Published in final edited form as:

Am J Med Qual. 2015 January ; 30(1): 52–57. doi:10.1177/1062860613512518.

Validity of ICD-9-CM codes for the identification of complications related to central venous catheterization

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Abstract

Background—Two complications of central venous catheterization (CVC), iatrogenic pneumothorax and central line associated bloodstream infection (CLABSI), have dedicated International Classification of Disease-9-Clinical Modification (ICD-9-CM) codes. Despite increasing use of ICD-9-CM codes for research and pay-for-performance purposes, their validity for detecting complications of CVC has not been established.

Methods—Complications of CVCs placed between 7/2010-12/2011 were identified by ICD-9-CM codes in discharge records from a single hospital and compared with those revealed by medical record abstraction.

Results—The ICD-9-CM code for iatrogenic pneumothorax had a sensitivity of 66.7%, specificity of 100%, positive predictive value (PPV) of 100% and negative predictive value (NPV) of 99.5%. The ICD-9-CM codes for CLABSI had a sensitivity of 33.3%, specificity of 99.0%, PPV of 28.6%, and NPV of 99.2%.

Conclusions—The low sensitivity and variable PPV of ICD-9-CM codes for detection of complications of CVC raise concern for their use in research or pay-for-performance purposes.

Keywords

ICD-9-CM codes; pneumothorax; central venous catheters; bacteremia

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Conflicts of Interest: None

Disclaimer: The views expressed herein are those of the authors and do not necessarily represent the policy or position of the Dept. of Veterans Affairs or the United States government.

Introduction

Iatrogenic pneumothorax and central venous catheter-related blood stream infections (CLABSI) are complications of central venous catheterization that are associated with significant morbidity, mortality and increased medical costs in hospitalized patients¹⁻⁴. Both complications are considered potentially preventable through the vigilant use of evidence-based process measures of care such as proper hand hygiene and use of maximal barrier precautions in the case of CLABSI^{5, 6} and use of ultrasound guidance during catheter insertion in the case of iatrogenic pneumothorax⁷⁻⁹.

There is increasing interest in using International Classification of Disease-9-Clinical Modification (ICD-9-CM) codes from hospital discharge records both for research purposes and as an indicator of quality of care. The Agency for Healthcare Research and Quality (AHRQ) Patient Safety Indicators (PSIs) were developed to assist hospitals in the identification of potentially preventable in-hospital complications and adverse events using administrative data found in the typical discharge record¹⁰. Both CLABSI (999.31 and 999.32) and iatrogenic pneumothorax (512.1), have dedicated ICD-9-CM diagnosis codes that form the basis of two of the AHRQ's PSIs: PSI 6 (iatrogenic pneumothorax) and PSI 7 (CLABSI)¹¹. While the PSIs were originally intended for internal quality improvement purposes there is a growing trend towards the use of ICD-9-CM based coding algorithms for hospital profiling and pay-for-performance purposes. Along these lines, both iatrogenic pneumothorax related to central venous catheterization and vascular catheter-associated infection are currently listed among the Center for Medicare and Medicaid Services (CMS) Hospital Acquired Conditions (HACs) quality measures adopted by CMS to reduce payment for hospital acquired complications of care¹².

While the coding algorithms behind the AHRQ PSIs and CMS HACs are not identical, they both utilize similar ICD-9-CM diagnosis codes to identify procedural complications. Nevertheless, the validity of ICD-9-CM codes for detecting complications of central venous catheter utilization has not been well established. We sought to determine the sensitivity, specificity, positive and negative predictive values of ICD-9-CM codes for identifying iatrogenic pneumothorax and CLABSI associated with central venous catheterization.

Methods

Study Design

This study was a retrospective cross-sectional analysis using electronic medical record data from Boston University Medical Center and administrative data provided from the University HealthSystem Consortium (UHC). This study was approved by the Boston University Medical Campus Institutional Review Board.

Electronic Medical Record Identification of Procedures and Complications

At Boston University Medical Center, inpatient bedside medical procedures are documented using a standardized procedure note template. We identified adult patients (age ≥ 18) who had undergone central venous catheter placement from July 1st, 2010 to December 31st, 2011, by presence of a completed procedure note template in the electronic medical record.

Procedure characteristics including date of procedure, type of catheter and catheter insertion site were determined from the electronic procedure note. Dates of hospital admission and discharge were determined from the electronic medical record. For the purpose of our analysis the term central venous catheter refers to triple lumen catheters, dialysis lines and Swan-Ganz catheters: PICC lines were not included in this analysis.

For our gold standard definition of iatrogenic pneumothorax, we reviewed reports of all chest radiographs performed within 24 hours of internal jugular and subclavian venous catheter placement for documented pneumothorax. For our gold standard definition of CLABSI, we used data on this complication previously collected by the hospital's infection control nurses (targeted active surveillance prospective chart review on all patients with positive blood cultures to determine whether they met the Center for Disease Control/ National Healthcare Safety Network criteria for CLABSI⁵).

Administrative Database Coding of Procedures and Complications

The University HealthSystem Consortium (UHC) is an alliance of 119 academic medical centers and 293 of their affiliated hospitals that provides risk-adjusted patient-level performance measures to member institutions based on administrative data on all member hospitals' discharges¹³. The UHC clinical database resource manager (CDB-RM) is an online interactive tool used by database participants for performance improvement. Each record in the CDB-RM includes up to 40 ICD-9-CM diagnosis codes and 15 ICD-9 CM procedure codes.

We identified all CDB-RM discharge records from Boston University Medical Center during the study period that documented iatrogenic pneumothorax (ICD-9 CM diagnosis code 512.1) or CLABSI (ICD-9-CM diagnosis codes 999.31 or 999.32). Code 999.32 was introduced to the ICD-9-CM diagnosis code book in October 2011 and was included in our analysis of cases occurring after that time¹⁴. To determine the sensitivity of the ICD-9-CM codes, we compared how often patients who met our gold standard definition for each complication had the appropriate ICD-9-CM diagnosis code documented in their hospital discharge record (i.e., true positives / true positives + false negatives). To determine the specificity of the ICD-9-CM codes, we compared how often patients with no complication of central venous catheterization based on our detailed chart review had no associated ICD-9-CM code indicating a complication (i.e., true negatives / true negatives + false positives). Complications indicated to be "present on admission" in the administrative data were considered to be negative for complications, as is specified in both the AHRQ and CMS HAC coding algorithms^{11, 12}. For our analysis we excluded cases in which ICD-9-CM codes for a complication appeared to be true complications (based on our detailed chart review) of another procedure performed during the same hospitalization (e.g., iatrogenic pneumothorax following transthoracic needle biopsy, unrelated to central venous catheterization performed during same hospitalization).

We calculated descriptive statistics for continuous variables with means and standard deviations and for categorical variables as frequencies and percentages.

Results

Over the 18-month study period 1252 central venous catheterization procedures were documented using the electronic procedure note template during 996 unique hospital admissions (Figure 1). Clinical characteristics of these procedures are described in Table 1. Iatrogenic pneumothorax was identified on post-procedure chest radiograph in 1.1% (12/1069) of internal jugular and subclavian venous catheterization procedures. CLABSI was associated with 0.96% (12/1252) of all (i.e., internal jugular, subclavian, and femoral) central venous catheterization procedures.

The ICD-9-CM code for iatrogenic pneumothorax had a sensitivity of 66.7% (8/12), specificity of 100% (842/842), positive predictive value 100% (8/8) and negative predictive value 99.5% (842/846). The ICD-9-CM codes for CLABSI had a sensitivity of 33.3% (4/12), specificity of 99.0% (969/979), positive predictive value of 28.6% (4/14), and negative predictive value of 99.2% (969/977), (See Tables 2a and 2b).

Discussion

ICD-9-CM based coding algorithms are used extensively in health services research to study healthcare utilization and the effectiveness of specific healthcare interventions; they are also used by healthcare organizations to monitor quality of care and to assist with case-finding for quality improvement efforts. However, they are also increasingly being used for public reporting and pay-for-performance¹². Despite their widespread use, the diagnostic and procedural codes culled from administrative databases are infrequently validated¹⁵. To the best of our knowledge this is the first study to specifically evaluate the sensitivity and specificity of ICD-9-CM codes for detecting complications associated with central venous catheterization. Over a period of 18 months at a large academic teaching hospital we found that the use of ICD-9-CM codes documented in the discharge records to detect potentially preventable adverse events related to central venous catheterization missed a clinically significant portion (11/24, 45.8%) of the complications of interest.

The AHRQ patient safety indicators are ICD-9-CM based coding algorithms that were originally intended to improve detection of potentially preventable adverse events in acute care hospitals using readily available hospital discharge data for internal quality improvement purposes¹⁰. Our data suggest that at the internal level, the ICD-9-CM codes that form the basis of the AHRQ PSIs related to central venous catheterization lack the sensitivity needed to serve as effective quality improvement tools for the detection of complications at our institution. While the sensitivity of the ICD-9-CM code for iatrogenic pneumothorax has not been previously established, Moehring et al. also found the sensitivity of the ICD-9-CM based coding algorithm used by the CMS HAC to detect vascular catheter-associated infections occurring at 3 hospitals in North Carolina to be low (14%)¹⁶. Of note, although the coding algorithms that comprise the CMS HAC and AHRQ PSI for central venous catheter associated infections are similar, they are not identical. While both algorithms exclude complications that are considered “present on admission,” the AHRQ PSI also excludes patients in certain high risk groups (e.g., cancer and immunosuppression). In addition, while during our study period the AHRQ coding algorithm for CLABSI

included both codes 999.31 and 999.32 (after October 2011), in both our study period and that of Moehring et al. the CMS HAC only included 999.31^{11, 12}.

Previous studies on the validity of ICD-9-CM codes for detecting in hospital complications have suggested that the positive predictive value of such codes is highly variable¹⁷⁻²¹. Similar to the findings of other authors evaluating the positive predictive value of the ICD-9-CM codes for iatrogenic pneumothorax and CLABSI²²⁻²⁵, in our study the positive predictive value of ICD-9-CM codes for detecting iatrogenic pneumothorax was high (100%), whereas for CLABSI it was quite low (29%). This juxtaposition of the positive predictive value of ICD-9-CM codes being high for detection of iatrogenic pneumothorax and low for the detection of CLABSI highlights variability in the difficulty of both diagnosing and appropriately documenting complications of central venous catheterization. While the diagnosis of iatrogenic pneumothorax is essentially dichotomous (i.e. either present or not), the diagnosis of CLABSI requires consideration of several clinical criteria (including characteristics of both the central venous catheter and culture results) which increases the likelihood that this complication will be inappropriately documented by clinicians or assessed by coders. Further validation of these codes in settings with differing prevalence is necessary before they can be reliably used in research or as the basis of coding algorithms for public facility comparisons and for pay-for-performance purposes, as is currently mandated for the CMS HACs¹². Furthermore, our results suggest that whenever possible, complication rates of central venous catheterization abstracted from medical records should be preferred over those derived from administrative data. When medical record abstraction is not possible, the high positive predictive value of the ICD-9 codes for iatrogenic pneumothorax associated with central venous catheterization provides reassurance that cases of pneumothorax identified through billing data are likely to represent “true positives.” The combined low sensitivity and low positive predictive value of the ICD-9 codes for CLABSI, however, significantly limit the utility of these codes for use in most settings.

Our study has limitations. Although our findings are consistent with existing literature, the single center nature of our study limits generalizability to other hospital settings. Moreover, while complications associated with central venous catheterization are a significant cause of morbidity and mortality in hospitalized patients, the absolute event rate in our study was low (24 of 1252 procedures, 1.9%). While the rate of iatrogenic pneumothorax seen in our study is similar to that described in the literature,^{1, 26} our study is unique in that we report the incidence of CLABSI in terms of events per catheter and not events per catheter day, making it difficult to compare our CLABSI rate to that of other institutions. In addition, while our gold standard definition of iatrogenic pneumothorax (which identified complications based on radiographic findings) would be expected to be highly sensitive, the accepted gold standard for CLABSI (targeted active surveillance of hospital acquired infections) is subject to human error²⁵. Finally the ICD-9-CM codes 999.32 (bloodstream infection due to central venous catheter) and 999.33 (local infection due to central venous catheter), were added to the ICD-9-CM code book at the end of our study period in October 2011¹⁴. Code 999.32 has since been added to the AHRQ PSI 7 coding algorithm and both 999.32 and 999.33 have been added to the CMS HAC for vascular catheter associated

infection^{11, 12}. Further research is needed to determine whether these coding changes have improved the criterion validity of the coding algorithms for CLABSI.

The low sensitivity of ICD-9-CM codes for detecting complications associated with central venous catheterization raises concern for their use both locally for internal quality improvement and more broadly as the basis of algorithms to be used for public reporting and pay-for performance purposes. If ICD-9-CM based coding algorithms are to continue to be used for public facility comparison and fee-for-service purposes, educational interventions to improve documentation of complications of central venous catheterization, particularly occurrences of CLABSI, must be considered.

Acknowledgments

Research Funding: This work was supported by the National Cancer Institute [Grant K07 CA 138772]. Dr. Wiener and Dr. Borzecki are also supported by the Department of Veterans Affairs.

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Figure 1.
Study Flow Diagram

Table 1

Characteristics and Complications of Central Venous Catheterization

	N	%
Total Procedures	1252	
Total Admissions	996	
Catheter Type		
Triple Lumen	962	76.8
Dialysis	207	16.5
Swan Ganz	83	6.6
Catheter Site		
Internal Jugular	670	53.5
Subclavian	399	31.9
Femoral	183	14.6
Complications		
Pneumothorax	12	1.1
CLABSI	12	0.96

Table 2a

Iatrogenic Pneumothorax Coding Validity

	Gold Standard (+)	Gold Standard (-)
Administrative Data (+)	8	0
Administrative Data (-)	4	842

Numbers shown represent unique hospital discharges

Sensitivity = 66.7%, specificity = 100%, positive predictive value = 100%, negative predictive value = 99.5%.

Table 2b

CLABSI Coding Validity

	Gold Standard (+)	Gold Standard (-)
Administrative Data (+)	4	10
Administrative Data (-)	8	969

Numbers shown represent unique hospital discharges

Sensitivity = 33.3%, specificity = 99.0%, positive predictive value = 28.6%, negative predictive value = 99.2%