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Type and frequency of healthcare encounters can predict poor surgical outcomes in anterior cruciate ligament reconstruction patients

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ABSTRACT

Background: Several challenges are associated with collecting clinically meaningful post-operative outcomes. The widespread implementation of electronic medical records (EMR) offers a new opportunity to evaluate surgical outcomes using routinely collected data in these systems. This study evaluated whether surgical outcomes can be ascertained from EMR's hospital and outpatient encounters. Specifically, we evaluated anterior cruciate ligament reconstructions (ACLR) outcomes.
Methods: A retrospective cohort study of 6985 ACLRs performed between 2/2005-9/2012 was conducted. Patient encounters during days 1–90 and days 91–180 after ACLR surgery were the exposures of interest. Nine hospital and eight outpatient encounter types were evaluated. The main endpoint of the study was revision surgery six months after ACLR.
Results: The cohort was 66.7% male, the mean age was 28 (standard deviation = 11) years-old, and the incidence of revision was 1.5% (n = 105). After adjustments, in days 1–90 post-ACLR, compared to patients with 0–4 orthopedic office visits, patients with 5–9 (hazard ratio (HR) = 9.9, 95% confidence interval(CI), 4.3–23.2) and those with 10 or more (HR = 13.8, 95%CI, 5.6–33.8) visits had a higher risk of revision. In days 91–180, patients with any outpatient hospital encounters (HR = 2.5, 95%CI 1.4–4.5) had a higher risk of revision than patients without visits. Additionally, patients with 4–5 regular office visits (HR = 3.8 times, 95%CI, 2.0–7.0) had a higher risk of revision surgery than those with 0–1 visits.
Discussion: The number of post-operative outpatient visits was associated with ACLR revision surgery. Using EMR encounters to assess surgical outcomes is a viable option for monitoring ACLR patients. The simple assessment of visit types and number of encounters alone can provide valuable information regarding the normal course of rehabilitation of a surgical patient and possible deviation from this normal course. In large cohorts of patients, this type of patient surveillance can assist surgeons with monitoring their patients.

1. Introduction

Several challenges are associated with collecting clinically meaningful post-operative outcomes of surgical procedures [1,2]. These challenges include availability of data, data access, data quality, privacy concerns, common definitions, and costs associated with collection among others [1,3]. Use of secondary data (existing data) to ascertain specific surgical outcomes in large cohorts of patients has been explored in surgical specialties but as electronic medical records (EMR) are widely implemented [4] new opportunities arise. In the United States, EMRs are becoming ubiquitous [4], and detailed patient encounter information is readily available in several institutions and are already leveraged for the improvement of understanding and care of certain conditions [5–7]. Patient encounter information collected via EMRs includes not only the existing inpatient and surgical encounters, but all types of visits or contact that a patient has with a provider or healthcare system. This wealth of information is becoming a reality for researchers and will eventually be widely available and easily accessible. These encounters, or utilization or services, could be used as indicators for poor surgical outcomes or other procedures. Additionally, several of the EMRs being implemented nationally use similar platforms,

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suggesting wide generalization for the use of these encounters for detection of certain outcomes is possible.

To determine whether patient encounters could be used as proxy indicators for poor surgical outcomes, we chose anterior cruciate ligament reconstructions (ACLR) as a case example. ACL injury is a common and disabling knee injury [8,9]. Non-operative treatment is an option for ACL injury, but surgical reconstruction is a common treatment modality [10]. ACLRs are difficult surgical procedures to evaluate as they require extensive contact between patients and observers, and have several measures of surgical success and failure. Some commonly used endpoints to indicate ACLR failure include: (1) patients' inability to return to pre-ACL injury level sports, (2) patient reported low activity and function, (3) low disease-specific patient reported outcome measurement scores, (4) scoring below a specific patient reported outcome measurement cut off point, (5) excessive graft laxity after surgery, (6) requirement of subsequent surgical procedures (e.g. hardware removal), and finally (7) subsequent revision of the reconstructed ACL graft (i.e. the ultimate failure episode for this procedure) [11,12].

To evaluate whether encounters with a healthcare system after ACLR surgery could be indicators for possible revision of the reconstructed ACL, we evaluated the type and number of visits a patient had after primary ACLR surgery in a large integrated healthcare system in Southern California. This study's objective was to determine if hospital or outpatient encounters during the rehabilitation period after surgery were associated with a higher risk of eventual ACLR revision surgery.

2. Methods

2.1. Study design, setting, data sources, and sample

A retrospective analysis of prospectively collected data was undertaken. Patients who underwent ACLRs in a large integrated healthcare system were identified using an Anterior Cruciate Ligament Reconstruction Registry (ACLRR) [13,14] and their subsequent encounters information was obtained from the system's EMR [15]. Data were linked using the unique medical record numbers of the membership population. The integrated healthcare system is composed of over 9.5 million members throughout the United States in seven geographical regions [16].

The ACLRR collects intraoperative information on ACLR cases performed at hospitals within the integrated healthcare system using paper forms completed by the operating surgeon [13,14]. The data are sent to a central data repository for entry and quality control. Demographic, patient (e.g., body mass index (BMI), diabetes), surgeon, and facility characteristics as well as outcomes associated with the procedures are collected by the registry using several sources within the system, including the patients' EMR, administrative claims data, the Geographically Enriched Member Socio-demographics Database, and membership and mortality files. Voluntary participation in the registry was 93% in 2011 [14].

The encounter information for this study was obtained from the implemented EMR system [15]. The EMR is an Epic product (Verona, Wisconsin, USA) that was fully implemented in 2008. It monitors hospital and outpatient encounters. Hospital encounters are mostly inpatient hospitalizations encounters, but can also include non-inpatient encounters that occur in a hospital. For example, an outpatient encounter that occurs in a hospital could be a radiology or laboratory encounter during an emergency room visit.

All primary ACLR cases registered from February 1, 2005 to September 30, 2012 that did not have a post-operative complication (infections, deep vein thrombosis, and pulmonary embolisms), or short term (within six months) revision, or re-operation before the revision surgery, were included in the sample. The study sample included data from 78 surgeons at 13 medical centers of the Southern California region covered by the ACLRR.

2.2. Outcome of interest

The endpoint of this study was aseptic revisions that occurred at least 6 months (181 days) after the primary ACLR. Revision surgery in this study was defined as the aseptic failure of the primary ACL graft that required removal and replacement of the original graft. Revision operations were prospectively captured by the registry using both passive surveillance (i.e. surgeon-reported via registry forms), active surveillance (i.e. independent screening and review of patients' EMR for revision cases based on coding algorithms), and patient reported [13]. All revisions recorded by the registry were manually reviewed for confirmation of graft failure.

2.3. Exposures of interest

The exposure of interest was the type and frequency of medical encounters that occurred in days 1–90 and days 91–180 after ACLR surgery. There were nine hospital encounter types evaluated: hospital admission with surgery, hospital ambulatory surgery, charge router—auto hospital account records, emergency room visit, home health, inpatient, outpatient procedure, observation, and outpatient encounter. There were eight outpatient encounter types evaluated: office visit, orthopedic allied health/nurse visit, orthopedic office visit, family practice visit, internal medicine visit, urgent care, occupational medicine/physical therapy, and hospital encounter. Most encounters occurred infrequently in our sample and therefore only the most prevalent four encounters were evaluated in detail, these included: outpatient hospital encounter, office visits, orthopedics office visits, and occupational medicine/physical therapy visits. Due to the low frequency of outpatient hospital encounters these were evaluated as a binary event after surgery. The remaining medical encounters were evaluated as intervals of varying length determined by analyzing histograms for their frequency per time period. The intervals chosen for office visits were: 0–1, 2–3, 4–5, $\geq$6 for both time periods; for orthopedic medicine: 0–4, 5–9, $\geq$10 for days 1–90, 0–2, $\geq$3 for days 91–180; and for occupational medicine/physical therapy: 0–5, 6–10, $\geq$11 for both time periods. The reference level for all variables was the interval that included 0.

2.4. Covariates

Patient factors and graft type used in the original surgery were obtained from the ACLRR. Patient characteristics evaluated were age (<22 vs. $\geq$22 years old), race (white, Hispanic, black, Asian, Native American, other, and unknown), sex, and BMI (categorized according to the World Health Organization's obesity levels: normal weight, <25 kg/m^2; overweight, 25–30 kg/m^2; obese, $\geq$30 kg/m^2). Graft type was categorized into the most prevalent types (i.e. patellar bone-tendon-bone autograft, hamstring autograft, allograft, and other).

2.5. Statistical analysis

Means, standard deviations (SDs), frequencies, medians, and interquartile ranges (IQRs) were used to describe the study sample. Chi-square tests were used to see if a difference in revision incidence among categorical variables was statistically significant. Cox proportional hazards models were used to evaluate the association between medical encounters and the outcome of interest. Proportional hazards assumptions were tested using log(-log) curves and a Kolmogorov-type supremum test. If proportional hazards assumptions were not met, a time dependent covariate created