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Validation of an ICD code for accurately identifying emergency department patients who suffer an out-of-hospital cardiac arrest

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Abstract

Aim—International classification of disease (ICD-9) code 427.5 (cardiac arrest) is utilized to identify cohorts of patients who suffer out-of-hospital cardiac arrest (OHCA), though the use of ICD codes for this purpose has never been formally validated. We sought to validate the utility of ICD-9 code 427.5 by identifying patients admitted from the emergency department (ED) after OHCA.

Methods—Adult visits to a single ED between January 2007 and July 2012 were retrospectively examined and a keyword search of the electronic medical record (EMR) was used to identify patients. Cardiac arrest was confirmed; and ICD-9 information and location of return of spontaneous circulation (ROSC) were collected. Separately, the EMR was searched for patients who received ICD-9 code 427.5. The kappa coefficient (κ) was calculated, as was the sensitivity and specificity of the code for identifying OHCA.

Results—The keyword search identified 1717 patients, of which 385 suffered OHCA and 333 were assigned the code 427.5. The agreement between ICD-9 code and cardiac arrest was excellent ($\kappa=0.895$). The ICD-9 code 427.5 was both specific (99.4%) and sensitive (86.5%). Of the 52 cardiac arrests that were not identified by ICD-9 code, 33% had ROSC before arrival to the ED. When searching independently on ICD-9 code, 347 patients with ICD-9 code 427.5 were

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found, of which 320 were “true” arrests. This yielded a positive predictive value of 92% for ICD-9 code 427.5 in predicting OHCA.

Conclusions—ICD-9 code 427.5 is sensitive and specific for identifying ED patients who suffer OHCA with a positive predictive value of 92%.

Keywords

Cardiac arrest; Administrative Data; Validation; ICD

INTRODUCTION

Administrative and claims data have been identified as a robust cost-effective data source for investigating large samples of patients with a uniform diagnosis [1, 2]. The utilization of claims data for research purposes requires demonstration that codes are valid for identifying affected subjects given that administrative databases are created primarily for billing purposes [3–5]. For various conditions, such as out-of-hospital cardiac arrest (OHCA), administrative data may be a resource for investigating outcomes, regionalized care, and processes of care. OHCA affects over 300,000 Americans annually, with patients distributed geographically across the country [6, 7]. Administrative databases provide a large scale, cost effective manner for investigating diseases such as cardiac arrest, however, to date, the validity of identifying OHCA patients has been in question.

In the United States, the International Statistical Classification of Diseases and Related Health Problems (ICD-9) assigned the unique numeric code 427.5 to represent “cardiac arrest”. Despite the lack of formal validation of this ICD-9 code for research purposes, many investigations have utilized this code to identify a cohort of subjects [8–10]. For example, Richardson et al. utilized ICD-9 code 427.5 to identify a cohort of patients admitted to the hospital following cardiac arrest who had early establishment of “do not attempt resuscitation” orders in the statewide California Database of hospital admissions and found that early DNR order is associated with fewer interventions and procedures in this patient population [8]. Additionally, Mumma et al. analyzed the California Office of Statewide Health Planning Patient Discharge Database to examine the availability and utilization of cardiac resuscitation centers. Patients enrolled in this study were identified if they had ICD-9 code 427.5 “cardiac arrest” listed as “present on admission” [11]. In October of 2015, ICD-10 was introduced, however, this iteration of billing codes simply changed the single ICD-9 code to a single ICD-10 code to identify “cardiac arrest”. Despite this recent change, the frequency with which this single ICD code is utilized in research has persisted with few formal validation studies to ensure the accuracy of this code for investigative purposes.

In this study, we will examine the validity of the ICD-9 code 427.5 for capturing patients who suffered an out-of-hospital cardiac arrest in administrative databases between 2007 and 2012 (prior to the introduction of ICD-10). We hypothesize that ICD-9 code 427.5 will accurately identify patients with cardiac arrest either in the emergency department or with OHCA that have cardiopulmonary resuscitation ongoing at arrival to the emergency department, but, may not capture patients who have return of spontaneous circulation prior to hospital arrival. This internal single center validation of the ICD-9 code 427.5 for OHCA

will provide evidence to support the utilization of this code for larger scale investigations utilizing national administrative and claims databases.

METHODS

Study design and data

We performed a retrospective observational study from a single academic emergency department. Data were obtained from all visits to the emergency department between January 2007 and July 2012. This study was approved by the Institutional Review Board at the University of Pennsylvania with a Waiver of Informed Consent.

Patients

Patients were identified via keyword search of emergency department electronic medical records for all adult (18 years old) visits during the study time period. Keywords searched in the emergency physician (both resident and attending physicians) and nursing notes were “ACLS”, “CPR”, “PEA”, “asystole”, “VFIB”, “VT”, “cardiac arrest”, “Epi”, “code sheet”, “ROSC”, “resuscitation” and “AED”. These keywords were selected a priori and agreed upon by the principal investigator and all authors as being appropriate keywords for this disease process. After the keyword search identified this initial population, cardiac arrest was confirmed on chart review by two investigators (SMP, SBC). Patients had to meet basic standard Utstein Principles as documented in the medical record in order to be included in the “cardiac arrest” cohort. ICD-9 information and location of return of spontaneous circulation (ROSC) was collected for each patient. This cohort was utilized in the “forward” analysis and is based on keyword search (Figure 1).

We separately searched the electronic medical record during the same study period for patients receiving the ICD-9 code 427.5. As described previously, the medical record was reviewed by two investigators (SMP, SBC) to determine if each patient with ICD-9 code 427.5 met standard Utstein criteria for cardiac arrest. This cohort was utilized in the “backward” analysis and is based on assignment of ICD-9 code 427.5 (Figure 1).

Analysis

The kappa coefficient (κ) was calculated to examine the agreement between true arrest and use of the ICD-9 code, as was the sensitivity and specificity of 427.5 at identifying OHCA.

RESULTS

Cases

After conducting the keyword search, a total of 1,717 cases were found; of these, 385 were deemed a true cardiac arrest using Utstein criteria by chart review. Of these 385 arrests, 333 were given the ICD-9 code of 427.5. This was deemed the “forward” analysis to find cardiac arrest patients coded as 427.5 and is described in Figure 1- “Forward Validation”. The “backward” analysis for this study began with the ICD-9 code 427.5, which returned 347 total cases, 320 of which were true cardiac arrests. This is shown in Figure 1, “Backward

Validation”. The agreement between the ICD-9 code 427.5 and true cardiac arrest was found to be excellent ($\kappa=0.895$ and a 95% CI 0.869–0.921).

Sensitivity, Specificity, PPV, and NPV

The sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of ICD-9 427.5 are shown in Table 1. There were 333 true cardiac arrests that were coded as 427.5 and 27 cases that were coded with 427.5 that did not experience cardiac arrest, yielding a positive predictive value of 92.5%. There were 52 true cardiac arrests that were not coded as 427.5 that should have been, and 353,037 ED cases that were true negatives for cardiac arrest that did not have an ICD-9 code of 427.5, which produced a negative predictive value near 100%. The sensitivity of the ICD code was found to be 86.5% and the specificity was found to be near 100%.

OHCA with ROSC Prior to Arrival

There were 52 cardiac arrest cases that were not identified with ICD-9 427.5. Upon chart review, 17 (33%) of these cases were found to have had return of spontaneous circulation prior to arrival at the emergency department. Conversely, the 333 true cardiac arrests that were coded with 427.5 achieved ROSC within the ED at the hospital or expired after arrival at the hospital.

OHCA Not Identified with ICD-9 427.5

We identified a total of 385 true cardiac arrests through our keyword search but only 333 of them had an ICD-9 code 427.5. We looked at the first four ICD-9 codes listed under the encounter of these 52 patients not identified by 427.5 and did not find any uniformity that could further delineate the population. We hypothesized that ICD-9 427.5 plus one or two other ICD-9 codes could identify a larger cardiac arrest population, thus bringing our sensitivity of the codes higher, but were unsuccessful.

DISCUSSION

We found that ICD-9 code 427.5 is both sensitive (86.5%) and specific (100%) for capturing ED cases of OHCA who achieve ROSC within the hospital setting, with a positive predictive value of 92%.

Kappa’s coefficient is a measure of precision, or agreement between observers, and within this study those “observers” are the keywords that we chose to identify true cardiac arrest within the ED population of our hospitals. We found accordance between ICD-9 code 427.5 and true cardiac arrest via these keywords to be significant ($\kappa=0.895$ and a 95% CI 0.869–0.921), which means that cases with words or phrases such as, “ACLS,” “CPR,” and “ROSC” have experienced a cardiac arrest and will be coded correctly with the ICD-9 code for cardiac arrest.

Other researchers have also looked at the validity of this ICD-9 code for cardiac arrest. De Bruin, et al, studied seven different ICD-9 codes, including 427.5, using hospital discharge diagnoses and found a PPV of 82% for ventricular arrhythmias and cardiac arrests within a

Medicare population [12] Their methods differ from ours in that they looked at discharge diagnosis while we looked at keywords within the medical record for our “forward” analysis and utilized deductive reasoning using the ICD-9 code 427.5 for the “backward” analysis [12]. Our entire cohort was also identified by ED visit, which potentially misses in hospital cardiac arrests that the De Bruin researchers identified in their cohort. Finally, De Bruin only used what we defined as a “backward” analysis, looking at ICD code and then determining PPV, while our study additionally used keywords to determine a NPV for the ICD-9 code [12].

Coppler, et al have also looked at this ICD-9 code (amongst others for cardiac arrests) with differing results. They found that various ICD-9 codes do not identify OHCA within the regional healthcare system studied [13]. Coppler used a method similar to our “backward” analysis in that they created a cohort of patients based on the ICD codes they were analyzing, then reviewed these patient records to see if they were coded correctly and determine a positive predictive value [13]. Then they used arrests that were in a registry at their institution to determine sensitivity of the ICD code. Coppler found that the PPV of the ICD-9 codes they looked at was just 40% and the sensitivity to be 100% for patients who expired upon arrival to the ED but only 19% for OHCA who survived in transport to the ED [13]. Coppler did not specify if these patients who survived achieved ROSC within our outside the ED. They concluded that the ICD-9 codes they looked at were inaccurate for predicting OHCA and were biased toward OHCA with high mortality, while we found that the code 427.5 is accurate for predicting OHCA and might be biased toward OHCA with lower mortality because patients with ROSC prior to arrival at ED were not always correctly identified [13].

Implications

The utilization of coding systems is important in healthcare for billing and tracking purposes, and with the advent of electronic medical record systems the ICD has made retrospective chart-abstraction research much easier for quality improvement purposes amongst others. Ensuring that these codes are properly utilized across multiple healthcare systems and environments is a difficult task.

Our keyword search yielded a cohort of true OHCAs, of which 17 were not identified with the ICD-9 code 427.5 for cardiac arrest. We believe this is because they achieved ROSC prior to arrival in the ED. Patients who are not correctly identified as having experienced cardiac arrest might receive a different level of care, they might not be properly identified for research purposes, and they might not be billed correctly.

Limitations

The OHCA cases for this study were all pulled from hospitals that are of the same overall hospital system. Thus, the different employees that assign codes for different patient cases are likely trained more similarly than if they were a part of different hospital systems. This means that at baseline, these codes are more precise (i.e.—more similar to each other) than if we were to look at three different hospitals within three different hospital systems. Despite

this, we found the ICD code to be both precise and accurate for predicting OHCA, so this potential confounding is likely low.

We utilized a retrospective chart review and data pull experimental design in order to be resource-effective and to lay the groundwork for future studies of this nature. A prospective validation of the ICD code would be helpful in the future to ensure that diagnosis is correct each time.

This study was performed looking at the ICD-9 code 427.5. The medical profession now utilizes the ICD-10. Luckily the ICD-10 code for cardiac arrest is also a single code that directly translates from 427.5, so the relevance of this study remains high, as it would likely yield the same results, just with a different combination of letters and numbers for the ICD-10 [14].

CONCLUSION

Using both a keyword search and looking at the ICD code directly and then identifying true cardiac arrests from both cohorts, we found that the ICD-9 code 427.5 for cardiac arrest is both sensitive (86.5%) and specific (100%) for identifying OHCA.

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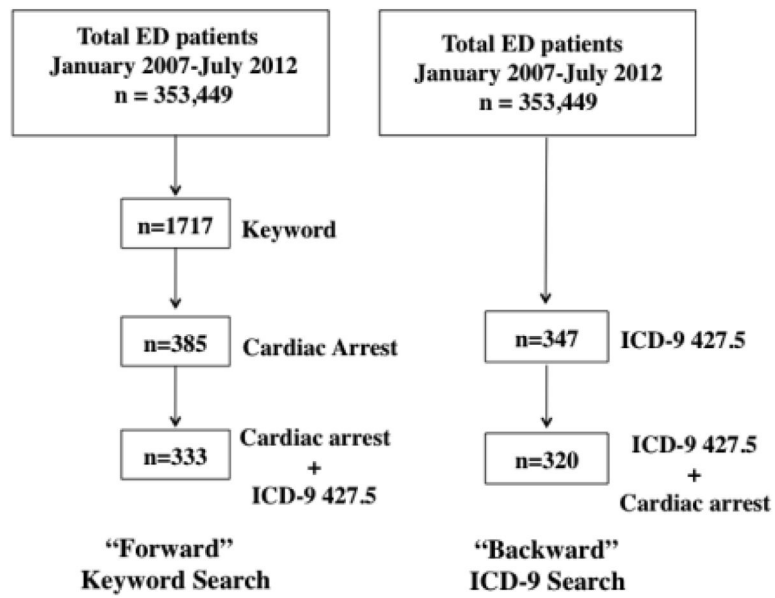


Figure 1. Flow chart indicating patient selection based on the “Forward” selection using keywords versus the “Backward” selection utilizing ICD 9

Table 1

2X2 Table analyzing cardiac arrest versus ICD 9 code 427.5

	“True” Cardiac Arrest	No Cardiac Arrest		
(+) ICD9 427.5	333	27	PPV	92.5%
(-) ICD9 427.5	52	353,037	NPV	100% *
	86.5%	100% *		
	Sensitivity	Specificity		

* 99.999%

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