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DETERMINANTS AND VARIATIONS OF HOSPITAL COSTS IN PATIENTS WITH LUMBAR RADICULOPATHY HOSPITALIZED FOR SPINAL SURGERY

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The study protocol was approved by the local ethics committee of the University Hospital Brussels (Universitair Ziekenhuis Brussel or UZ Brussel)/Vrije Universiteit Brussel (B.U.N. 143201526926).

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Introduction

Low back pain has a substantial impact on today's society and healthcare systems. Lifetime prevalence rates of low back pain in the general population range from 50% to 90%[1-3], of which 5-10% suffer from back pain associated leg pain[3]. In these patients presenting lumbar radiculopathy, surgical interventions are often indicated, especially when conservative care fails and symptoms keep on aggravating, and/or when motor deficits are present[4-7]. Conservative care (e.g., education, medication, physical therapy) is often preferred over surgical interventions (e.g., microdiscectomy, laminectomy, fusion) due to the higher direct healthcare costs related to the latter[4-7].

In the case of spine surgery, the costs related to the initial hospitalization will make up a major part of the direct healthcare costs[8]. Therefore, the intramural cost is an important factor to consider in the evaluation of the economic burden of such surgical interventions. Unfortunately, interpretation of intramural care costs is not straightforward, as one should consider several factors influencing costs, e.g., patient-related factors, such as the presence of comorbidities[9-11] and socio-economic status[9,12]. Also, type of surgery should be taken into account, as minimally invasive techniques tend to lead to shorter hospital stay[13-16], which is often used as a proxy for lower hospital costs. By combining hospital claims data with minimal hospital data it becomes possible to identify such determinants of intramural healthcare and related costs.

Information regarding hospital costs related to spinal surgery is of importance to clinicians, to increase their understanding of the economic impact of surgical interventions. Additionally, it will give them the opportunity to inform patients about their expected hospital costs in an accurate way. The latter is deemed to be important as patients undergoing surgery for lumbar radiculopathy are unsatisfied with the received information regarding this matter[17]. The identification of determinants will eventually lead to the

possibility of estimating intramural healthcare costs for various subgroups of patients, which can be beneficial for health policy makers. Considering the high incidence of these surgical interventions - lumbar fusion and laminectomy are part of the top 10 most common surgeries in the USA[18] - this will be of great interest for society.

Therefore, the present study aims at determining intramural costs related to surgery for lumbar radiculopathy, as well as identifying determinants of intramural costs based on minimal hospital and claims data.

Materials and methods

This retrospective study was written in accordance with the STROBE (Strengthening of the Reporting of Observational Studies in Epidemiology) guidelines[19]. The protocol was approved by the local ethics committee of the University Hospital Brussels (UZ Brussel)/Vrije Universiteit Brussel (BLINDED).

Data collection

Data were collected from the UZ Brussel data warehouse, a hospital with a capacity of 721 beds and nearly 32,000 admissions a year. Data extraction was performed by an independent medical information manager from the UZ Brussel. Patients 18 years and older, undergoing surgery for lumbar radiculopathy from January 1, 2016 until December 31, 2016 were included. Eligible patients were identified based on 'International Classification of Diseases – 10th edition – Clinical Modification' (ICD-10-CM) codes matching the diagnosis of lumbar radiculopathy (table 1).

Variables

The following data were extracted: (1) age; (2) sex; (3) primary diagnosis (ICD-10-CM codes); (4) secondary diagnoses (ICD-10-CM codes); (5) type of surgery (ICD-10-PCS codes); (6) severity of illness (SOI); (7) hospitalization dates; (8) type of hospital admission and (9) all claims incurred for the hospital stay.

Possible ICD-10-CM codes for primary diagnosis were identical to the ones used for selecting eligible patients (table 1). Additional ICD-10-CM codes appointed to patients, were registered as secondary diagnoses and categorized into 24 subgroups for analysis (available upon request). Type of surgery was determined based on ICD-10-PCS (Procedure Coding System) codes (available upon request). Severity of illness was presented as minor, moderate, major or extreme. The process for determining SOI contains several steps and is based on the primary diagnosis, (combinations of) secondary diagnoses, age and (response to) procedures. The complete procedure can be found in the 3M APR DRG Classification System Reference Guide (available upon request)[20]. For type of hospital admission, the distinction was made between admissions via the emergency department and elective hospitalizations.

For all provided healthcare and related claims during hospitalization, National Institute for Health and Disability Insurance (NIHDI) nomenclature codes were extracted. The NIHDI is the public institution for social security in Belgium, managing and controlling the obligatory insurance for medical care and alimony. Total intramural costs were determined by the sum of the incurred claims for the delivered health services and the average day price for Belgium in 2016. The latter was obtained by consultation of the Belgian Health Care Knowledge Centre (KCE).

Additionally, all extracted NIHDI nomenclature codes were categorized into different clusters of healthcare costs (available upon request). The clusters ‘Anesthesia’, ‘Clinical biology’, ‘Medical imaging’ and ‘Physiotherapy’ include all claims related to the respective specialisms, including lump sums and honoraria. ‘Consultations’ comprises all claims for consultations with medical doctors. All codes for the execution of perioperative and other examinations are clustered under ‘Examinations’. ‘Honoraria’ and ‘Lump sums’ comprise all honorarium and lump sum codes not related to certain interventions or

examinations. Pharmacy claims were subdivided into 'Medication' and 'Parapharmacy'. The cluster 'Residence' contains all claims related to the residence of the patient (i.e., 'hotel costs'), including nursing claims, and the average day price for Belgium in 2016. All costs were displayed in euros 2016.

Data analysis

First, descriptive statistics were performed for all variables. Second, univariate non-parametric analyses (Mann-Whitney U and Kruskal-Wallis analyses) were used to explore associations between total healthcare claims and all other variables separately. Third, generalized linear models (GLM) with gamma distributions and log links were executed to determine factors significantly associated with total hospital costs. Variables showing significance in the univariate analyses were considered in the GLM-model. Forward modelling based on Akaike Information Criteria (AIC) and $p<.05$ was applied to achieve the most parsimonious multivariate model. An iterative process was used, consecutively adding, and if non-significant in the model, removing variables from the model, starting with the variable with the lowest p-value in the univariate analysis. Sex and age were forced into the model because of their known influence on hospital costs[9,12,21-27]. Length of stay was not included in the final model due to the direct link with total hospital cost, which would lead to model deterioration. As a gamma distribution varies between 0 and ∞+ the minimum cost was subtracted from the total cost for each patient. Model assumptions were checked by analyzing multicollinearity in the variable set of the final model and a graphical analysis of the standardized normality plots of the residuals. Extreme outliers based on length of stay were omitted from the analyses. Statistics were performed using Stata Statistical Software Release 12 (College Station, TX: StataCorp LP).

Results

Sample

In total, 141 patients who underwent surgery for lumbar radiculopathy during the year 2016 were identified. Two extreme outliers based on length of stay (> 20 days) were excluded from the analyses, resulting in 139 cases.

An overview of the sample characteristics can be found in table 2.

Hospital costs

Mean total hospital costs were calculated at € 5,016 ± 188 (median: € 4,382) per patient (table 2). Distribution of total costs over different subcategories of claims is displayed in table 3. The category 'Residence', which includes the day price and all claims related to nursing, comprised a mean proportion of 53% of total hospital costs, being the most expensive category. The second highest amount was claimed for the surgical procedure, encompassing a mean proportion of 18%, followed by claims related to anesthesia (8%) and clinical biology (5%).

Factors influencing hospital costs

Table 2 presents both descriptive data of total hospital costs in subgroups of the sample and the results of the univariate analyses. First of all, patients with minor SOI had significantly lower hospital costs compared to patients with moderate or major SOI ($p<.001$). Second, total costs varied significantly depending on the primary diagnosis of the patient ($p=.033$). Furthermore, the presence of several secondary diagnoses led to significantly higher costs, more specifically, 'Complications related to surgery' ($p=.023$), 'Urogenital disorders' ($p=.012$) and 'Preadmission comorbidities' ($p=.009$). Third, considering the surgical

interventions, 'Fusion or dynamic stabilization' resulted in significantly higher total hospital costs (p<.001), as did 'Repair of dura mater or spinal meninges' (p=.013). Fourth, patients undergoing an emergency procedure, had significantly higher costs compared to those undergoing elective surgery (p=.016). Finally, more than 5 days of hospitalization resulted in significantly higher intramural costs compared to shorter stays (p<.001).

Those variables showing a significant relation with total hospital costs in the univariate analysis were included in the GLM multivariate analyses based on forward modelling. The surgical procedure 'Fusion or dynamic stabilization' was significant in the model. Therefore, all other surgical procedures were also included in the model to ensure a complete representation of all surgical techniques. The final model is presented in table 4.

Controlling for all other variables in the model, patients with moderate/major SOI had 49% higher hospital costs compared to patients with minor SOI (p=.01). The presence of secondary diagnosis 'Preadmission comorbidities' incurred 46% higher costs (p=.03) compared to those without such comorbidities. Patients who admitted the hospital through the emergency department had 72% higher costs compared to patients who underwent elective surgery (p<.001). Last, patients undergoing fusion surgery had 211% higher hospital costs compared to patients not having this intervention (p<.001).

Discussion

This study gives an overview of the intramural healthcare costs in patients undergoing surgery for lumbar radiculopathy in a tertiary care hospital located in the capital city of Belgium. Furthermore, variables influencing total hospital costs were identified. Mean total hospital costs were € 5,016 ± 188 per patient. The highest costs were claimed for the actual residence in the hospital (i.e., 'hotel costs'), followed by claims related to the surgical procedure. Variables significantly influencing total intramural costs were SOI,

the presence of secondary diagnosis 'Preadmission comorbidities', admission to the hospital (elective vs emergency) and receiving fusion or dynamic stabilization surgery.

Total costs in this study are composed of the part payed by the patient (or his/her hospitalization insurance) and the part covered by health insurance, ensuring a complete representation of the expenses by both patient and society. Phan et al. (2015) conducted a systematic review investigating the total hospital costs for lumbar fusion surgery in the US and Canada[28]. In our study the mean total hospital cost, when undergoing lumbar fusion surgery, was € 9,154 ± 550, while the former systematic review found a mean hospital cost between € 10,394 [$ 12,011] and € 32,610 [$ 37,681]. This indicates that hospitalization for lumbar fusion surgery, and possibly for all lumbar procedures, is more expensive in North America, compared to Belgium. This might not be surprising, as it is widely known that healthcare utilization is more expensive in the US compared to European countries[29].

More than half of the total costs comprised claims related to hospital residence, including the day price. This reflects the strong relationship between length of stay and total hospital costs, wherefore the former variable was omitted from the multivariate analysis. Another study found that 1% change in length of stay results in 0.47% change in hospital costs in patients who underwent spine surgery[21]. Strikingly, only 18% of the total costs were claimed for the actual reason for hospitalization, namely, the surgical procedure.

The drivers of hospital costs identified by the present study are partly in line with findings of research in other populations. Missios et al. (2015) investigated predictors of hospital costs for spine surgery in general in the US[21]. They found that, among other factors, the execution of fusion surgery and the presence of comorbidities were significant predictors for hospital costs. These results were confirmed by our study, as undergoing fusion surgery had the highest influence on hospital costs, and the presence of comorbidities was also pointed out as a driver of hospital costs. Likewise, other research highlighted the fact that arthrodesis surgery[8,30] and comorbidities[24,25,30,31] are associated with higher hospital costs.

In our multivariate analysis, only the cluster 'Preadmission comorbidities' remained a significant driver of hospital costs when controlling for other confounders. Among others, this cluster includes history of malignancy, a comorbidity which was also identified as an influencer of hospital costs by Minhas et al. (2015)[24]. On the contrary, the latter and Kalanithi et al. (2012), found that the presence of obesity (BMI ≥ 30) was a significant predictor for hospital costs. This finding was not confirmed by our study, nor in the univariate or the multivariate analyses[24,31]. One possible explanation for this discrepancy might be the fact that previous studies[24,31] were focused solely on fusion/arthrodesis surgeries, whereas the present study included all surgical interventions for lumbar radiculopathy.

Missios et al. (2015) found a significant influence of age and sex, which was not confirmed by our study[21]. Yet, the influence of age on hospital costs was already affirmed by a number of studies in several populations[22-26]. A possible explanation for the non-significance in our analyses, might be the small sample size in combination with a rather small influence on hospital costs.

Another important variable influencing hospital costs in our sample was type of admission to the hospital, with emergency admissions being significantly more expensive compared to elective hospitalizations. This finding is in accordance with the results of Kukreja et al. (2016), who found that patients undergoing emergency fusion surgery had a significantly longer length of stay compared to patients undergoing elective interventions[32]. Also, the independent association between SOI and hospital costs as revealed by our analyses, could be affirmed by findings in another population, namely patients receiving total joint arthroplasty[33].

Strengths and limitations

Notwithstanding the high prevalence of surgeries for lumbar radiculopathy[3] and the availability of cost-utility and cost-effectiveness studies[34-36], this study is - to the best of our knowledge - the first study in

Europe to give an extensive overview of the inhospital costs related to the primary hospitalization for surgery for lumbar radiculopathy, as well as variables possibly influencing these intramural costs. Therefore the results will be of high interest to clinicians and their patients, as well as healthcare policy makers. This study indicates that total hospital costs are influenced by preoperative characteristics of patients undergoing surgery for lumbar radiculopathy. Furthermore, we were able to quantify the difference in hospital costs based on these influencers. Another important methodological strength is the fact that all patients undergoing surgery for lumbar radiculopathy in 2016 in the UZ Brussel were considered, therefore reducing selection bias.

When interpreting the results of this study, some limitations should be taken into account. First of all, data were extracted from secondary databases, which might have induced bias due to coding errors. Second, we transformed the data into dummy variables, possibly influencing the results, however clustering was thoroughly discussed with all authors, including researchers, clinicians and a medical information manager. To avoid loss of information for the readers, all details concerning the clustering are available upon request. Third, due to the limited sample size, it was not meaningful to interpret the GLM model as an equation to estimate total costs, nonetheless it delivered us an overview of factors significantly influencing intramural costs while controlling for other confounders. Fourth, only data from one tertiary care hospital, the University Hospital of Brussels, were included in the analyses. Because of this specific setting, the results are not entirely generalizable. However, by using the average day price for Belgium in 2016, and not the particular one of the University Hospital of Brussels, we partly controlled for this potential source of bias. The influence of this issue on the results is deemed to be limited for the identification of factors influencing total hospital costs, but it might be reflected in the distribution of costs over several subgroups of healthcare costs.

Recommendations for future research

Multicentric studies including both tertiary and secondary care hospitals exploring intramural healthcare costs in patients undergoing surgery for lumbar radiculopathy are warranted. These will lead to the possibility of defining a generalizable model for hospital cost estimation, including the influence of the level of the hospital.

Conclusion

Mean hospital costs related to surgery for lumbar radiculopathy in a tertiary care hospital in Belgium were € 5,016 ± 188 per patient. The severity of illness, comorbidities, admission to the hospital (elective vs emergency) and receiving fusion were identified as independent drivers for hospital costs. As this is the first study examining (determinants of) health care costs for lumbar surgery in Europe, future studies should investigate (determinants) of healthcare costs for lumbar surgery in secondary care hospitals in other European countries.