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Quantifying the excess cost and resource utilisation for patients with complications associated with elective knee arthroscopy: A retrospective cohort study

Megan A. Bohensky [a,b,*], Zanfina Ademi [a], Richard deSteiger [c], Danny Liew [a], Vijaya Sundararajan [d,e], Andrew Bucknill [f], Chris Kondogiannis [f], Caroline A. Brand [a,b]

[a] Melbourne EpiCentre, Department of Medicine, University of Melbourne, VIC, Australia
[b] Centre for Research Excellence in Patient Safety, Monash University, Melbourne, Australia
[c] Epworth HealthCare, University of Melbourne, Australia
[d] Department of Medicine, St. Vincent's Hospital, University of Melbourne, Australia
[e] Department of Medicine, Southern Clinical School, Monash University, Australia
[f] Department of Orthopaedics, Melbourne Health, Melbourne, Australia

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ABSTRACT

Background: Recent studies have demonstrated morbidity associated with elective knee arthroscopy. The objective of the current study was to quantify resource utilisation and costs associated with postoperative complications following an elective knee arthroscopy.
Methods: We undertook a retrospective, longitudinal cohort study using routinely collected hospital data from Victorian public hospitals during the period from 1 July 2000 to 30 June 2009. A generalised linear model was used to examine relative cost and length of stay for venous thromboembolism, joint complications and infections. Log-transformed multiple linear regression and retransformation were used to determine the excess cost after adjustment.
Results: We identified 166,770 episodes involving an elective knee arthroscopy. There were a total of 976(0.6%) complications, including 573 patients who had a venous thromboembolism (VTE) (0.3%), 227 patients with a joint complication (0.1%) and 141 patients with infections (0.1%). After adjustment, the excess 30-day cost per patient for venous thromboembolism was $USD +3227 (95% CI: $3211–3244), for joint complications it was $USD +2247 (95% CI: $2216–2280) and for infections it was $USD +4364 (95% CI: $4331–4397).
Conclusion: This is the first study to quantify resource utilisation for complications associated with elective knee arthroscopy. With growing attention focused on improving patient outcomes and containing costs, understanding the nature and impact of complications on resource utilisation is important.

1. Introduction

Knee arthroscopy is a commonly performed, minimally invasive orthopaedic procedure. Recent population-based studies have demonstrated that there is a small, yet measurable, degree of associated morbidity. The most common complications reported in the literature are venous thromboembolic disease (VTE), infection and haemarthrosis [1].

Rates of symptomatic 90-day pulmonary embolism after knee arthroscopy have been estimated as ranging from 0.3 to 2.2 per 1000 patients [2,3], compared to an incidence of 0.03 per 1000 within the general population [4]. The 90-day rates of symptomatic deep vein thrombosis (DVT) have been estimated as ranging from 1.2 to 3.6 per 1000 patients [5,6], compared to 0.1 per 1000 within the general population [4]. In the UK, Jameson et al. identified the rate of any wound complication to be 0.22%, while others have estimated the risk of infection after arthroscopy as ranging from 0.08% to 0.4% [7,8]. Haemarthrosis has been recognised as occurring in approximately one to two percent of knee arthroscopy cases [7,9]. However, the majority of these do not require re-hospitalisation.

Although the incidence of complications in knee arthroscopy is low [10], the cost of post-operative complications associated with other types of surgeries is known to be high [11–13]. There is a high volume of knee arthroscopies performed each year [6,14,15] and likely growth in volume over the coming years as the population ages and the burden of musculoskeletal disease increases. As this growth may be correlated with an increasing number of post-operative

* Corresponding author at: Melbourne EpiCentre, Department of Medicine, The University of Melbourne, Australia, Royal Melbourne Hospital, Level 7 East, Parkville, VIC 3004, Australia. Tel.: +61 3 9342 4549, +61 40 1036 232 (mobile); fax: +61 3 9342 8780.
E-mail address: megan.bohensky@unimelb.edu.au (M.A. Bohensky).

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complications, the objectives of the current study were to quantify resource utilisation of patients with post-operative complications and the cost of managing these patients from the perspective of the Australian health system. Accounting for the excess costs associated with post-operative complications will allow health systems, insurers and clinicians to make informed decisions about the allocation of resources for prevention initiatives.

2. Methods

This study was a retrospective, population-based analysis of hospital admissions data, linked to provide longitudinal information about patients" readmissions (first 30 postoperative days). These data include all elective adult (≥20 years) public and private hospital episodes in Victoria, Australia coded to orthopaedic or rheumatology diagnosis related groups from 1 July 2000 to 30 June 2009. We selected all patients with a procedure code indicating a knee arthroscopy to define our cohort (Appendix 1). Patients were excluded if they had an additional procedure during the admission (n = 16,807, 8.5%), or if costing data were missing (n = 3072, 1.7%).

2.1. Data sources

The Victorian Admitted Episodes Dataset (VAED) is maintained by the Victorian State Department of Health and includes all hospital episode data and linked death certificate data [16]. The quality of data is assessed through routine auditing of public hospital data to determine the accuracy of ICD-10-AM coding [17]. Records belonging to the same patient are linked to one another at the Victorian Department of Health to identify all hospital admissions belonging to a single patient over time and to match these records with death registration data. Linkage staff use probabilistic and stepwise deterministic linkage methods based on a combination of patient identifying variables and quality check the linkage using internal logic checks and random manual case review.

2.2. Outcomes

For patients with identified post-operative complications, we examined cumulative 30-day hospitalisation-related costs and length of stay, inclusive of the index arthroscopy procedure. Each hospital episode is assigned by specialised software into clinically meaningful groups using the Australian Refined Diagnosis Related Groups (AR-DRG) classification system. The system was developed by the Australian Department of Health and Ageing and is based on hierarchies of diagnoses and procedures accounting for patient comorbidities. Average hospital costs for each AR-DRG are estimated each year from a representative sample of public, private and private day hospitals, including imaging, pathology, resource use in the ICU and operating theatre and prescribed pharmaceuticals. We extracted costing data for 2008/09 from the National Hospital Cost Data Collection for public and private hospitals [18]. Costs were converted from Australian dollars ($AUD) to US dollars ($USD) with exchange rates as at 2 January 2009 ($1.00 AUD = $0.71 USD).

2.3. Post-operative complications

Adverse outcomes known to be complications of knee arthroscopy based on the literature were defined using ICD-10-AM diagnosis codes (Appendix 1) [5,6]. Adverse outcomes were categorised into the following three groups: VTE, including pulmonary embolism (PE) and DVT; joint complications, including haemarthrosis, effusion and synovitis and synovial fistula; and infections, including post-operative infection and cellulitis. Codes are assigned prefixes by clinical coders in Victoria to indicate the timing of diagnoses. "P-prefix" codes indicate that a diagnosis was the primary reason for admission, while "C-prefix" codes indicate that a diagnosis arose after admission. We used the C-prefix code to identify complications that occurred during the arthroscopy episode, while the P-prefix was used to identify re-admission diagnoses up to 30 days post-operatively to confirm that the diagnosis was the primary reason for the patient's readmission. These codes have been used in other studies [19,20]. If a patient experienced both a DVT and a PE, we counted the complication as a PE only (n = 57). If patients experienced both a post-operative infection and cellulitis, we counted the complication as a post-operative infection (n = 9).

2.4. Additional covariates

To assess the independent relationship of post-operative complications on total cost and length of stay, we considered additional factors that may influence these outcomes. Patient age, gender, marital status, country of birth (English speaking versus non-English speaking) and hospital type were generated from VAED variables. Age was coded into three categories (20–39 years, 40–59 years and 60 plus years). Patient co-morbidity scores were defined using a published algorithm for the Charlson index based on ICD-10-AM codes [21,22], incorporating a look-back period through any hospital admission two years prior to the arthroscopy admission [23]. A diagnosis of osteoarthritis was determined by ICD-10-AM codes ('M17') during the arthroscopy episode. Each patient's statistical local area (SLA) of residence at their time of admission was linked to Socio-Economic Index for Australia (SEIFA) [24] from 2001 Australian census data for patients admitted until June 2002 and to 2006 Australian census data for patients admitted after June 2002. Categories of the index of economic resource, one of four area-based measures of socio-economic status were utilised.

2.5. Statistical analyses

Descriptive and bivariate analyses were undertaken of cohort characteristics and resource utilisation for the initial arthroscopy admission and readmissions within 30 days. The costs were reported as mean (standard deviation), and median (interquartile range (IQR)) and length of stay was reported as median days (IQR).

We used generalised linear models (GLM) to estimate the adjusted relative increase in cost and length of stay for post-operative complications using a Gamma and Poisson error distribution, respectively, including a log-link function. Due to the complicated relationship of death with costs and length of stay, we conducted a sensitivity analysis excluding all patients that died during the follow-up period (n = 44). We tested for interactions between all significant predictors in the model.

A multivariate linear regression analysis was conducted to identify the excess costs associated with complications after adjustment for significant demographic and health-related factors. The linear regression analysis provided a cross-validation of GLM analysis in light of the complexities of analysing costing data. We used the log transformation of total costs (up to 30 days post-operatively) and the smearing estimator developed by Duan [25] to retransform covariates from the log-scale back to the original scale (Australian dollars). We clustered the analysis by hospital identifier using a Huber–White sandwich estimator of variance to adjust for within-hospital correlation. We included variables in the regression analysis if $p < 0.25$ in bivariate analysis or they were clinically significant based on clinical opinion and the literature. The lowest socio-economic category and youngest age group were used as the reference group for socio-economic status and age, respectively. The largest group was used as the reference value for all other categorical variables. We conducted a sensitivity analysis imputing the mean costs for the cases with missing cost data (n = 3072, 1.7%). Excess costs associated with each complication were calculated as the mean total inpatient costs of VTE, joint complication, and infection groups minus the mean total inpatient stay cost of those without complications. The aggregate excess cost for complication category was estimated by