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Original Article

Validation of the Use of Discharge Diagnostic Codes for the Verification of Secondary Atrial Fibrillation in Administrative Databases

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ABSTRACT

Background: "Secondary" atrial fibrillation (AF) denotes AF that is precipitated by short-term triggers and that may be reversible. Using administrative data to study secondary AF is of interest, but the ability of these data to verify secondary AF has not been studied.

Methods: We conducted a cross-sectional analysis of 1000 randomly selected hospitalizations of patients discharged alive between January 1, 2016 and March 31, 2020, with AF coded as the most responsible diagnosis (type 1), post-admit comorbidity (type 2), or secondary diagnosis (type 3). We compared diagnosis types to AF category

RÉSUMÉ

Contexte : Une fibrillation auriculaire (FA) « secondaire » signifie que la FA est précipitée par des déclencheurs apparus depuis peu et pouvant être réversibles. L'utilisation de données administratives en vue d'étudier la FA secondaire peut être pertinente, mais la possibilité que ces données permettent d'évaluer les FA secondaires n'a pas été étudiée.

Méthodologie : Nous avons effectué une analyse transversale de 1 000 hospitalisations, sélectionnées au hasard, de patients ayant reçu leur congé alors qu'ils étaient en vie entre le 1er janvier 2016 et

Atrial fibrillation (AF) is the most common sustained cardiac arrythmia[1] and portends substantially increased risks of death, heart failure, and stroke.[2-4] Although AF is mostly a chronic disease, it also can be precipitated in-hospital by short-term triggers, such as surgery, infection, electrolyte disturbances, pneumonia, and chronic obstructive pulmonary disorder (COPD) exacerbations.[5-8] AF that is triggered by a short-term precipitant often appears to resolve after its reversal. Such cases of temporary AF have been designated as "secondary AF," in contrast to "primary AF," which develops without acute provocation and is expected to be longer-lasting.[8,9] Secondary AF comprises a large portion of new-onset AF that is diagnosed in-hospital.[5,6] Despite this, the data on management patterns and the prognosis of secondary AF are limited. This lack of data has resulted in minimal guidance being provided about secondary AF in clinical practice guidelines.[8,10-13]

The knowledge gaps regarding the management patterns and outcomes of people with secondary AF can be reduced by using population-based studies leveraging administrative datasets, as they can be used to create highly inclusive cohorts with long-term follow-up. Administrative datasets can also be used to verify diagnosis of secondary AF in people who may be candidates for clinical trials investigating management approaches. In theory, this can be accomplished by leveraging administrative datasets to verify first-ever AF diagnoses of secondary AF in people who were hospitalized for a different diagnosis. Given that these data are collected primarily for administrative purposes, determining their validity before using them for clinical research is important. Accordingly, the goal of this study was to assess the performance of an

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(secondary or not) as determined by a physician blinded to the discharge diagnosis type. We calculated the positive predictive value (PPV) of the designation of secondary AF in comparison to physician determination.

Results: A total of 421 hospitalizations had AF documented as a type 2 diagnosis; this had a PPV of 94.8% for physician determination of secondary AF. After excluding hospitalizations with preexisting AF, and those for which AF type could not be determined by the physician, the PPV of a type 2 diagnosis (n = 391) for secondary AF was 99.7%. Type 3 diagnoses of AF (n = 222) mostly captured hospitalizations with preexisting AF (87.8% of type 3 diagnoses).

Conclusions: A type 2 diagnosis can be used to verify secondary AF in people who were first diagnosed with AF while hospitalized for other causes. This verification facilitates cohort studies and clinical trial recruitment of people with this AF subtype, although it should not be used to determine the prevalence or incidence of secondary AF.

le 31 mars 2020, et dans le dossier desquels la FA était codée comme étant le diagnostic principal de l'hospitalisation (type 1), une affection concomitante diagnostiquée après l'admission à l'hôpital (type 2) ou un diagnostic secondaire (type 3). Nous avons comparé les types des diagnostics à la catégorie de FA (secondaire ou pas), déterminée par un médecin qui ignorait le type de diagnostic confirmé au moment du congé. Nous avons calculé la valeur prédictive positive (VPP) de la désignation de FA secondaire, comparativement à ce que le médecin a déterminé.

Résultats : Au total, 421 hospitalisations étaient associées à un diagnostic confirmé de FA de type 2, ce qui a produit une VPP de 94,8 % pour ce que le médecin avait déterminé comme étant une FA secondaire. Après l'exclusion des hospitalisations de patients qui présentaient une FA préexistante et de ceux pour qui le type de FA ne pouvait pas être déterminé par le médecin, la VPP d'un diagnostic de FA de type 2 (n = 391) pour une FA secondaire était de 99,7 %. Les diagnostics de FA de type 3 (n = 222) étaient principalement associés à des hospitalisations de patients présentant une FA préexistante (87,8 % des diagnostics de type 3).

Conclusions : Un diagnostic de FA de type 2 peut servir à vérifier la présence d'une FA secondaire chez les personnes ayant reçu un premier diagnostic de FA alors qu'elles étaient hospitalisées pour d'autres causes. Cette vérification facilite les études de cohortes et le recrutement pour des essais cliniques de personnes atteintes de ce sous-type de FA, mais elle ne doit pas servir à déterminer la prévalence ou l'incidence de la FA secondaire.

algorithm for verification of secondary AF in people who were first documented with AF during an acute hospitalization, and for whom AF was not the primary reason for hospitalization. Our hypothesis was that AF that was first diagnosed in-hospital under such circumstances would have a high positive predictive value (PPV) for secondary AF.

Material and Methods

All medical diagnoses made in hospitalized patients in Canada are recorded in the Canadian Institute for Health Information's Discharge Abstract Database (CIHI-DAD). The diagnoses are classified into diagnosis types based on the impact the condition had on the patient's in-hospital care.[14] Diagnosis type M (most responsible diagnosis) refers to a condition that is the most responsible for a patient's stay in the hospital. If a patient is hospitalized for more than one condition, the one responsible for the greatest portion of the stay is selected as the most responsible. Diagnosis type 1 (pre-admit comorbidity) refers to a condition that existed prior to the patient's stay in the hospital. Diagnosis type 2 (post-admit comorbidity) refers to a condition that arises after the patient is admitted to the hospital. Both type 1 and type 2 diagnoses are comorbid diagnoses and require fulfillment of at least one of the following criteria of significance: requires treatment beyond maintenance of the preexisting condition; increases length of stay by at least 24 hours; and/or significantly affects the treatment received. Diagnosis type 3 refers to a secondary diagnosis for which a patient may or may not receive treatment. A type 3 diagnosis cannot meet any of the criteria of significance listed above.[14]

We conducted a cross-sectional analysis using electronic medical record data, which was approved by the University Health Network research ethics board. The hospital's data services department provided us with a randomly selected sample of 1000 hospitalizations of patients who were discharged alive between January 1, 2016 and March 31, 2020 from Toronto General Hospital (TGH), Toronto Western Hospital (TWH), or Princess Margaret Cancer Centre with a type M, type 2, or type 3 diagnosis of AF. These 3 hospitals together comprise the University Health Network in Toronto. Patients who were coded as having a type 1 diagnosis of AF were not included, because our objective was to study AF that was first recognized in-hospital (rather than as a pre-admit comorbidity).

A second-year internal medicine resident (B.S.) reviewed the discharge summary associated with each hospitalization. The reviewer was blinded to the diagnosis type that had been recorded by the hospital's medical records department. The description of the clinical course and any available electrocardiogram results were used to verify the diagnosis of AF. The physician reviewer was asked to determine whether the AF was characterized more aptly as primary AF or secondary AF, based on whether the AF was felt to be the primary cause of hospitalization or a secondary issue that arose during hospitalization. The reviewer also determined if the AF was newly diagnosed or rather had been documented in the patient's past medical history. She also collected patient age, sex, hospital (TGH, TWH, or Princess Margaret Hospital [PMH]), and calendar year of discharge. The presence of sinus rhythm at time of discharge was also recorded if that could be determined from the discharge summary. No personal health information (eg, date of birth) was collected. The AF category and prior AF status were classified as undetermined for hospitalizations for which the discharge summary could not be accessed.

Table 1. Characteristics of patients included in the validation study (n = 983)

Median age, y (Q1–Q3)	70 (62–78)
Sex	
Male	609 (60.9)
Female	374 (37.4)
Hospital	
Toronto General Hospital	781 (79.4)
Toronto Western Hospital	183 (18.6)
Princess Margaret Hospital	17 (1.7)
Not documented	2 (0.2%)
Year of discharge	
2016	182 (18.5)
2017	240 (24.4)
2018	257 (26.1)
2019	247 (25.1)
2020	57 (5.8)
AF prior to hospital admission	
Yes	441 (44.9)
No	540 (54.9)
Unknown	2 (0.2)
Sinus rhythm at discharge	
Yes	313 (31.8)
No	29 (3.0)
Unknown	641 (65.2)

Values are n (%), unless otherwise indicated.
AF, atrial fibrillation; Q1, 25th percentile; Q3, 75th percentile.

Statistical analysis

Baseline characteristics were summarized using the median, with 25th-75th percentiles (Q1-Q3) for continuous variables, and counts with percentages were used for categorical variables. The physician reviewer's determination of AF category (primary vs secondary) was treated as the reference standard for the purposes of this analysis. This categorization was compared to the categorization of AF per the discharge diagnosis type assigned in the hospital discharge record. If AF was coded as the most responsible diagnosis in the hospital discharge record (ie, diagnosis type M), it was categorized as primary. Our main approach in making the determination of secondary AF was to use this categorization if the case was documented as a post-admit comorbidity (diagnosis type 2). We also explored the performance of AF as a secondary diagnosis (diagnosis Type 3) for determination of secondary AF.

We calculated the positive predictive value (PPV) of the designation of secondary or primary AF in the hospital discharge record, in comparison to the reference standard (physician determination). The primary analysis included all hospitalizations, including those for which the AF category could not be determined after chart review, and hospitalizations of patients with preexisting AF. We conducted sensitivity analyses after excluding people documented in the discharge summary as having preexisting AF, and charts in which the AF diagnosis type could not be determined by the reviewer (ie, a complete case analysis). As a secondary analysis, kappa statistics were calculated to determine the agreement between the physician determination of AF diagnosis type vs that on the discharge summaries.[15] We also conducted a post hoc analysis to determine the distribution of AF diagnosis types and the PPV at each of the 3 hospitals in the University Health Network. All statistical analyses were conducted using SPSS, version 28 (IBM, Armonk, NY).

Table 2. A comparison of the atrial fibrillation discharge diagnosis type against atrial fibrillation category, as determined by physician review for all hospitalizations (n = 1000)

Diagnosis	Primary	Secondary	Undetermined	Total
Type M	307	42	8	357
Type 2	1	399	21	421
Type 3	11	194	17	222
Total	319	635	46	1000

Type M, most responsible; type 2, post-admit comorbidity; type 3, secondary.

Results

Patient characteristics

Of the 1000 hospital discharges provided, 14 charts could not be accessed, and 3 were duplicates of patients that were already included. The characteristics of the 983 included patients are summarized in Table 1. Most patients were male (60.9%), and the median age at hospital admission was 70 years (Q1-Q3 62-78 years).

Of the 1000 hospitalizations with AF diagnoses, most (78.2%) were discharges from TGH. With regard to AF diagnosis type, 357 (35.7%) were classified in the hospital discharge record as having diagnosis type M; 421 (42.1%) were classified as diagnosis type 2; and 222 (22.2%) were classified as diagnosis type 3. Based on physician chart review, 442 hospitalizations (44.2%) involved patients documented as having a diagnosis of AF prior to their hospital admission.

Validation of diagnostic codes

We included all 1000 hospitalizations with a type M, 2, or 3 AF diagnosis in the primary analysis. A breakdown of the 1000 hospitalizations according to the hospital discharge record, and whether they were determined to be primary or secondary AF according to physician review, is presented in Table 2. The PPV of a type 2 diagnosis of AF in the hospital discharge record for classifying AF as secondary was 94.8%, and the PPV of a type 3 diagnosis was 87.4%. The PPV of a type M diagnosis for classifying AF as primary was 86.0%. The overall kappa score was 0.55. The analysis stratified by each specific hospital revealed significant differences in the distribution of AF diagnosis, as summarized in Table 3 ($P < 0.001$). Nonetheless, the PPV of a type 2 diagnosis for predicting secondary AF was above 90% at all 3 hospital sites (97.1% at TGH; 90.4% at TWH; 100% at PMH).

Among 357 hospitalizations with a type M diagnosis, 237 (66.4%) were documented in the medical record to have AF prior to hospital admission. Similarly, of 222 hospitalizations with a type 3 diagnosis of AF, 195 (87.8%) were found to have AF pre-admission. In contrast, only 10 (2.4%) of the 421 hospitalizations with a type 2 diagnosis had AF pre-admission. The results of the analyses after excluding the 442 hospitalizations with preexisting AF and the 18 hospitalizations for which prior AF status was unknown are presented in Table 4. For hospitalizations for which the AF was newly recognized, the PPV of a type 2 diagnosis for classifying AF as secondary was 96.8%, and the PPV of a type M diagnosis for classifying AF as primary was 84.2%. Conversely, the PPV for classifying AF as provoked was only 52.2% for a type 3 AF diagnosis in

Table 3. A comparison of the atrial fibrillation discharge diagnosis type against hospital location (n = 1000)

Diagnosis	TGH	TWH	PMH	Unknown	Total
Type M	294 (37.6)	56 (30.6)	0 (0.0)	7 (38.9)	357
Type 2	347 (44.4)	52 (28.4)	15 (88.2)	7 (38.9)	421
Type 3	141 (18.0)	75 (41.0)	2 (11.8)	4 (22.2)	222
Total	782	183	17	18	1000

Values are N (% of hospital), unless otherwise indicated.

PMH, Princess Margaret Hospital; TGH, Toronto General Hospital; TWH, Toronto Western Hospital; Type M, most responsible; type 2, post-admit comorbidity; type 3, secondary.

Table 5. A comparison of the atrial fibrillation (AF) discharge diagnosis type against AF category as determined by physician review after excluding patients with prior AF and/or unknown AF type according to physician review (n = 517)

Diagnosis	Primary	Secondary	Total
Type M	96	17	113
Type 2	1	390	391
Type 3	1	12	13
Total	98	419	517

Type M, most responsible; type 2, post-admit comorbidity; type 3, secondary.

hospitalizations with AF newly recognized in-hospital. However, for 10 of these hospitalizations with a type 3 diagnosis (43.5%), the reviewing physician could not classify the AF as primary vs provoked. The overall kappa score for this subset of the study sample was 0.79.

After excluding hospitalizations with prior AF and those with an undetermined AF category, we were left with 517 hospitalizations with newly recognized AF and for which AF diagnosis type could be characterized. A breakdown of diagnosis types is presented in Table 5. The PPV of a type 2 diagnosis for determining provoked AF was 99.7%, and the PPV of a type 3 diagnosis for determining provoked AF was 92.3%. The PPV of a type M diagnosis for classifying AF as primary AF was 85.0%. The overall kappa score for this subset of the cohort was 0.83.

Discussion

In this cross-sectional validation study, we demonstrated that appropriate utilization of discharge diagnosis types in the Canadian Institute for Health Information's Discharge Abstract Database can be used to categorize patients as likely having primary or secondary AF. The PPV was high, compared to physician determination of AF type after chart review. In particular, a discharge diagnosis of AF as a type 2 diagnosis had a PPV of $> 90\%$ for detecting AF that was not the primary reason for hospitalization and that was not recognized before hospital admission. When we further excluded people who had been documented to have preexisting AF, the PPV of a type 2 diagnosis for determining secondary AF rose to $> 95\%$. A point we want to highlight is that the PPVs in the sensitivity analyses excluding people with undetermined AF status and preexisting AF are likely overestimated. A type M diagnosis also performed well for verifying primary AF, with a PPV of 86%. Type 3 diagnoses of AF captured mostly people with preexisting AF, who constituted 87.8% of such diagnoses, indicating that they should not be used for the study of people with secondary AF in administrative data.

Table 4. A comparison of the atrial fibrillation (AF) discharge diagnosis type against AF category as determined by physician review after excluding hospitalizations with prior AF (n = 540)

Diagnosis	Primary	Secondary	Undetermined	Total
Type M	96	17	1	114
Type 2	1	390	12	403
Type 3	1	12	10	23
Total	98	419	23	540

Type M, most responsible; type 2, post-admit comorbidity; type 3, secondary.

Overall, our analysis suggests that a type 2 discharge diagnosis of AF can be used to leverage administrative datasets for the study of people whose AF was first recognized in-hospital during an admission for another cause. The PPVs of the discharge diagnostic type 2 in verifying patients with secondary AF were higher than 90% in all our analyses. This finding suggests that type 2 diagnoses can be used to verify patients with a high likelihood of having secondary AF. The reliability of this approach can be increased further if the lookback period in administrative datasets is used to exclude any diagnoses of AF that were made before hospital admission.

Data regarding the management of patients with secondary AF are highly limited, especially in those admitted for noncardiac and nonsurgical reasons. This scarcity is particularly relevant for stroke prophylaxis with anticoagulants, which balances the risk of stroke with that of bleeding.[16] The risk of stroke in patients with secondary AF is less established than it is in people with primary AF, and patients with secondary AF are also more likely to have multiple comorbidities than similarly aged patients with primary AF.[5,17] Lubitz et al.[6] performed a longitudinal observational study following participants from the Framingham Heart Study with AF first detected between 1949 and 2012. The results of the study demonstrated that the risk of recurrent AF was high, whether the AF was primary or secondary, and that the long-term risks of stroke and mortality were similar for participants with primary vs secondary AF. The authors called for future studies that could help determine whether increased AF surveillance and adherence to primary AF management principles is warranted in patients with secondary AF.[6] Another study led by Siontis et al. utilized administrative data from Minnesota to demonstrate that secondary AF after noncardiac surgery was associated with a lower risk of recurrence but similar stroke risk as primary AF that was unrelated to surgery.[18] However, whether patients with secondary AF would benefit from receiving anticoagulation at the same thresholds as people with primary AF is unclear. Quon et al.[7] conducted a retrospective cohort study using Quebec administrative data to assess the risk of ischemic stroke and hemorrhage in patients with secondary AF. The authors found that no association was present between anticoagulation and lower risk of ischemic stroke in patients with secondary AF, and therefore concluded that using anticoagulants in some patients with secondary AF is of limited benefit.

A specific point of debate is the need for anticoagulation of secondary AF in the setting of cardiac surgery. Oraii et al. reported that new-onset postoperative AF following coronary artery bypass graft (CABG) surgery was associated with increased risk of overall mortality and stroke midway through their 49-month follow-up time but that it did not portend longer-term mortality risk if people who had early stroke were censored.[19] In a systematic review of 9 observational studies, Wang et al. reported that anticoagulation of people with secondary AF following cardiac surgery was associated with minimally lower risk of arterial thromboembolism (2 less events per 1000 person-years), but also with increased risk of bleeding (42 more events per 1000 person-years).[20]

Most prior studies on secondary AF have focused on stroke risk and the need for anticoagulation. A less appreciated finding is that people discharged from the hospital with AF have a high risk of death,[17] and that stroke contributes to only a negligible proportion of the mortality risk associated with AF.[21,22] This finding highlights the importance of close follow-up after hospital discharge for people with secondary AF, geared at addressing their overall health status. Indeed, the American College of Cardiology (ACC)/American Heart Association (AHA)/Heart Rhythm Society (HRS) guidelines recommend "careful follow-up" for patients with newly diagnosed secondary AF. For cardiovascular diseases other than AF, ample data have demonstrated that early follow-up is associated with improved outcomes for patients after discharge from the hospital or the emergency department (ED), particularly if patient care is shared among cardiologists and generalists.[23-26]

For AF, the data are more limited on physician follow-up and its association with patient outcomes. Most available data are specific to patients with primary AF who are discharged from the ED. In a study of 14,907 patients discharged from Ontario EDs with a new primary diagnosis of AF between 2007 and 2012, only half had follow-up within a week, and 18.0% had still not obtained follow-up care at 30 days.[27] Another study of 2902 propensity score-matched pairs of individuals with newly diagnosed primary AF in the ED demonstrated that cardiologist care within a year of diagnosis was associated with lower mortality (5.3% vs 7.7%).[28] Data from Ontario indicated that fewer than half the patients who are diagnosed with primary AF in the ED are started on anticoagulation after discharge, despite being eligible for it based on their age.[29] We suspect that similar or larger gaps in care occur for hospitalized patients with newly diagnosed secondary AF. These are important questions about secondary AF that can be addressed using administrative data, by applying the approach tested in this study.

The Ontario administrative datasets offer a potentially valuable resource for investigating patients with secondary AF, their management, and their prognosis following discharge. Tu et al. demonstrated that Ontario administrative database diagnostic codes used to identify patients with AF had a specificity of over 95%.[30] Validating the accuracy of diagnostic codes for determining primary vs secondary AF, however, is crucial before conducting further studies using administrative data. The Minnesota study led by Siontis et al. identified patients with secondary AF using International Classification of Diseases, version 9 diagnostic codes, and each diagnosis had to be validated by trained nurse abstractors.[18] In contrast, the study by Quon et al. utilized International Classification of Diseases, version 10 diagnostic codes to identify and diagnose patients with secondary AF without reviewing the accuracy of these codes, which was highlighted as a limitation of the study.[7] Collectively. these studies highlight the fact that administrative data can be useful for studying secondary AF but validation of the appropriateness of using diagnostic codes in verifying secondary AF is required.

Our study has several limitations. First, all patients in our cohort received care from 3 hospitals within one health network (TGH, TWH, PMH), but they all fall within one healthcare system (University Health Network) in one urban centre (Toronto). Therefore, the results of this study might not be generalizable to a wider population outside of this healthcare system. Another limitation is that we did not verify all diagnoses of AF with electrocardiograms. Thus, for most patients, we relied on the description of the clinical course within the discharge summary. Additionally, we relied on discharge summaries for identification of preexisting AF, and review of these may have not been sensitive enough to identify all previously recognized AF. We also did not collect data on whether the AF was diagnosed before or after hospital admission. Our approach was limited to reviewing AF diagnoses made within the specific hospitalization, and we did not determine if AF was provoked by an event preceding the admission to the hospital (including previous hospitalizations). Another limitation of our study was the use of only one physician chart reviewer. In several cases, the physician was not able to determine whether AF was primary or secondary, and categorization of such instances may have been improved with the use of a second chart reviewer. Finally, our sample was defined by people having been documented with AF as one of the discharge diagnoses. This definition means that we did not include patients who would have had AF that was not documented in the discharge diagnoses. Accordingly, we could only verify true and false positives, that is, we could not determine sensitivity and negative predictive value, as we could not distinguish true from false negatives. This means that type 2 diagnoses of AF should not be used to interrogate administrative datasets to report on the population-wide incidence and/ or prevalence of secondary AF. Rather, their use should be limited to determining the characteristics and outcomes of a subset of people who have a high likelihood of having secondary AF.

Conclusions

A type 2 diagnosis can be used to verify secondary AF in people hospitalized for other causes, particularly if preexisting diagnoses of AF are excluded. This strategy can leverage administrative datasets to study the management and outcomes of hospitalized patients with secondary AF while allowing for comprehensive long-term follow-up. The high PPV also can be useful to verify people with secondary AF for recruitment into pragmatic clinical trials, by leveraging administrative datasets. However, this approach should not be used to determine the prevalence or incidence of secondary AF, given its undetermined sensitivity.

Ethics Statement

We conducted a cross-sectional analysis using electronic medical record data, which was approved by the University Health Network research ethics board.

Patient Consent

The authors confirm that patient consent is not applicable to this article. This is a retrospective case report using de-identified data; therefore the IRB did not require consent from the patient.

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Disclosures

The authors have no conflicts of interest to disclose.

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