

Comparison of the hospital costs for two-stage reimplantation for deep infection, single-stage revision and primary total elbow arthroplasty

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Abstract

Background: The purpose of the present study was to determine the cost of two-stage reimplantation for the treatment of deep infection after total elbow arthroplasty (TEA) and compare this with primary and aseptic revision TEA.

Methods: Three hundred and seventy-one primary TEA and 286 revision TEAs (including 47 elbows requiring two-stage reimplantation) were performed. Total direct medical costs during each hospitalization were obtained from our institutional research database and compared for three groups: primary TEA, revision for nonseptic reasons and two-stage reimplantation for deep infection.

Results: The mean cost of an uncomplicated primary TEA and aseptic revision TEA was \$18,464 and \$18,796, respectively. The mean overall cost associated with two-stage reimplantation increased to \$34,286. Two-stage reimplantation increased both Part A (hospital costs) and Part B (professional costs). The mean Part A cost for septic revision TEA was \$29,102 versus \$15,844 for primary TEA. The mean Part B cost for septic revision TEA was \$5,184 versus \$2,621 for primary TEA.

Conclusions: Two-stage reimplantation for treatment of an infected TEA costs 186% the hospital cost of a primary uncomplicated or aseptic revision TEA. The overall cost to society is even greater if we take into account the cost of antibiotic therapy in between stages and lost days from work.

Keywords

cost, infection, revision total elbow arthroplasty, septic

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Introduction

Deep periprosthetic infection is considered by many the most challenging complication associated with total elbow arthroplasty (TEA). Infection after elbow arthroplasty not only leads to increased morbidity for the patient, but also results in a substantially increased economic burden for the entire healthcare system.^{1–8} Currently, the incidence of deep infection after primary elbow arthroplasty ranges from 1% to 8%.^{3,9–13} Taking into account that the number of elbow arthroplasty procedures continues to increase, the cost of managing the infected elbow arthroplasty is expected to grow as well.

The financial burden associated with treatment of deep infection complicating hip or knee arthroplasty

has been analyzed extensively. The estimated total hospital cost associated with the treatment of deep infection after hip and knee arthroplasty in the USA was \$320 million in 2001 and \$566 million in 2009; by 2020, this cost is projected to be approximately \$1.62 billion.¹⁴ The financial burden associated with treatment of infected elbow arthroplasty is likewise expected to be substantial but, to our knowledge, there is very little

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available information on the specific costs of treating a deep periprosthetic elbow infection.

Although selected deep infections after elbow arthroplasty may be addressed with a single-stage revision, debridement or component resection, two-stage reimplantation is the most common treatment strategy used for the infected TEA).^{12,15} The purpose of the present study was to compare the cost of two-stage reimplantation for the treatment of deep infection after TEA with the cost of an uncomplicated primary TEA and a nonseptic revision TEA.

Materials and methods

Study population

The present study was performed after institutional review board (IRB) approval. Using our institutional total joint registry database,¹⁶ all patients who underwent primary or revision TEA over a 9-year period (2003 through 2012) were identified.

The study cohort included 371 primary TEAs in 353 patients and 286 revision single-stage TEAs in 246 patients, including 47 elbows that had undergone a two-stage reimplantation for deep infection. Four patients had bilateral simultaneous primary TEAs; there were no simultaneous bilateral revision or reimplantation TEAs. The mean age at the time of surgery was 59 years (range 17 years to 91 years) in the primary TEA group and 61 years (range 17 years to 94 years) in the revision TEA group. The primary TEA group comprised 261 (70%) females compared to 191 (67%) females in the revision TEA group. The mean body mass index at the time of surgery was 26.9 kg/m² in the primary TEA group and 29.4 kg/m² in the revision TEA group.

Cost analysis

Total direct medical costs during each hospitalization were compared for three groups: primary TEA revision for nonseptic reasons and two-stage reimplantation for deep infection. Costs were obtained from an institutional research database. As described previously,¹⁴ this unique database provides standardized inflation-adjusted estimates of the costs of billed services and procedures. The value for each unit of service during hospitalization was adjusted to national cost norms using bottom-up valuation techniques. Part A billed charges (e.g. room and board, operating room charges, implants) were adjusted by using Medicare department level cost-to-charge ratios and wage indexes. Annual cost-to-charge ratios for each cost centre were obtained from the publicly available files from the Medicare. Part B physician services were valued using Medicare

reimbursement rates. Medicare reimbursement rates for physician services are composed of costs associated with physician work, practice expense and professional liability insurance. Each of these three elements is assigned a Relative Value Unit (RVU) for each Current Procedural Terminology (CPT) code. These RVUs are then adjusted for geographical areas for different medical costs and wage differentials. All Part A and Part B costs were then adjusted to nationally representative unit costs in 2013 inflation-adjusted dollars. Cost data included all medical costs during hospitalization (related or unrelated to orthopedics). For primary and aseptic revision TEA, total costs were estimated per hospital episode. For two-stage reimplantation, the total costs from each hospital episode were combined. Costs were then categorized manually using the CPT and Uniform Billing (UB04) codes.

Results

Overall cost

The overall hospital costs, billed charges (Part A costs), physician services (Part B costs) and length of stay for the three study groups (primary TEA, aseptic revision TEA and two-stage reimplantation TEA) are summarized in Table 1. The median overall hospital cost of primary TEA was \$16,019. The median cost for aseptic revision TEA was \$16,242. The median overall cost associated with two-stage reimplantation increased to \$30,338. Thus, the median cost of a two-stage reimplantation was 186% of the cost of a primary TEA. Costs data were skewed to the right, with median hospital costs being lower than the mean costs.

Length of stay and cost categories

The cost difference between septic revision TEA and aseptic revision or primary TEA was evident for both Part A and Part B costs. Approximately 85% of the total costs were Part A costs (hospital services) and 15% were Part B costs (professional services). The median Part A cost for septic revision TEA was \$26,124 per person compared to \$13,676 for aseptic revision TEA and \$13,551 for primary TEA. The median Part B cost for septic revision TEA was \$4,529 per person compared to \$2,657 for aseptic revision TEA and \$2,348 for primary TEA. The need for two separate hospital stays for two-stage reimplantation arthroplasties led to a longer hospital stay for this group. The median hospital stay for these patients was 7.0 days. This is in comparison with a median of 3.0 days for both primary TEA and aseptic revision TEA.

Costs associated with two-stage reimplantation were more than double the cost of primary or aseptic

Table 1. Overall hospital costs and length of stay in primary, aseptic revision and two-stage reimplantation total elbow arthroplasty (TEA).

Per person	Primary TEA (n = 353)	Aseptic TEA (n = 202)	2-Stage reimplantation (n = 47)
Total cost			
Mean (CI)	18,464 (16,700, 20,228)	18,796 (17,686, 19,907)	34,286 (30,259, 38,312)
Median	16,019	16,242	30,338
P25, P75	13,993, 19,218	14,028, 20,488	26,336, 38,825
Part A			
Mean (CI)	15,844 (14,331, 17,356)	15,832 (14,878, 16,786)	29,102 (25,715, 32,488)
Median	13,551	13,676	26,124
P25, P75	12,266, 16,758	11,556, 17,624	22,495, 33,333
Part B			
Mean (CI)	2,621 (2354, 2887)	2,964 (2775, 3154)	5,184 (4477, 5890)
Median	2,348	2,657	4,529
P25, P75	2,033, 2,764	2,143, 3,372	3,924, 5,954
Length of stay			
Mean (CI)	3.4 (3.1, 3.8)	3.4 (3.1, 3.7)	7.7 (6.6, 8.7)
Median	3.0	3.0	7.0
P25, P75	2.0, 4.0	2.0, 4.0	5.0, 10.0

CI, confidence intervals; P25 and P75, 25th and 75th percentiles, respectively.

revision TEA with regard to every aspect of the care except implant costs (Table 2). A longer length of stay for two-stage reimplantation (7.0 days versus 3.0 days) resulted in median room and board costs of \$7,928, compared to \$3,231 and \$3,142 for primary and aseptic revision TEA, respectively. Similarly, the operating room and anesthesia costs in two-stage reimplantation were approximately double the costs of primary or aseptic revision TEA. The pharmacy/medication costs and the laboratory costs were particularly high in the two-stage reimplantation group. The median implant costs for all three groups were similar. Physical therapy was billed in certain cases where patients required extra attention from the therapists within the hospital.

Discussion

The economic burden of healthcare is worrisome. For years, healthcare spending in the USA has outpaced the growth of inflation, population and the national gross domestic product. Joint replacement is proven to be a

highly cost-effective surgical intervention. However, the management of complications after joint replacement is quite costly. The avoidance of complications is extremely important not only to minimize patient morbidity, but also to maintain the value of joint replacement surgery. Understanding the costs and financial implications of various complications after joint replacement is paramount for raising awareness about the importance of preventing complications, as well as guiding the distribution of resources dedicated to various aspects of healthcare.

The cost of managing complications has been extensively studied in the field of arthroplasty of the lower extremities. Replacement of joints in the upper extremity has increased exponentially over the last few years, with predicted annual growth rates of 7.6% for primary TEA and 14.0% for revision procedures.¹⁷ However, the financial implications of managing complications after elbow arthroplasty have not been analyzed in detail. Infections are one of the complications that have been analyzed the most after hip or knee arthroplasty.

Table 2. Categories of hospital costs in primary, aseptic revision and two-stage reimplantation total elbow arthroplasty (TEA).

Per person	Primary TEA (n = 353)	Aseptic TEA (n = 202)	Two-stage reimplantation (n = 47)
Room and board			
Mean (CI)	\$3952 (\$3329, \$4574)	\$3750 (\$3424, \$4076)	\$8587 (\$7364, \$9810)
Median	\$3231	\$3142	\$7928
P25 to P75	\$2241 to \$4308	\$2154 to \$4339	\$5471 to \$11,259
Operating room: anaesthesia			
Mean (CI)	\$6300 (\$5924, \$6675)	\$7309 (\$6860, \$7758)	\$12,355 (\$10,766, \$13,943)
Median	\$5825	\$6140	\$11,243
P25 – P75	\$5031 to \$6705	\$5503 to \$7367	\$10,012 to \$12,241
Implants			
Mean (CI)	\$4886 (\$4678, \$5095)	\$4364 (\$4076, \$4652)	\$4700 (\$4164, \$5236)
Median	\$4654	\$3977	\$4826
P25 to P75	\$3494 to \$5801	\$2938 to \$5660	\$3083 to \$5484
Pharmacy/medications			
Mean (CI)	\$890 (\$758, \$1,022)	\$919 (\$818, \$1,020)	\$2,504 (\$2,110, \$2899)
Median	\$682	\$739	\$2,142
P25 to P75	\$540 to \$926	\$578 to \$1,049	\$1693 to \$3161
Labs/pathology			
Mean (CI)	\$549 (\$345, \$753)	\$787 (\$685, \$888)	\$2061 (\$1458,\$2665)
Median	\$248	\$621	\$1596
P25 to P75	\$96 to \$537	\$277 to \$1039	\$960 to \$2243
Imaging			
Mean (CI)	\$383 (\$124, \$642)	\$177 (\$132, \$221)	\$451 (\$296, \$605)
Median	\$78	\$78	\$291
P25 – P75	\$73 to \$158	\$73 to \$173	\$197 to \$349
Physical therapy			
Mean (CI)	\$85 (\$65, \$104)	\$71 (\$50, \$92)	\$122 (\$57, \$186)
Median	\$0	\$0	\$0
P25 to P75	\$0 to \$133	\$0 to \$119	\$0 to \$161
Other supplies			
Mean (CI)	\$558 (\$502, \$614)	\$650 (\$588, \$712)	\$1,288 (\$1070, \$1506)

(continued)

Table 2. Continued

Per person	Primary TEA (n = 353)	Aseptic TEA (n = 202)	Two-stage reimplantation (n = 47)
Median	\$453	\$556	\$1203
P25 to P75	\$312 to \$674	\$348 to \$869	\$668 to \$1677
Miscellaneous			
Mean (CI)	\$676 (\$606, \$746)	\$663 (\$610, \$715)	\$1617 (\$1414, \$1819)
Median	\$596	\$597	\$1449
P25 to P75	\$515 to \$651	\$515 to \$697	\$1169 to \$1894

Infection is considered to be a devastating and relatively common complication after elbow arthroplasty. The financial burden associated with treatment of deep infection complicating hip or knee arthroplasty is substantial. Deep periprosthetic infection is considerably more common after elbow arthroplasty than after hip and knee arthroplasty. Two-stage reimplantation is the most common treatment modality for deep periprosthetic infection.^{12,15} As the number of primary and revision elbow arthroplasties performed every year continues to increase, deep infection after elbow arthroplasty will continue to demand more and more resources.

The results of the present study indicate that the hospital cost of two-stage reimplantation for the management of deep periprosthetic elbow infection is substantial. At our institution, the hospital cost of a two-stage reimplantation was 186% of the cost of a primary elbow arthroplasty or a revision TEA for nonseptic indications. There was no substantial increase in cost related to either imaging studies or implants. The increase in cost was mostly related to the need for two surgeries and hospitalizations, in addition to additional pharmacy and laboratory costs. The present study did not consider other costs incurred outside of the hospital for patients undergoing a two-stage reimplantation, such as outpatient parenteral antibiotic treatment, extended-care facility charges or days lost from work. The addition of those expenses would undoubtedly increase the cost for the healthcare system and society even more.

The findings of the present study highlight two important points. First, they emphasize the need to prevent infection after elbow arthroplasty. This would not only decrease overall patient morbidity, but also translate into substantial financial savings and improve resource utilization. Second, they highlight line items that could potentially be addressed to reduce the cost of treating a deep infection with a two-stage reimplantation, as a result of decreasing the hospital stay for each of the two stages and avoiding multiple debridement procedures before resection.

However, the results should be interpreted in light of potential limitations. All three procedures considered in the present study were performed in accordance with the preferences of the individual treating surgeons, introducing potential variability in costs. As mentioned above, we did not analyze the outpatient costs, which would have further increased the costs of treating an infected TEA. We were also unable to analyze other costs to society, such as lost worker productivity or extended-care facility charges. Finally, the costs were normalized to 2013 inflation-adjusted values, potentially inflating the costs applied over the entire study period. The strengths of the present study include the large number of primary and revision total elbow arthroplasties, a prospective follow-up utilizing our institutional joint registry, and the use of an accurate comprehensive cost database.

In summary, two-stage reimplantation for the treatment of deep infection after elbow arthroplasty is very costly, leading to a substantially increased financial burden and demand on hospital resources. Infection after elbow arthroplasty significantly diminishes the cost effectiveness of primary TEA. The importance of innovative strategies with respect to preventing infections and other complications after elbow arthroplasty cannot be overemphasized because these will lead to decreased morbidity, as well as substantial financial savings.

Level of evidence

Level III

Declaration of Conflicting Interests

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Ethical review and patient consent

Each author certifies that his or her institution approved the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research.

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