

DOI: 10.4274/jarem.galenos.2020.2767

J Acad Res Med 2020;10(2):133-7

Cost Analysis in Knee Revision Arthroplasty: A Study at the Research and Training Hospital in Turkey

Revizyon Diz Artroplastisi Ameliyatlarında Maliyet Analizi: Türkiye’de Eğitim Araştırma Hastanesi Çalışması

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Cite this article as: Dırvar F, Uzun Dırvar S, Yıldırım T, Cengiz Ö, Talmaç MA. Cost Analysis in Knee Revision Arthroplasty: A Study at the Research and Training Hospital in Turkey. J Acad Res Med 2020;10(2):133-7

ABSTRACT

Objective: This study aimed to investigate the costs covered by the hospital during inpatient treatment of patients who underwent knee revision arthroplasty in the orthopedics and traumatology clinics of a public hospital and compare with the invoiced amount.

Methods: The demographic information and revision reasons of 50 patients who underwent total knee revision arthroplasty in a public hospital between 01.01.2016 and 30.09.2017 were determined using hospital information management system records. The patients were categorized into two groups: septic and aseptic. For each patient, the costs of medical consumables, medicine/serum, medical treatment, surgery, anesthesia, imaging services, laboratory procedures, blood and blood products, meal and companion costs, device depreciation expenses, consultation, control examination, preoperative patient preparation stage, surgery, visit and other costs were calculated separately during inpatient treatment.

Results: The average total cost of a patient was 24,005.00 TL, whereas the average invoice amount was 21,490.00 TL, with a difference of 2,515.00 TL. This difference was 3,193.00 TL and 2,166.00 TL in the septic and aseptic groups, respectively. In the septic group, the duration of hospital stay, medication, treatment, surgery, anesthesia, laboratory, imaging, blood center, consultation, visit, meal cost, total cost, and invoice amount were significantly higher than the aseptic group ($p \leq 0.05$).

Conclusion: Regulations by the social security institution are needed to ensure the fiscal sustainability of the public hospital's. In addition, following the medical and technical innovations in revision surgery can help reduce the costs.

Keywords: Revision, knee joint, arthroplasty, cost analysis, hospital economics

ÖZ

Amaç: Bir kamu hastanesinin ortopedi ve travmatoloji kliniğinde diz revizyon artroplastisi ameliyatı yapılan hastaların yatarak tedavi gördüğü süreçte, kurumca katlanılan maliyetlerinin araştırılması ve fatura edilen miktar ile karşılaştırılması amaçlanmıştır.

Yöntemler: 01.01.2016 ile 30.09.2017 tarihleri arasında bir kamu hastanesinde total diz revizyon artroplastisi ameliyatı yapılan 50 hastanın demografik bilgileri ve revizyon nedenleri tespit edilmiştir. Hastalar septik ve aseptik olarak iki gruba ayrılmıştır. Hastaların, yatarak tedavi gördüğü sürece katlanılan tıbbi sarf, ilaç/serum, tedavi, ameliyat, anestezi, görüntüleme, laboratuvar, kan ve kan ürünleri, yemek, refakatçi maliyetleri, cihaz amortisman giderleri, konsültasyon, kontrol muayenesi, ameliyat öncesi hasta hazırlık aşaması, vize ve diğer maliyetleri her bir hasta için ayrı ayrı hesaplanmıştır.

Bulgular: Bir hastanın toplam maliyeti ortalama 24.005,00 TL iken fatura tutarı ortalama 21.490,00 TL tespit edilmiş olup arada 2.515,00 TL fark bulunmaktadır. Bu fark septik gruptaki hastalarda 3.193,00 TL, aseptik gruptaki hastalarda 2.166,00 TL olarak tespit edilmiştir. Septik grupta yatış süresi, ilaç, tedavi, ameliyat, anestezi, laboratuvar, görüntüleme, kan merkezi, konsültasyon, vize, yemek maliyeti, toplam maliyet ve fatura tutarı aseptik gruptan anlamlı ($p \leq 0,05$) olarak daha yüksek bulunmuştur.

Sonuç: Kamu hastanesinin mali sürdürülebilirliğinin sağlanması için Sosyal Güvenlik Kurumu tarafından düzenlemelerin yapılmasına ihtiyaç bulunmaktadır. Ayrıca, revizyon cerrahisinde medikal ve teknik yeniliklerin takip edilmesi maliyetin azalmasına yardımcı olabilir.

Anahtar kelimeler: Düzeltme, diz eklemi, artroplastisi, maliyet analizi, hastane ekonomisi

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It was presented as an oral presentation at the 28th National Turkish Orthopedics and Traumatology Congress 30 October-4 November 2018.

Received Date/Geliş Tarihi: 13.01.2019 **Accepted Date/Kabul Tarihi:** 08.01.2020

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INTRODUCTION

The Nationwide Inpatient Sample (United States) surveys of hospital discharge records projected the demand for primary total knee arthroplasty (TKA) to increase by 673% from 450,000 (95% prediction interval, 425,000 to 477,000) in 2005 to 3.48 million procedures (95% prediction interval, 2.95 to 4.14 million) by 2030. The results of the same report projected the TKA revisions to increase from 38,300 (95% prediction interval, 32,600 to 44,300) in 2005 to 268,200 (95% prediction interval, 192,700 to 381,400) by 2030 (an increase of 601%) (1).

For an economical operation and sustainability of a hospital, the costs of complex cases requiring higher budgets should cover the variable costs per patient, which enables to cover the hospital's total fixed costs by the income from other more common procedures (2).

The calculation of the costs of the services in hospital's is a difficult issue because common costs are wide in hospitals, diverse health services are offered, and the complexity of service units causes difficulties in cost estimations. Public hospitals offer profit-free services, and no direct relationship is found between the income from service provision and cost of services. It is only possible to determine whether a hospital gains or losses from a surgery by determining the costs in a real or real-like way. Diagnostic and treatment methods of health services financed by the Social Security Institution (SSI) in our country are indicated in the Health Practice Notifications (HPN) and annex lists, and HPN scores are compared in line with the opinions of experts based on the difficulty of the procedures (3,4). The SSI considering the cost estimates based on scientific cost analysis studies should be useful to determine the reimbursement prices to the hospitals (5).

This study aimed to investigate the costs covered by the hospital during the inpatient treatment of patients who underwent knee revision arthroplasty in the orthopedics and traumatology clinics of a public hospital and compare with the invoiced amount.

METHODS

After obtaining institutional review board approval, the demographic information and revision reasons of 50 patients who underwent total knee revision arthroplasty in a public hospital between 1 January, 2016 and 30 September, 2017 were determined using the Hospital Information Management System (HIMS) records. All total revision procedures due to infection and component loosening were included. The patients were categorized into two groups: septic and aseptic.

The treatment costs of patients in public hospitals in Turkey are maintained according to the lists in the Health Application Notification (HAN) and annexes in the appendix announced by the SSI. In these lists, a code has been determined for each surgical procedure, and the amount to be paid to the institution is indicated by the codes. The physician enters the code of each surgical procedure. In this study, the data of the patients with the code for total hip revision arthroplasty were included, but those

with partial revision arthroplasty code were excluded. Two-stage revision arthroplasty surgeries in patients with septic origin were included. The duration and cost of hospitalization for each stage were added to the data set for each patient and included in the study.

For each patient, the costs of medical consumables (revision tibia and femur component, gloves, sutures, etc.), medicine/serum costs, medical treatment costs (injections, transfusion, arterial catheterization, wound debridement, enema, vascular access, etc.), costs of surgery and anesthesia procedures (revision knee arthroplasty, joint debridement, implant removal, spacer application, anesthesia, epidural block, etc.), costs of imaging services (direct graph, length graph, MR, CT, reporting, etc.), costs of laboratory procedures (biochemistry, microbiology, etc.), costs of blood and blood products (erythrocyte suspension, FFP, etc.), patient meals and companion costs, device depreciation expenses, consultation, control examination, preoperative patient preparation stage, surgery, visit and other costs were calculated separately during the inpatient treatment, and the cost of each patient covered by the hospital was determined after calculating the sum of all the abovementioned costs.

While doing these calculations, after the amounts of all the goods and services covered for each patient during inpatient treatment are determined through HIMS, the average purchasing unit prices of the goods and services used for these patients from the hospital purchasing unit, the goods and services procurement contracts, the point multiples determined by the laboratory and imaging service procurements, the billings paid to the Red Crescent Blood Center, the main scores and coefficients to be paid for the processes in the HPN annex lists, data of the salary trust department, warehouse records, data from other related units, and the expense determination tables in the cost analysis studies published by the Ministry of Health were used (4).

In accordance with the applicable legislation, the invoices according to the HPN and annex lists have been determined for each patient from the hospital records. The total costs covered and SSI bill amounts were compared to determine the difference. The study was approved by the University of Health Sciences, Metin Sabancı Baltalimanı Training and Research Hospital Expertise Education Committee in Medicine Observational Research Ethics Committee (approval number: 16.10.2017-16). The demographic information was determined using HIMS records.

Statistical Analysis

The mean, standard deviation, median lowest, highest, frequency, and ratio values were used in the descriptive statistics. The distribution of the variables was measured using the Kolmogorov-Smirnov test. The Mann-Whitney U test was used in the analysis of quantitative independent data, and chi-squared test was used in the analysis of qualitative independent data. SPSS 22.0 program (IBM Corp., Released 2013, IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY, USA) was used in the analyses.

RESULTS

Of the 50 patients, 37 were women, and 13 were men, with a mean age of 69 years. The aseptic and septic groups were composed of 33 and 17 patients, respectively. Table 1 shows the data of patients undergoing knee revision arthroplasty and their costs. The average cost of a patient was 24,005.00 TL (Turkish Lira), whereas the average invoice amount was 21,490.00 TL, with a difference of 2,515.00 TL. When comparing patients who underwent surgeries for septic and aseptic reasons, the average cost of the surgery (two-stage) for septic and reasons was 28,968.00 TL and 21,448.00 TL, respectively, whereas the invoice amount was 25,775.00 TL and 19,282.00 TL, with a difference of 3,193.00 TL and 2,166.00 TL, respectively.

The age and sex distribution, duration of the surgery, medical expenditure, patient acceptance, operation team, device depreciation, and companion expenses did not differ significantly in the aseptic and septic groups ($p>0.05$). In the septic group, the duration of hospital stay, medication, treatment, surgery, anesthesia, laboratory, imaging, blood center, consultation, visits, meal costs, total cost, and invoice amount were significantly higher than the aseptic group ($p<0.05$) (Table 2).

DISCUSSION

The main purpose of the studies on the total cost of patients during inpatient treatment is to find possible ways to reduce the costs based on health care without compromising the quality of the health care services (6-10). However, cost analysis is difficult and time consuming. Administrative, financial, and medical data should be reliable to establish the direct cost. Necessary regulations must be made to ensure the presentation of the money spent on the patient when requested and the motivation of the staff responsible for providing services to the patient at the first instance should be increased, and the functionality in fulfilling their responsibility should be ensured (10).

In this study, the payment of the patients who underwent revision knee arthroplasty during inpatient treatment based on HPN prices by the SSI was made below the hospitalization cost. When the literature is examined, similar results are found in studies conducted by unit cost analysis (11). Because the number of patients who underwent revision knee arthroplasty is expected to increase in the future (1), we believe that SSI needs to make corrective actions, such as revision of HPN prices in revision knee arthroplasty to ensure the sustainability of financial resources in public hospitals.

Table 1. Descriptive statistics of the data

| Descriptive statistics of the data | | | | |
|---------------------------------------|--------|---------------------|---------------|-------------------------------------|
| | | Minimum-maximum | Median | Mean \pm SD (n, %) |
| Age | | 4.0-84.0 | 68.5 | 68.6 \pm 7.6 |
| Gender | Female | | | 37 (74.0%) |
| | Male | | | 13 (26.0%) |
| Surgery time (min) | | 120.0-300.0 | 180.0 | 188.1 \pm 41.7 |
| Length of stay (days) | | 2.0-174.0 | 14.0 | 24.4 \pm 33.2 |
| Medical consumption expenses (TL) | | 6832-48801 | 13,449 | 14,932 \pm 7591 |
| Drug expenditures (TL) | | 17.1-4461.7 | 196.9 | 531.3 \pm 924.6 |
| Treatment expenses (TL) | | 271.8-3882.4 | 521.9 | 784.2 \pm 706.3 |
| Operation, anesthesia expenses (TL) | | 1141.9-9796.9 | 1746.3 | 2009.0 \pm 1384.4 |
| Laboratory expenses (TL) | | 20.0-773.0 | 75.7 | 118.4 \pm 129.9 |
| Imaging expenses (TL) | | 1.5-188.5 | 18.1 | 29.9 \pm 34.1 |
| Blood and blood product expenses (TL) | | 0.0-6907.5 | 664.0 | 1023.3 \pm 1191.5 |
| Consulting expenses (TL) | | 24.1-1349.6 | 132.6 | 230.9 \pm 287.1 |
| Patient admission expenses (TL) | | 113.0-113.0 | 113.0 | 113.0 \pm 0.0 |
| Surgical team expenses (TL) | | 707.1-1767.7 | 1060.6 | 1108.5 \pm 245.5 |
| Device depreciation expenses (TL) | | 29.4-72.9 | 43.9 | 45.8 \pm 10.1 |
| Visit Team and other expenses (TL) | | 216.8-18,859.9 | 1517.5 | 2642.5 \pm 3593.8 |
| Patient meal expenses (TL) | | 30.3-2636.1 | 212.1 | 369.4 \pm 502.3 |
| Companion expenditures (TL) | | 0.0-374.6 | 20.1 | 66.9 \pm 92.7 |
| Total cost (TL) | | 9924-82,767 | 19,961 | 24,005\pm14,094 |
| Invoice amount (TL) | | 7687-109,005 | 17,423 | 21,490\pm16,301 |

SD: standard deviation, min: minute, TL: Turkish lira

Table 2. Comparison of septic and aseptic revision knee arthroplasty data

| Comparison of septic and aseptic revision knee arthroplasty data | | | | | | |
|--|--------|----------------------|---------------|----------------------|---------------|--------------------------------|
| | | Aseptic | | Septic | | P |
| | | Mean ± SD (n, %) | Median | Mean ± SD (n, %) | Median | |
| Age | | 67.9±7.6 | 68.0 | 70.0±7.6 | 71.0 | 0.485 ^m |
| Sex | Female | 25 (75.8%) | | 12 (70.6%) | | 0.693 ^{χ²} |
| | Male | 8 (24.2%) | | 5 (29.4%) | | |
| Surgery time (min) | | 188.5±39.3 | 180.0 | 187.4±47.1 | 180.0 | 0.967 ^m |
| Length of stay (days) | | 16.5±27.2 | 7.0 | 39.7±38.8 | 29.0 | 0.000^m |
| Medical consumption expenses (TL) | | 14690±8659 | 12564 | 15402±5114 | 14465 | 0.108 ^m |
| Drug expenditures (TL) | | 231.6±562.5 | 106.9 | 1113.3±1200.0 | 658.2 | 0.000^m |
| Treatment expenses (TL) | | 554.1±416.0 | 392.2 | 1230.7±927.7 | 815.4 | 0.000^m |
| Operation. Anesthesia expenses (TL) | | 1696.1±769.2 | 1479.3 | 2616.5±2022.9 | 2191.4 | 0.006^m |
| Laboratory expenses (TL) | | 81.9±88.3 | 61.1 | 189.3±167.4 | 153.0 | 0.000^m |
| Imaging expenses (TL) | | 25.3±36.5 | 12.7 | 38.8±27.5 | 26.5 | 0.002^m |
| Blood and blood product expenses (TL) | | 675.7±707.4 | 538.0 | 1697.9±1616.7 | 1044.4 | 0.000^m |
| Consulting expenses (TL) | | 135.8±199.4 | 96.4 | 415.4±343.5 | 337.4 | 0.000 ^m |
| Patient Admission expenses (TL) | | 113.0±0.0 | 113.0 | 113.0±0.0 | 113.0 | 1.000 ^m |
| Surgical team expenses (TL) | | 1110.8±231.8 | 1060.6 | 1103.9±277.6 | 1060.6 | 0.967 ^m |
| Device depreciation expenses (TL) | | 45.9±9.5 | 43.9 | 45.6±11.4 | 43.9 | 0.967 ^m |
| Visit team and other expenses (TL) | | 1786.8±2951.4 | 758.7 | 4303.7±4205.9 | 3143.3 | 0.000^m |
| Patient meal expenses (TL) | | 249.7±412.5 | 106.1 | 601.5±587.9 | 439.4 | 0.000^m |
| Companion expenditures (TL) | | 51.5±80.6 | 13.4 | 96.8±109.1 | 93.7 | 0.130 ^m |
| Total cost (TL) | | 21,448±13,438 | 18,083 | 28,968±14,406 | 26,236 | 0.001^m |
| Invoice amount (TL) | | 19,282±11,905 | 15,307 | 25,775±22,378 | 19,168 | 0.038^m |

^mMann-Whitney U test, ^{χ²}Chi-squared test, SD: standard deviation, min: minute, TL: Turkish lira

Similar studies have reported that septic knee revision arthroplasty is significantly more costly than aseptic knee revision arthroplasty (12-14). In our study, the cost of inpatient treatment for septic-based revision knee arthroplasty was approximately 7,520.00 TL more than that for aseptic-based revision knee arthroplasty.

In the literature, blood products and drug expenditures are significantly higher in the inpatient treatment of septic-based revision surgery, and while analyzing the costs covered by the hospital in the cost analysis of septic total knee revision surgeries, two separate hospitalizations for the two-stage revision and personnel costs should be included in the costs (14). This study is significant because all costs during inpatient treatment covered by the hospital are calculated, and the duration of hospitalization, medicine, treatment, surgery, anesthesia, laboratory, imaging, blood center, consultation, visits, meal costs, total costs, and billing costs in the septic group were significantly higher than the aseptic group ($p < 0.05$).

Factors causing infection include obesity, diabetes mellitus, male sex, American Society of Anesthesiologists score of ≥ 3 , diagnosis of osteonecrosis, diagnosis of posttraumatic arthritis, quadriceps-release exposure, and operative time as a risk factor, with a 9%

increased risk per 15 minimum increment. High-risk patients should be counseled, and modifiable clinical conditions should be optimized (15).

For long-term survival, total knee prosthesis is required to be aligned in neutral or with a slight anatomic valgus (16). Navigation should be applied to improve the results of TKA in line with the limb and component alignment (17).

Blood loss constitutes a significant cost item for the hospital. To reduce bleeding, techniques, such as skin heating, gentle soft tissue dissection during surgery, use of a new bipolar electrocautery device, use of cardiac stent, and if not contraindicated, discontinuation of anticoagulant drugs, and use of preoperative intra- and postoperative tranexamic acid drugs, can be applied (18,19).

Studies conducted to shorten the length of hospital stay may be an appropriate attempt to reduce the cost of inpatient treatment. Patients undergoing revision TKA for non-septic reasons may be included in fast-track protocols. Outcome seems to be similar to those of primary TKA regarding length of stay, morbidity, and satisfaction (20).

Study Limitations

In the literature, the mean length of hospitalization of revision knee arthroplasty surgeries is reported to be shorter (21). We can explain the longer duration of hospitalization in our study with the lack of adequate home care services after discharge in our country; thus, pain control and rehabilitation process of the patients in the early postoperative period are performed in the hospitals. In addition, the reasons for the longer hospitalization period in patients undergoing septic revision knee surgery include inclusion of two-stage revision arthroplasty surgeries in the study, inclusion of the cost and duration of each step, and process of hospitalization for spacer and spacer revision to the data set of each patient, the use of some antibiotics parenterally administered in two-stage revision surgeries (aztreonam, vancomycin, imipenem, meropenem, linezolid, ertapenem, doripenem, sulbactam, kolistimetat, cefuroxime sodium, and daptomycin) being possible only during hospitalization according to the HAN (3), and inability to discharge the patient until antibiotic treatment is completed.

CONCLUSION

As a result, to ensure the financial sustainability of the public hospital in the inpatient treatment of the patients who underwent this surgery, there is a need for the SSI to adjust, such as increasing the HPN prices. In addition, following the medical and technical innovations in revision surgery can help reduce the costs.

Ethics Committee Approval: The study was approved by the Metin Sabancı Baltalimanı Training and Research Hospital Expertise Education Committee in Medicine Observational Research Ethics Committee (approval number: 16.10.2017-16).

Informed Consent: The demographic information were determined through hospital information management system records.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept - F.D., S.U.D., Ö.C.; Design - F.D., S.U.D., T.Y.; Supervision - S.U.D., Ö.C., M.A.T.; Resources - F.D., S.U.D.; Materials - S.U.D.; Data Collection and/or Processing - F.D., S.U.D.; Analysis and/or Interpretation - F.D., Ö.C., M.A.T.; Literature Search - F.D.; Writing Manuscript - F.D., Ö.C.; Critical Review - T.Y.

Conflict of Interest: The authors have no conflict of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support.

Etik Komite Onayı: Çalışma Sağlık Bilimleri Üniversitesi, Metin Sabancı Baltalimanı Eğitim ve Araştırma Hastanesi Tıpta Uzmanlık Eğitim Kurulu Gözlemsel Araştırmalar Etik Kurulu tarafından onaylandı (onay numarası: 16.10.2017-16).

Hasta Onamı: Demografik bilgiler hastane bilgi yönetim sistemi kayıtları üzerinden belirlendi.

Hakem Değerlendirmesi: Editörler kurulu dışında olan kişiler tarafından değerlendirilmiştir.

Yazar Katkıları: Fikir - F.D., S.U.D., Ö.C.; Tasarım - F.D., S.U.D., T.Y.; Denetleme - S.U.D., Ö.C., M.A.T.; Kaynaklar - F.D., S.U.D.; Malzemeler - S.U.D.; Veri Toplanması ve/veya İşlemesi - F.D., S.U.D.; Analiz ve/veya Yorum - F.D., Ö.C., M.A.T.; Literatür Taraması - F.D.; Yazıyı Yazan - F.D., Ö.C.; Eleştirel İnceleme - T.Y.

Çıkar Çatışması: Yazarların beyan edecek çıkar çatışması yoktur.

Finansal Destek: Yazarlar bu çalışma için finansal destek almadıklarını beyan etmişlerdir

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