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Identification and Validation of Vertebral Compression Fractures using Administrative Claims Data

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Abstract

Introduction—Vertebral compression fractures (VCFs) are the most common type of osteoporotic fracture. Administrative claims data might be useful to identify VCFs, but this approach to case finding has received limited evaluation.

Methods—Using the administrative claims databases of a large regional U.S. health care organization, we identified adults with a claim with a VCF diagnosis code from January 2003 to June 2004 and excluded persons with malignancy. We examined the positive predictive values (PPV) of several claims algorithms to correctly identify any confirmed (prevalent or incident) VCF, and separately, incident VCFs.

Results—A total of 259 persons were identified with a VCF suspected based on their administrative claims data. A claims algorithm that required a VCF diagnosis on any claim had a PPV to identify any confirmed VCF of 87 % (95% confidence interval 82−91%). The PPV of this algorithm to identify a confirmed incident VCF was 46% (95% confidence interval 37−54%). An algorithm that required a spine imaging test followed by a physician visit with a VCF code within 10 days, or a hospitalization with a primary diagnosis code, had higher PPVs (PPV = 93%, 95% CI 87−98% for any confirmed VCF; PPV = 61%, 95% CI = 49 − 74% for incident VCFs).

Conclusion—A simple case finding approach to identify VCFs using administrative claims data can identify prevalent VCFs with high accuracy but misclassified more than half of incident VCFs. A more complex claims algorithm may be used but still will result in some misclassification of incident VCFs.

Keywords

Osteoporosis; validation; vertebral compression fractures; administrative claims

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Introduction

Vertebral compression fractures (VCFs) account for approximately half of all osteoporosis-related fractures [1]. Bone turnover is typically greater in vertebral bodies than at sites with more cortical bone and is most quickly affected by the deleterious effects of certain drugs such as glucocorticoids [2]. The benefit of the existing anti-fracture therapies, quantified as the relative risk reduction (RRR) for fracture, is greater for VCFs than for other types of fractures [3-5].

Incident VCFs are typically diagnosed by radiographs or other types of spine imaging, in conjunction with a physicians' clinical assessment. Both the radiology test and physician office visit at which VCFs are diagnosed can be identified using administrative claims data. Thus, this data source might be useful to identify VCFs that are diagnosed in routine clinical practice.

Due to cost and feasibility concerns of conducting comparative studies using randomized controlled trial (RCTs), observational studies using administrative claims databases have been used to evaluate the comparative effectiveness of different agents on the risk of fracture [6]. Because administrative claims databases collect data for the purposes of reimbursement and not clinical care, their validity to accurately identify specific medical events needs to be established. Past observational studies that have been dependent on use of administrative claims data to identify fractures generally have been limited to non-vertebral fractures given the lack of VCF validation studies (6).

Due to this evidence gap, we assess the accuracy of claims-based algorithms to identify both prevalent and incident VCFs. An algorithm to identify prevalent VCFs might be useful to identify a confirmed VCF as a risk factor for future fractures and to provide a mechanism to recognize osteoporosis. A claims-based algorithm that could identify incident VCFs would be useful to establish a temporal association between osteoporosis treatments and these fractures.

Methods

Study Design

After local Institutional Review Board approval, we used administrative claims data from a large not-for-profit health care insurer with over 3-million enrollees to create a cohort of patients suspected to have a VCF based on administrative data. These data included inpatient, outpatient, and physician claims as well as patient demographics. For each suspected VCF, medical records and radiology reports were obtained and used as the gold standard to classify VCFs as incident or prevalent. We examined various claims algorithms and examined their sensitivity, specificity, and positive predictive values to correctly classify incident and prevalent VCFs.

Eligibility and Identification of Suspected VCFs

Based upon the resources available to perform medical record review, we randomly selected 259 persons age > 18 years with a diagnosis code for VCF (see appendix 1). Claims from 1/1/2003 to 6/30/2004 defined the study period. The date of the first claim during the study period with a VCF diagnosis code defined the "index date". We also inspected claims data during a 12 month baseline period prior to the index date. Persons undergoing vertebroplasty or kyphoplasty procedures were excluded from the cohort (n = 48) since we believed that undergoing this procedure was prima facie evidence of a VCF. Individuals with medical claims suggesting a malignancy were excluded (see appendix 1). Due to the large number of persons with pathologic fracture diagnoses (ICD-9 code 733.13) but no evidence of cancer in the claims data, we included this diagnosis in our screen for VCFs.

Radiology and Medical Record Reviews

After identifying patients suspected to have a VCF using the administrative data, the health care insurer requested radiology records from the appropriate treating facility and physician. All imaging reports (**chest and spine radiographs**, magnetic resonance imaging, computerized tomography, and/or bone scans) within ± 1 month of the index date were requested. Up to three requests, approximately 3 to 4 weeks apart followed by telephone calls to non-responsive facilities, were made as needed. In approximately 20% of cases, physician offices also sent us medical records from office visits that supplemented the radiologic data.

Classification of VCFs

Radiology and medical records were independently reviewed by two investigators and VCFs were confirmed or refuted. The timing of confirmed VCFs was further classified as incident, prevalent, or unable to determine (UTD). A radiologists' assessment of the acuity of the fracture in the written radiology report was used as the gold standard to classify the timing of VCFs. When fracture onset was not specifically mentioned by the radiologist, the presence of bone edema on MRI, or physician office notes that documented a new VCF in conjunction with confirmed VCF on an imaging test, also satisfied the definition of an incident VCF. Suspected VCFs for which there was no associated imaging test obtained were excluded from analyses of prevalent VCFs; these may or may not have represented a true prevalent VCF, but there was no way to confirm with radiologic data. For algorithms defining an incident VCF, these cases were included and but not classified as an incident fracture, since we assumed that an imaging test would be required to diagnose a new VCF. The timing of all other confirmed VCFs was classified as unable to determine (UTD). Discordance in record reviewers was adjudicated by consensus of a physician panel of co-authors.

Statistical analysis

A global measure of medical comorbidity was quantified by the sum of 30 separate disease indicators based on the work of Elixhauser et al [7]. We then developed claims-based algorithms designed to identify a prevalent or incident VCF, with the goal of maximizing specificity and associated positive predictive value (PPV). Our algorithms incorporated varying combinations of the type of medical claim with a VCF diagnosis (physician encounter, inpatient, or other), receipt of a prior spine imaging test, and whether or not they had a prior VCF diagnosis in the claims data during the baseline period.

As part of a sensitivity analyses, we used our preferred claims algorithm and varied assumptions regarding the acuity of the UTD VCFs. At one extreme, all UTD VCFs were considered as incident, and at the other extreme, all UTD VCFs were classified as prevalent. For each of these, and compared to a case finding procedure that accepted any VCF diagnosis on any type of medical claim, we quantified the sensitivity, specificity, and positive predictive values to correctly classify both prevalent and incident VCFs. Ninety-five percent confidence intervals were approximated using the binomial distribution.

Since these results might be used in future analyses to evaluate the comparative effectiveness of medications used to prevent VCFs, we used published formula [8] to evaluate the effect of misclassification of VCFs on various hypothetical relative risk reductions (RRRs) that might be associated with use of an osteoporosis medication. Assuming that misclassification is non-differential (i.e. unrelated to drug exposure), we estimated the hypothetical relationship between a true RRR compared to the observed RRR under varying assumptions regarding the amount of misclassification estimated from our earlier analyses. SAS version 9.1 was used for analysis (SAS Institute, Cary, NC).

Results

We identified 259 persons with a suspected VCF based on claims data. The mean ± standard deviation age was 62 ± 12 years, and 56% were women. Based upon patterns of health services utilization in the 12 months prior to the index date, they averaged 9.5 ± 9.9 physician visits per year. The mean comorbidity count was 1.9 ± 2.0. For 10 (4%) of the persons with VCF claims, there was no spinal imaging performed within ± 1 month of the VCF claim. Because there were no radiology records to review and confirm cases, we excluded these cases from analyses of prevalent VCFs. They were included in the incident VCF analysis and classified as "not confirmed". For the remaining 249 individuals, we were able to obtain the desired medical and radiology records for 186 (75%) of persons. After medical record review, we confirmed 40 (22%) cases as prevalent VCFs and 63 (34%) as incident VCFs. For 25 (13%) of cases, we did not confirm any VCF. For the remaining 58 (31%) cases, we confirmed that there was a VCF, but the radiology and physician records were not able to evaluate whether the VCF was incident or prevalent; the timing of these VCFs was therefore classified as UTD. For the 161 confirmed VCFs, the type of imaging test used for VCF classification was MRI (33%), computerized tomogram scan (16%), bone scan (7%), and radiograph (45%).

Table 1 shows the positive predictive value (PPV) of various claims algorithms that might be used to identify a VCF. As shown, a VCF claim of any type was able to identify a confirmed prevalent VCF with high PPV, but fewer than half of these claims identified an incident VCF. The PPVs of inpatient VCF claims were high but identified few VCFs. The PPV of an algorithm that required a radiologic imaging procedure followed by a physician claim for a VCF within 10 days was 59%. Shortening or lengthening this interval from 5 to 30 days produced similar results (data not shown). Additional variations that incorporated whether the patient had a prior claim for a VCF or a spine imaging test more than 30 days before the index date did not appreciably change our results and are not shown. Our preferred algorithm for an incident VCF combined a radiologic test followed within 10 days by a physician visit with a diagnosis of VCF, or a hospitalization with a VCF diagnosis in the primary position; the PPV for this algorithm was 61%.

Table 2 further describes the diagnostic properties of our preferred claims-based algorithm, varying our assumptions regarding the 58 fractures for which we could not classify acuity. Depending on how these fractures were handled, the PPVs ranged from 74% to 42%.

Table 3 shows the effect of misclassifying VCFs on the RRRs that might be observed with use of an osteoporosis medication. Due to the misclassification of VCFs, all observed RRR were closer to the null compared to the true RRRs. As misclassification increased (i.e. the PPV decreased), the magnitude of the difference between the observed RRR and the true RRR also increased.

Discussion

We found that a all medical claim with a diagnosis code of a VCF had a high PPV to identify a confirmed clinical VCF. However, fewer than half of these fractures were new VCFs. A more specific claims algorithm that required an imaging test followed within 10 days by a physician office visit with a diagnosis of VCF, or a hospitalization with a primary diagnosis of VCF, resulted in a higher PPV (61%). The PPVs of this algorithm to identify incident VCFs may have been higher (up to 74%), depending on the assumptions regarding the timing of the VCF.

In terms of study strengths, in contrast to other fractures such as hip [9,10], there has been limited evaluation of a claims-based definition for accurately identifying clinical VCF. Moreover, we had a sufficient sample size that allowed us to compare various permutations of claims-based algorithms to classify VCFs. As a possible limitation, our approach to classify

incident VCFs may have been overly conservative and thus yielded lower PPVs. In large osteoporosis cohort studies, the occurrence of new back pain with an x-ray showing a vertebral fracture satisfies the definition for an incident fracture, even though these two elements might be unrelated to one another. Thus, the true PPV for incident fractures associated with our preferred claims algorithm could be closer to 75%, as shown in Table 2. We also lacked sufficient statistical power to identify recurrent incident clinical VCFs; future studies that use claims data to differentiate a second new VCF as separate from follow-up visits for the first new VCF are needed.

In conclusion, we examined the positive predictive values of several claims-based algorithms to identify prevalent and incident VCFs. These algorithms are likely to be useful in future studies to identify a prevalent VCF as a risk factor for a future fracture or as a marker diagnostic of osteoporosis. Although even the most specific algorithms will modestly misclassify incident VCFs, these results may be useful in future observational studies to evaluate the effectiveness of osteoporosis medications on the risk of a new VCF.

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Appendix

APPENDIX

Appendix 1

Diagnostic and Procedure Codes Used for Identification of Vertebral Compression Fractures (VCFs) and Selected Exclusions

Description of Codes	Codes Used in Study
ICD-9 codes for identifying vertebral fractures	805.2, 805.4, 805.8, 733.13
CPT codes used for vertebroplasty/ kyphoplasty identification	22520, 22521, 22522, 76012, 76013
HCPCS codes used for vertebroplasty/ kyphoplasty identification	S2360, S2361, S2362, S2363
CPT codes for spinal radiology	72xxx
ICD-9 codes used to exclude patients with malignancies and pathologic bone processes apart from osteoporosis (includes codes for malignant neoplasms, non-specific hemangiomas, bone and plasma cell neoplasms)	140.xx to 208.xx, 228.09, 238.0, 238.6, 239.2

References

1. Bone Health and Osteoporosis: A Report of the Surgeon General. U.S. Dept of Health and Human Services; Rockville, MD: 2004.
2. De Vries F, et al. Fracture risk with intermittent high-dose oral glucocorticoid therapy. Arthritis Rheum 2007;56(1):208–14. [PubMed: 17195223]
3. Black DM, et al. Randomised trial of effect of alendronate on risk of fracture in women with existing vertebral fractures. Lancet 1996;348:1535–41. [PubMed: 8950879]
4. Cummings SR, Black DM, Thompson DE, Applegate WB, Barrett-Connor E, Musliner TA, Palermo L, Prineas R, Rubin SM, Scott JC, Vogt T, Wallace R, Yates AJ, LaCroix AZ. Effect of alendronate on risk of fracture in women with low bone density but without vertebral fractures. J Am Med Assoc 1998;280:2077–2082.

5. Harris ST, et al. Effects of risedronate treatment on vertebral and nonvertebral fractures in women with postmenopausal osteoporosis: a randomized controlled trial. JAMA 1999;282:1344–1352. [PubMed: 10527181]
6. Silverman SL, et al. Effectiveness of bisphosphonates on nonvertebral and hip fractures in the first year of therapy: the risedronate and alendronate (REAL) cohort study. Osteoporos Int 2007;18(1):25–34. [PubMed: 17106785]
7. Elixhauser A, et al. Comorbidity measures for use with administrative data. Med Care 1998;36(1):8–27. [PubMed: 9431328]
8. Green MS. Use of predictive value to adjust relative risk estimates biased by misclassification of outcome status. Am J Epidemiol 1983;117(1):98–105. [PubMed: 6823958]
9. Baron JA, et al. Internal validation of Medicare claims data. Epidemiology 1994;5(5):541–4. [PubMed: 7986870]
10. Ray WA, et al. Identification of fractures from computerized Medicare files. J Clin Epidemiol 1992;45 (7):703–14. [PubMed: 1619449]

Table 1

Positive Predictive Value of Various Administrative Claims Data Patterns to Correctly Classify Confirmed Prevalent or Incident Vertebral Compression Fractures* (n = 259 suspected)

	Confirmed Prevalent or Incident Fracture (N = 161)	Incident Fracture (n = 63)
	PPV (%)	PPV (%)
1) VCF diagnosis on a claim of any type (n = 259)	87 (82−91)	46 (37−54)
2) VCF diagnosis on a hospitalization claim, primary or secondary diagnosis (n = 35)	92 (69−98)	67 (45−88)
2a) VCF diagnosis on a hospitalization claim, primary diagnosis (n = 22)	94 (69−98)	91 (74−100)
3) VCF diagnosis on an Evaluation and Management (E/M) claim from a physician (n = 124)	93 (87−98)	52 (39−64)
4) VCF diagnosis on an E/M claim from a physician, with a spine imaging test on the same day or in the previous 10 days (n = 108)	92 (87−98)	59 (46−72)
5) VCF diagnosis on an E/M claim from a physician, preceded by spinal imaging within the previous 10 days; OR VCF diagnosis on a hospitalization claim, primary diagnosis (n = 111)	93 (87−98)	61 (49−74)

VCF = Vertebral Compression Fracture; PPV = Positive Predictive Value

* radiology reports and medical records were used as the gold standard. Fractures unable to be classified as new or old were excluded from this analysis (n = 58)

Table 2

Sensitivity Analysis showing the Sensitivity, Specificity, and Positive Predictive Value of a Claims-Based Algorithm to Correctly Classify **Incident** Vertebral Compression Fractures, with Variations Based on Re-Classifying the Fractures with Uncertain Acuity

	Se* (95% CI)	Sp* (95% CI)	PPV (95% CI)
VCF diagnosis on an E/M claim from a physician, preceded by spinal imaging within the previous 10 days; OR VCF diagnosis on a hospitalization claim, primary diagnosis**	56 (43−68)	69 (58−80)	61 (49−74)
All UTD fractures excluded			
As above	51 (42−60)	69 (58−80)	74 (64−83)
All UTD fractures classified as new			
As above	56 (43−68)	62 (53−70)	42 (31−52)
All UTD fractures classified as old			

Se = Sensitivity; Sp = Specificity; PPV = Positive Predictive Value; CI = Confidence Interval UTD = Unable to Determine, indicating that a VCF was confirmed but could not be classified as new or old (n =58)

* compared to a case finding procedure that accepted any VCF diagnosis on any type of medical claim

** same results as shown in the last row of Table 1

Table 3

Effect of Misclassifying Vertebral Compression Fractures on the Observed Relative Risk Reduction of Fracture associated with Exposure to a Hypothetical Osteoporosis Medication (from [8])

True RRR (%)	PPV of Claims Algorithm to Identify a VCF (%)*	Observed RRR (%)
10	74	8
	61	6
	49	5
30	74	24
	61	21
	49	17
50	74	43
	61	38
	49	33

VCF = Vertebral Compression Fracture; RRR = Relative Risk Reduction

This analysis shows how the true relative risk reduction associated with a hypothetical osteoporosis medication is attenuated depending on the amount of outcome misclassification of vertebral compression fractures.

*estimates derived from the sensitivity analysis in Table 3