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Evaluation of three co-morbidity measures to predict mortality in patients undergoing total joint arthroplasty

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SUMMARY

Objective: To evaluate the 90 days and 1 year mortality predictive ability of the RxRisk-V, Charlson, and Elixhauser co-morbidity measures in total hip arthroplasty (THA) and total knee arthroplasty (TKA) patients.

Method: A retrospective study of 11,848 THAs and 18,972 TKAs (2001–2002) was conducted. Death within 90 days and 1 year of the surgery were the main endpoints. Co-morbidity measures were calculated using either medication or hospitalisation history. Logistic regression models were employed and discrimination and calibration were assessed. Specifically, models with unweighted and weighted measure scores, models with the specific conditions, and a model combining conditions identified by all measures were assessed.

Results: In THAs, the best performing prediction models included co-morbidities from all three measures (90 days: $c = 0.84$, $P = 0.284$, 1 year: $c = 0.79$, $P = 0.158$). Individually, the model with Charlson conditions performed best at 90 days mortality ($c = 0.80$, $P = 0.777$) and the Charlson and Elixhauser performed similarly at 1 year (both $c = 0.77$, $P > 0.05$). In TKAs, the best performing prediction model included co-morbidities from all measures (90 days: $c = 0.82$, $P = 0.349$, 1 year: $c = 0.78$, $P = 0.873$). Individually, the model with Elixhauser conditions performed best with 90 days mortality ($c = 0.79$, $P = 0.435$) and all performed similarly at 1 year ($c = 0.74$–0.75, all $P > 0.05$).

Conclusions: A combined model with co-morbidities identified by the Elixhauser, Charlson, and RxRisk-V was the best mortality prediction model. The RxRisk-V did not perform as well as the others. Because of the Elixhauser and Charlson's similar performance we suggest basing the choice of measurement use on factors such as the need of specific conditions and modelling limitations.

Background

The incidence of joint arthroplasty has dramatically increased in the past couple of decades[1–4]. Along with the increase in incidence, a change in patient profiles has also been observed[5–9]. Patients with several co-morbid conditions, which would have precluded them from having joint arthroplasty in the past, are now undergoing these procedures. The number of co-morbid conditions in patients undergoing elective arthroplasty has even doubled in certain countries[5,6]. Further, not only has the prevalence of many conditions like diabetes, obesity, rheumatologic conditions, renal disease, heart disease, and depression[10–14] increased in this patient population, the conditions have also been implicated in higher risk of post-arthroplasty mortality[15–22]. Seemingly contradictory, the rates of mortality after total joint arthroplasty surgery have reportedly decreased in patients over the last few years[6,17,23,24]. This is likely due to a patient selection bias with healthier patients more likely to be selected for surgery[24,25]. These patients typically having a lower overall mortality risk after the first 30 days after surgery than the general population. This highlights the need to determine whether co-morbidities in a joint arthroplasty population affect mortality in a similar fashion as they do in the general

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population and ascertaining which co-morbidity measure performs best in this patient population.

There are several well established measures to capture both the co-morbidity burden and specific co-morbid conditions in large cohorts of patients using existing secondary data such as claims data[26]. In orthopaedics the Charlson[27] and Elixhauser[28] measures are regularly used to identify specific conditions and co-morbidity burden of patients using diagnostic codes of inpatient encounters. There is substantial evidence that both are good predictors of death in total joint arthroplasty patients and useful for case-mix adjustments for mortality[29]. Additionally, both the Charlson and Elixhauser have been evaluated as predictors of infection and revision in cohorts of joint arthroplasty patients[10,30,31]. However, less commonly used in orthopaedics are pharmacy based co-morbidity measures. The RxRisk-V[32] is one of the most commonly used pharmacy based measures used in health services and pharmacoepidemiological research and there has been no validation of whether it is a good predictor of death in a cohort of joint arthroplasty patients. The RxRisk-V has, however, been evaluated as a predictor of infection and revision with satisfactory results in this patient population[30,31]. Identifying the best performing co-morbidity measures for mortality prediction and case-mix adjustments will assure better confounding adjustment in large cohort analysis of joint arthroplasty patients. Additionally, having alternative measures can give researchers latitude when conducing analysis to leverage their datasets (e.g., encounters or pharmacy) of preference or availability and also understand the shortcomings of the measures in comparison to others.

In this study, we compared the performance of a medication prescription based co-morbidity measure in predicting 90 days and 1 year mortality after total joint arthroplasty to the more commonly used inpatient diagnoses based measures. Specifically, we evaluated the predictive ability of the RxRisk-V[32], Charlson[27], and Elixhauser[28] co-morbidity measures with 90 days and 1 year mortality. We evaluated the unweighted and weighted measure scores, models with the specific conditions, and a model combining conditions identified by all measures. Unweighted scores are simple counts of conditions and weighted scores use an algorithm to calculate the scores accounting for the severity of the conditions a patient has.

Methods

Study design, setting, and sample

A retrospective study was conducted on a cohort of patients who underwent total hip arthroplasty (THA) and total knee arthroplasty (TKA) procedures between 2001 and 2012 and that were subsidized by the Australian Government Department of Veterans' Affairs (DVA). De-identified administrative inpatient encounter information and prescription medicine (inpatient and outpatient) data for this captured population was obtained.

The sample included adults (≥18 years old) who had all health services subsidized by the DVA, and underwent primary unilateral THA and TKA procedures. Using International Classification of Disease, 10th Revision, Australian Modification (ICD-10-AM) codes, THA (4931800) and TKA procedures (4951800, 4952100, 4952102, 4952400) were identified. Only patients with primary diagnoses associated with elective primary arthroplasty procedures were included.

Co-morbidity measures and data sources

The RxRisk-V[32], which evolved from the Chronic Disease Score, is a co-morbidity prescription based measure that uses patients' medication history to determine the prevalence of 45 conditions[33]. In this study a modified RxRisk-V was used with 42 conditions, the conditions ostomy, neurogenic bladder, and urinary incontinency were excluded. This measure is predictive of cost of care[32,33] and mortality[34–36] in different patient samples and using both inpatient and outpatient pharmacy data[34,36]. The sum of the co-morbidities identified by this measure was considered the unweighted RxRisk-V score and the weighted score was based on the weighting algorithm published by Johnson *et al.*[34].

The Charlson co-morbidity measure uses inpatient hospitalisations for a set period of time to calculate a score based on the presence of 17 conditions[27,37]. The Charlson measure was originally developed to predict and assist with case-mix adjustment of mortality, but has been applied to several other outcomes, including some surgical outcomes[38,39]. The Charlson is the most commonly used co-morbidity algorithm in orthopaedic studies[40], and several adaptations exist. In this study we used the Quan *et al.*'s ICD-10-AM algorithm to identify the conditions[37]. The sum of the conditions identified by the Charlson co-morbidity measure was the unweighted Charlson score and the weighted score was based on the original weights proposed by Charlson *et al.*[27]

The Elixhauser co-morbidity measure, like the Charlson, also uses inpatient hospitalisations during a specific period to identify co-morbidities. The most commonly used form of this measure identifies the presence of 30 conditions and has been evaluated as a predictor of need for blood transfusions, length of stay, and mortality[37,41]. This measure was developed by the Agency for Healthcare Research and Quality (AHRQ) Healthcare Cost and Utilization Project and is widely used in health services research[28,42]. The sum of conditions identified by the Elixhauser was considered the unweighted Elixhauser score and the weighted score was calculated using weights proposed by van Walraven *et al.*[41].

The RxRisk-V and Charlson have six common co-morbidities, the Elixhauser and RxRisk-V have 10 common co-morbidities, and the Charlson and Elixhauser have 12 in common. Combined these measures identify 64 co-morbidities.

Using the DVA administrative databases all inpatient hospitalisations and prescription medicine history were accessed for the study. The database contains details of all prescription medications, medical, allied health services and hospitalisations provided to veterans for which DVA pays a subsidy. In the dataset, medications are coded according to the Anatomic, Therapeutic and Chemical Classification (ATC), and the Pharmaceutical Benefits Schedule (PBS) item codes. Hospitalisations are coded according to the ICD-10-AM. The DVA also maintains a client file, which contains information on gender, date of birth, date of death, and family status for a treatment population that in September 2011 was 242,000 people. In this study, the 12 months period preceding the discharge date of the arthroplasty procedure was used to ascertain the co-morbidities according to the two diagnoses based co-morbidity algorithms and the 12 months period preceding the admission date of the arthroplasty was used for the medication based algorithm. The arthroplasty procedure hospitalisation was included in the calculation of the diagnostic co-morbidity indices (ICD-10-AM adapted Charlson and Elixhauser).

Outcome

Ninety days and 1 year post-operative mortality was the main endpoint of this study. Date of death was obtained from the client file maintained by the DVA on its membership and time to death was calculated from the index date of the joint arthroplasty.

Covariates

Age, gender and primary diagnosis for the procedure were included in all models as covariates.