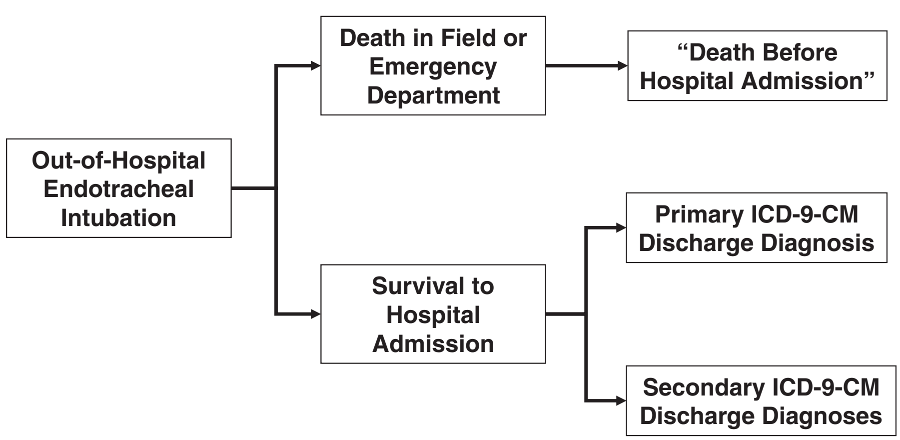

FIGURE 1. Overview of classification of medical conditions. We classified patients dying in the field or emergency department as "death before hospital admission." For patients surviving to hospital admission, we determined the primary and secondary medical conditions from the primary and secondary *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) discharge diagnosis codes. Each hospitalized patient had one primary and up to eight secondary diagnoses.

We analyzed the data using descriptive statistics. For each of the five imputed match sets, we examined the primary discharge diagnosis, calculating the binomial proportion of cases in each major ICD-9-CM disease category and subgroup. We determined the proportion of each disease category and subgroup relative to all patients with successful ETI as well as to admitted patients only. We analyzed the secondary diagnoses in a similar fashion, examining all eight secondary discharge diagnoses of admitted patients and calculating the proportion of each secondary disease category relative to admitted patients only.

Utilizing the primary and all eight secondary discharge diagnoses, we calculated the Charlson Index score using the Stata "Charlson" module. Combining the primary and secondary diagnoses and the Charlson score allowed estimations from each of the five imputed match sets using Rubin's method, implemented using the Stata "mi" command.[33] Because Rubin's method cannot combine medians, we examined the Charlson median and interquartile range for each imputed set separately. We analyzed the data using Stata 11.2 (StataCorp LP, College Station, TX).

RESULTS

During 2003–2005, 4,846 rescuers performed successful ETI on 33,117 patients. The 33,117 ETI patients included 21,753 with cardiac arrest, 8,162 with medical nonarrest conditions, and 3,202 with trauma nonarrest ETI. Across the five imputed probability-linked data sets, we matched a mean of 25,733 of 33,117 successful ETIs to hospital or death records (mean linkage rate 77.7%).

Of ETI cases matched to hospital and/or death records across the five imputations, a mean of 14,478 patients (56.3%; 95% confidence interval [CI]: 51.3–61.2) died prior to hospital admission (Table 1). Most of the patients who died prior to hospital admission suffered from nontraumatic out-of-hospital cardiac arrest (92.7%; 95% CI: 92.5–93.3%).

Across the five imputations, we linked a mean of 11,255 successful ETIs to hospitalization records. The mean age of the patients was 61 years (95% CI: 60–63), and the cohort was mostly male (56%; 95% CI: 55–57%). Of the hospitalized patients, the leading primary diagnosis groups were circulatory diseases (32.0%; 95% CI: 30.2–33.7%), respiratory diseases (22.8%; 95% CI: 21.9–23.7%), and injury or poisoning (25.2%; 95% CI: 22.7–27.8%), collectively comprising over 80% of the hospitalized cases. Prominent primary diagnosis subgroups included asphyxia and respiratory failure (15.2%), traumatic brain injury and skull fractures (11.3%), acute myocardial infarction and ischemic heart disease (10.9%), poisonings and drug and alcohol disorders (6.7%), dysrhythmias (6.7%), hemorrhagic and nonhemorrhagic stroke (5.9%), acute heart failure and cardiomyopathies (5.6%), pneumonia and aspiration (4.9%), and sepsis, septicemia, and septic shock (3.2%).

Most of the admitted ETI patients had secondary diagnoses that were circulatory (70.8%), respiratory (61.4%), or endocrine, nutritional, or metabolic (51.4%) diseases. Combined across the five imputed data sets, the mean Charlson Index score was 1.6 (95% CI: 1.5–1.7). Within each of the five imputed data sets, the median Charlson Index score was 1 (interquartile range [IQR]: 0–2, minimum 0, maximum 11).

DISCUSSION

The diseases afflicting out-of-hospital patients are often unclear on initial field presentation and may require confirmation—or discovery—in the hospital. In the setting of out-of-hospital ETI, knowledge of the pattern of illnesses when the current cause is uncertain is important not only for optimizing the care required by individual patients, but also for understanding the spectrum of medical conditions associated with out-of-hospital airway management. As was shown by prior studies, we observed that the majority of paramedic ETIs occur on patients with out-of-hospital cardiac arrest.[11,12] However, we also found that circulatory and respiratory diseases, injuries, and poisonings accounted for most of the remaining cases. While our use of hospital discharge diagnoses could be subject to classification bias, this method provided the best available approach, capitalizing on existing data from a large number of cases (over 11,000 hospitalizations after successful out-of-hospital ETI). Prospective ETI case identification and review would have proved logistically prohibitive.

While diagnostic information could influence airway management methods for individual patients, in aggregate they may also guide EMS system planning and education, identifying the relative range and frequency of specific medical conditions associated with paramedic ETI. Medical directors could use this information to define and prioritize airway management options and strategies for EMS agencies. For example, to avoid interruptions in cardiopulmonary resuscitation chest compressions, some EMS practitioners use supraglottic alternate airways (King LT, Combitube) for cardiac arrest airway management; our series suggest that this strategy may have a role in over half of out-of-hospital airway management efforts.[38,39] Rapid-sequence intubation is a viable strategy for facilitating ventilation and intracerebral pressure control in traumatic brain injury; our observations suggest a potential role for this approach in approximately 5% of out-of-hospital ETIs.[14,40,41] As a potential ventilatory management strategy for acute heart failure, asthma, and pneumonia, CPAP may play a role in approximately 12% of the patients in this series.[15,16]

Our study also highlights disease groups that often receive less emphasis in out-of-hospital airway care. For example, those patients with poisonings and alcohol and drug overdoses received 6.7% of ETI efforts, and patients with hemorrhagic or nonhemorrhagic stroke received over 6% of successful ETI efforts. Three percent of successful ETI cases involved sepsis, septicemia, bacteremia, or septic shock. These conditions may require specialized airway management approaches. For example, ventilation and intracerebral pressure control are important in the management of stroke patients and may merit pharmacologically assisted intubation or other neuroprotective approaches.[14] Given the concerns with the etomidate-induced adrenosuppression, the sepsis, septicemia, bacteremia, or septic shock cases may merit ETI facilitated by alternative sedative/induction agents.[42,43] These less common yet prominent conditions pose a challenge to medical directors, who must balance the need for specialized airway management strategies against the relatively limited opportunities for application by individual paramedics.

Over half of the admitted patients receiving field ETI had secondary circulatory, respiratory, or endocrine, nutrition, or metabolic conditions (for example, hypoglycemia and electrolyte abnormalities). The mean Charlson Index score of 1.6 exhibited by these patients indicates a population with a moderate number of comorbidities.[35] These observations underscore the need for ETI strategies that accommodate the presence of multiple comorbidities. For example, select patients may have reduced pulmonary reserve, limiting their tolerance of repeated or prolonged intubation efforts. Other patients may not be able to tolerate sedation-facilitated intubation using full unadjusted doses of medications. Our findings also highlight that studies of paramedic ETI must account for the confounding effect of comorbidities and severity of illness.[3,8,44,45] Prior studies have used out-of-hospital variables or the MediQual Severity of Illness Index to adjust for severity of illness, but these approaches have not been independently validated.[3,10,46] The observed comorbidities in this series highlight the need for risk-adjustment strategies specific to the out-of-hospital ETI population.

LIMITATIONS

Because the study data sets did not contain unique identifiers, we relied on probabilistic record linkage, which represented the best approach given the inherent data set limitations. Using multiple imputation methods with the available variables, our study achieved a linkage rate of 77.7%, which compares favorably with prior efforts that achieved linkage on the order of 45–70%.[47–49] While linkage rates can be higher with a greater number of variables, we were limited to the variables available across the PAEMS, PHC4, and PA Death data sets.[23,32]

Our study evaluated out-of-hospital ETI practice in Pennsylvania only. Although we drew upon a large number of ETIs, different patterns may exist in other U.S. regions. Medical directors must compare these findings with the characteristics of their individual practice settings. We did not have data on ETI or other complications, such as bleeding, vomiting, tube misplacement, inadvertent hyperventilation, or prolonged ETI efforts.[40,50–52] We used administrative data based on rescuer clinical reports. While paramedic clinical care reports may be subject to recall and reporting bias, these factors would not have changed the results of the study.

The PAEMS data set contained reportedly successful ETIs only. Up to 15% of out-of-hospital ETI efforts may fail.[11,12] We were unable to determine the discharge diagnoses of patients experiencing failed ETI efforts. The PAEMS data set did not have information on other performance parameters such as number of attempts or the contingency use of a supraglottic airway. The study data originated from 2000–2005. Since this time, the Commonwealth of Pennsylvania has implemented select airway protocol changes (for example, the mandatory use of waveform capnography), but none that would have changed the findings of the current study.

Despite maximizing linkage with multiple imputation methods, we still lack clinical information on nonlinked cases. We used administrative EMS, hospital, and death records, which may be subject to reporting bias. Medical record personnel at individual hospitals assigned discharge primary and secondary diagnoses, a process primarily designed for financial purposes.

While this analysis posits a connection between initial clinical presentation and final hospital diagnoses, a direct association may not always exist. For example, a patient with an initial presentation of cellulitis may later die from aspiration pneumonia and sepsis. We surmised that the majority of deaths before hospitalization occurred in those patients experiencing nontraumatic cardiac arrest. However, approximately 30% of out-of-hospital arrest patients survive to hospital admission; in this analysis, these patients would have likely received a primary discharge diagnosis other than cardiopulmonary arrest.[53] The data sets could not ascertain the diagnoses of patients dying in the field or the ED.

CONCLUSION

The majority of successful paramedic ETIs occurs on patients with cardiac arrest and circulatory and respiratory conditions. Injuries, poisonings, and other conditions compromise smaller but important portions of the paramedic ETI pool, and many patients have multiple comorbidities. These findings may guide the systemic planning of paramedic airway management care and education.

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