The economic impact of periprosthetic infection in total knee arthroplasty

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Background: Currently, the gold standard treatment for periprosthetic joint infection (PJI) after total knee arthroplasty (TKA) is 2-stage revision, but few studies have looked at the economic impact of PJI on the health care system. The objective of this study was to obtain an accurate estimate of the institutional cost associated with the management of PJI in TKA and to assess the economic impact of PJI after TKA compared to uncomplicated primary TKA.

Methods: We identified consecutive patients in our institutional database who had undergone 2-stage revision TKA for PJI between 2010 and 2014 and matched them on age and body mass index with patients who had undergone uncomplicated primary TKA over the same period. We calculated all costs associated with the 2 procedures and compared mean costs, length of stay, clinical visits and readmission rates between the 2 groups.

Results: There were 73 patients (mean age 68.8 [range 48–91] yr) in the revision TKA cohort and 73 patients (mean age 65.9 [range 50–86] yr) in the primary TKA cohort. Two-stage revision surgery was associated with a significantly longer hospital stay (mean 22.7 d v. 3.84 d, $p < 0.001$), more outpatient clinic visits (mean 8 v. 3, $p < 0.001$), more readmissions (29 v. 0, $p < 0.001$) and higher overall cost (mean $35 429.97 v. $6809.94, $p < 0.001$) than primary TKA.

Conclusion: Treatment for PJI after TKA has an enormous economic impact on the health care system. Our data suggest a fivefold increase in expenditure in the management of this complication compared to uncomplicated primary TKA.

Contexte : À l'heure actuelle, le traitement par excellence d'une infection de prothèse articulaire (IPA) survenant après une arthroplastie totale du genou (ATG) est l'arthroplastie de révision en 2 étapes. Toutefois, peu d'études se sont penchées sur les répercussions économiques de l'IPA sur le système de santé. La présente étude visait donc à estimer de façon précise le coût de prise en charge de l'IPA par les établissements, ainsi qu'à évaluer les répercussions économiques de l'IPA après une ATG, comparativement à celles d'une ATG primaire sans complications.

Méthodes : Nous avons recensé, dans la base de données de notre établissement, tous les patients consécutifs ayant subi une ATG de révision en 2 étapes pour une IPA entre 2010 et 2014, puis les avons jumelés en fonction de l'âge et de l'indice de masse corporelle avec des patients ayant subi une ATG primaire sans complications durant la même période. Nous avons calculé tous les coûts associés aux 2 interventions, et avons comparé la moyenne des coûts, de la durée d'hospitalisation, des visites cliniques et des réadmissions entre les 2 groupes.

Résultats : On comptait 73 patients (âge moyen 68,8 ans [plage 48–91 ans]) dans la cohorte d'ATG de révision, et 73 patients (âge moyen 65,9 ans [plage 50–86 ans]) dans la cohorte d'ATG primaire. L'ATG de révision en 2 étapes, comparativement à l'ATG primaire, a été associée à une durée d'hospitalisation significativement plus longue (moyenne 22,7 j c. 3,84 j; $p < 0,001$), à un plus grand nombre de visites en clinique externe (moyenne 8 visites c. 3 visites; $p < 0,001$), à un taux plus élevé de réadmission (29 réadmissions c. 0 réadmission; $p < 0,001$) et à des coûts globaux plus élevés (moyenne 35 429,97 $ c. 6809,94 $; $p < 0,001$).

Conclusion : Le traitement de l'IPA après une ATG a d'énormes répercussions économiques sur le système de santé. Selon nos données, les dépenses liées à la prise en charge de cette complication pourraient être 5 fois plus élevées que celles liées à une ATG primaire sans complications.

Periprosthetic joint infection (PJI) is one of the most common and devastating complications following total knee arthroplasty (TKA).[1] The incidence has been reported to range from 1% to 2% and is expected to continue to rise as the number of TKA procedures being performed increases.[2–4] The management of PJI represents a substantial economic burden on health care systems around the world.[5]

Management of PJI may involve irrigation and débridement with exchange of the insert, single-stage revision or 2-stage revision. Currently, 2-stage revision surgery remains the gold standard for treating PJI in most centres.[6,7] Revision TKA is a complex procedure that usually requires a specialized arthroplasty surgeon prepared to handle complex cases and revision instruments that are typically available in tertiary care centres.[8] It has been reported that the cost of treatment of infection after TKA is at least 3 times that of primary TKA and twice that for aseptic knee revision.[9–11] Frequent readmissions, a prolonged hospital stay, prolonged use of antibiotics, expensive implants and inpatient resources used have been suggested to contribute to the major difference in the cost between revision and primary TKA.[12,13]

To date, only a few studies have examined the institutional costs associated with managing infection after TKA, and most of these studies either used large databases, (which is difficult to apply to individual institution, as it precludes accurate costing) or had no comparison group.[5,13] Therefore, the purpose of the current study was to obtain an accurate estimate of the institutional cost associated with the management of PJI after TKA and to assess the direct institutional cost and hospital resource use of PJI compared to primary uncomplicated TKA.

Methods

We performed a retrospective study comparing patients who had undergone uncomplicated primary TKA to those who had undergone 2-stage revision surgery for PJI after TKA, with a minimum of 2 years of follow-up in both groups. Institutional review board approval was obtained before the onset of the study. This study was performed with the use of patient data in our institutional database collected prospectively at a single Canadian academic centre, from index surgical procedures that were performed between 2010 and 2014. We identified patients in the database who had undergone 2-stage revision TKA and matched them on age and body mass index to patients who had undergone uncomplicated primary TKA, in keeping with our previously published paper.[14] Osteoarthritis was the indication for all primary TKA procedures, and the Musculoskeletal Infection Society criteria were used to make the diagnosis of PJI.[15] Exclusion criteria were prior ipsilateral revision knee surgery and death before the second stage of the revision procedure.

All cases were managed by fellowship-trained arthroplasty surgeons in a tertiary care academic centre. Two-stage revision included removal of the primary implant, thorough irrigation and débridement, and implantation of a static or dynamic antibiotic-impregnated cement spacer. All patients were discharged from acute care following the first stage once they met the institutional discharge criteria and had a safe plan for transfer home or to their local facility. Discharge criteria include an acceptable level of pain managed with oral analgesic treatment and the ability to safely ambulate, as determined by the physiotherapist.

Before discharge, patients had a peripherally inserted central catheter inserted and had appropriate management in conjunction with the Infectious Diseases Division for 6 weeks followed by cessation of antibiotics for 2 weeks. In most cases, patients with prolonged wound drainage remained in hospital until the treating surgeon was satisfied that the patient would not require acute irrigation and débridement to achieve successful wound healing. Patients who required plastic surgery intervention for soft tissue coverage remained in hospital for several days to ensure the plastic surgery service was satisfied with the viability of the flap or graft. A subsequent reimplantation procedure was then performed if the inflammatory markers were found to be normal. Joint aspiration between the first and second stages was performed at the treating surgeon's discretion. A repeat first-stage procedure was performed if there was evidence of ongoing infection.

Inpatient resource use and hospital data including operating time, operative equipment, implants, antibiotics, anticoagulation, transfusions, postoperative recovery, length of hospital stay, readmission rates, inpatient consultations, inpatient physical therapy and investigations (including imaging and blood investigations) were obtained by a single independent reviewer from the institutional electronic medical record system. We obtained unit costs using administrative case-costing data from our institution. We used Microsoft Excel for data collection and analysis. All costs are reported in 2019 Canadian dollars.

Statistical analysis

We used descriptive statistics, including means and ranges, to describe continuous variables and reported categoric variables as absolute values and percentages. To compare the primary and revision TKA groups, we used the χ^2 test for categoric variables and an independent sample t test for continuous variables. A p value < 0.05 was considered statistically significant.

Results

We identified 73 patients (37 women and 36 men) who had undergone 2-stage revision TKA and matched them to

73 patients (47 women and 26 men) who had had uncomplicated primary TKA. The mean age was 65.9 (range 50–86) years in the primary TKA cohort and 68.8 (range 48–91) years in the revision cohort; the corresponding body mass index values were 35.5 (range 19–62) and 35.1 (range 29–59).

The mean cost for the revision TKA cohort was $35 429.97 (range $17 789–$1 187 247), significantly higher than that for the primary TKA cohort, $6809.94 (range $5823–$8523) ($p < 0.001$) (Table 1). Fifty-five percent of the total cost for the revision cohort was attributed to inpatient cost. Costs were significantly higher for the revision cohort than the primary cohort for the following services: operating room services, implants, anesthesia, hospital bed charges, investigations, medications and physical therapy ($p < 0.001$) (Table 2). Moreover, 2-stage revision TKA was associated with a longer hospital stay (22.7 d v. 3.84 d, $p < 0.001$) and more outpatient clinic visits (8 v. 3, $p < 0.001$) and readmissions (29 v. 0, $p < 0.001$) than primary TKA.

Discussion

Total knee arthroplasty is one of the most commonly performed procedures in orthopedics, with more than 70 000 cases performed in Canada in 2018, an increase of 17% over 2017.[16] As the number of TKA procedures performed continues to rise, it is expected that the incidence of complications will increase as well. Since PJI is one of the most common complications requiring revision after TKA, the burden of septic revisions will become an even larger cost driver than it is today. Previously estimated costs for treating PJI after TKA were about 3 times more than primary TKA and 2 times more than revisions for mechanical failure or aseptic loosening.[17,18] In the present study, we found that the cost associated with managing PJI after TKA was 5 times more than uncomplicated primary TKA. The majority of the cost was attributable to hospital bed charges (40.2%), implants (21.7%) and operating room services (23.1%). In addition, we found that patients with PJI had a significantly longer hospital stay, more hospital readmissions and more outpatient clinical visits than patients with uncomplicated TKA.

Table 1. Average cost for uncomplicated primary total knee arthroplasty and 2-stage revision surgery for periprosthetic joint infection after total knee arthroplasty, 2010–2014 (2019 Canadian dollars)

	Average cost (range), $		
Expense	Primary TKA $n = 73$	Infected TKA $n = 73$	p value
Inpatient	3063 (924–3455)	19 533 (4825–77 009)	< 0.001
Operative	3747 (4039–5638)	15 897 (14 547–64 551)	< 0.001
Total	6810 (5823–8523)	35 430 (17 789–1 187 247)	< 0.001

TKA = total knee arthroplasty.

Table 2. Average cost of specific services for the 2 groups (2019 Canadian dollars)

	Average cost (range), $	
Expense	Primary TKA	Infected TKA
Hospital bed charges	2408 (1254–10 661)	14 236 (3136–56 441)
Operating room services	1883 (1293–2521)	8197 (5206–27 629)
Implants	1865 (1756–2018)	7700 (3524–15 228)
Investigations	474 (118–1456)	2729 (537–6087)
Anesthesia	312 (210–402)	1530 (1062–4424)
Medications	266 (133–514)	1499 (761–4461)
Physical therapy	181 (94–801)	1069 (234–4239)

TKA = total knee arthroplasty.

Our findings are similar to those of other investigators. Kapadia and colleagues[13] conducted a cost analysis involving 21 patients who underwent 2-stage revision TKA matched to 21 patients who had uncomplicated primary TKA and found that the total cost associated with treatment of PJI was 5 times greater than that for primary TKA (US$116 383 v. US$28 249, $p < 0.001$). In addition, they reported 4 times as many readmissions (3.6 v. 0.1) and a mean hospital stay almost twofold longer (5.3 d v. 3.0 d) in the revision group than in the primary TKA group. Interestingly, the average length of stay for the infected cohort was much shorter than what we observed (5.3 d v. 22.7 d). This is an important finding since, in both studies, length of stay was identified as a major contributing factor toward the total cost. This discrepancy may be due to differences in practice between different health care systems or may simply reflect a difference in the way length of stay was defined in the 2 studies. We defined length of stay as the sum total of days spent in hospital across all stages of revision. Of note, patients were discharged home between stages.

This study differs from most published studies, in which cost was estimated from institutional billing data, since cost will vary substantially across institutions depending on the specific cost-to-charge ratios. On the other hand, direct case costing better reflects consumed resources and services, which would reflect the institutional burden more accurately, especially in a single-payer universal health care system as in Canada. In theory, the data presented in this paper should be similar among institutions serving similar regions and operating with similar practice patterns.

Despite the lower cost of orthopedics care in Canada than in other health care systems, the cost of primary and 2-stage revision is similar to that observed in the United States.[13] This suggests that our data can be generalized and used as a guide in future resource allocation and budget planning among tertiary centres offering similar care.

Overall, we showed that 2-stage revision surgery for infection after TKA represents a substantial economic burden on the health care system compared to uncomplicated primary TKA. One of the most significant contributing factors was found to be the length of hospital stay, which accounted for 40% of the total cost and cost 6 times more in the revision cohort than in the uncomplicated TKA cohort. The identification of this cost driver can be used to innovate and reduce the overall cost and burden of managing PJI after TKA.

We believe that creating well-defined clinical pathways that better coordinate interdisciplinary care would help deliver safe and efficient care. They would also help reduce the overall cost burden associated with 2-stage revision TKA.

Single-stage revision is a cost-effective approach that shows promising results in patients with PJI of the hip or knee. In a recent critical review, Vaishya and colleagues[19] studied a total of 699 patients who underwent single-stage or 2-stage revision for infection after TKA and noted that most studies did not show any significant difference between the 2 procedures. The functional scores during the early postoperative period were comparable in most studies. Haddad and colleagues[20] compared 28 patients who underwent single-stage revision to 78 patients who underwent 2-stage revision surgery for infection after TKA, with a minimum follow-up duration of 3 years. They found that none of the patients in the single-stage revision group had a recurrent infection or required a second revision. Moreover, all the functional scores in the single-stage revision group were comparable to those in the 2-stage revision group. Those authors concluded that single-stage surgery may be an alternative option to conventional 2-stage surgery; however, larger, randomized controlled trials are needed to validate these findings.

Limitations

There were some limitations to our study, including selection bias, largely related to its retrospective design. To minimize selection bias, we entered patients consecutively and limited exclusion criteria. Furthermore, we matched the groups on age and body mass index to limit the influence of variables that are known to affect resource use.[21,22] In addition, the overall accuracy of our estimate is closely tied to the quality of available institutional data on resource use. Costs pertaining to home-based physiotherapy, antibiotic administration, wound care and any other home services were not captured. However, we do not consider this as a limitation given that our aim was to estimate the institutional cost of PJI after TKA. In addition, patients undergoing 2-stage revision require more intensive home care; therefore, the reported cost differential between primary and revision TKA is likely underestimated.

Conclusion

Periprosthetic knee infection represents an enormous economic burden to the health care system. We found that the cost of 2-stage revision for PJI after TKA was 5 times that for uncomplicated primary TKA, with more than 40% of the cost driven by the associated hospital stay. These data should be useful in guiding future resource allocation and budget planning among tertiary care centres in order to mitigate this substantial cost burden.

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