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Direct Cost Analysis of Patients With Brain Tumors Submitted to Microsurgical Neurosurgical Procedures - An Epidemiological and Economic Analysis in a Large Developing Country

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Research Article

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Abstract

Purpose

In low- and middle-income countries, there is a lack of data on neurosurgical costs. These data are relevant to help international cooperation, especially for huge trials. This study aims to estimate the direct cost of an adult neurooncological patient during hospital admission in the largest philanthropic hospital in Latin America.

Methods

This observational economic analysis describes the direct cost of a neurooncological patient at Santa Casa de São Paulo, Brazil. For this analysis, only adult patients with the two more common primary brain tumors were considered.

Results

Between January 2008 and December 2019 a total of 1279 charts were reviewed. 53.57% were female patients. Most patients had an age range between 56 and 65 years (22.5%). A statistically significant sample of patients with meningiomas and gliomas were analyzed. The estimated mean cost of neurosurgical hospitalization was U$ 4.166. The operating room and ICU costs represented the largest proportion of the total cost (29.24% and 24.95%, respectively). 17.5% of patients had some types of infection and 66.67% them occurred in nonelective procedures. The mortality rate was 12.7% and 92.3% occurred in emergency procedures.

Conclusions

This study evaluated the cost of oncological neurosurgical patients. The operating room was the most expensive variable, followed by the ICU hospitalization period. Surgery performed in an emergency was more associated with infections and mortality. Findings from this study could be used by stakeholders and policymakers for resource allocation and to perform economic analyses to establish the value of neurosurgery in achieving global health goals.

Introduction

Five billion people worldwide do not have access to safe, affordable surgical, and anesthesia care when needed.[1] Access is the worst in low-income and lower-middle-income countries, where nine out of ten people cannot access basic surgical care.[1] Neurosurgery is considered a highly specialized and complex specialty.

Thirty-three million individuals face catastrophic health expenditure due to payment for surgery and anesthesia care each year. Several people do not have access to medical insurance. An additional 48 million cases of catastrophic expenditure are attributable to the nonmedical costs of accessing surgical care.[2,3] Besides, after surgeries, return to work is more challenging. A quarter of people who have a surgical procedure will incur a financial catastrophe because of seeking care. In low-income and lower-middle-income countries, the burden of catastrophic expenditure for surgery is the highest.[4,5]

Surgical conditions represent 11% of the global burden of disease.[3] Providing surgical care in subspecialties such as neurosurgery is even more challenging. Although procedures in neurosurgery are less common compared to other specialties, neurosurgical disorders, including brain tumors, represent a substantial burden and have high morbidity and mortality.[6] Neurosurgery is expensive and demands high technology to improve results, especially in brain tumors.

National Institute of Cancer, Brazil, estimates 11.090 new cases of brain tumors per year. High morbidity and mortality are the challenges of a brain tumor patient.[7]

Constantly, new researches improve knowledge about brain tumor behavior. Pathological, molecular, and genetic evaluations are required for a better classification. The proper classification helps guide optimized therapy.[8,9] The last World Health Organization classification was in 2016; however, several small consensuses were published after and brought new information about brain tumors.[9]

Patients with primary and secondary brain tumors have several differences regarding treatment, prognosis, and cost evaluation. Systemic commitment by a primary cancer generally causes impaired functional status, and so, surgical outcomes and costs could not be compared to patients with primary brain tumors. They also required more hospital admissions and surgical procedures.

Meningioma is the most common benign brain tumor, and glioblastoma (GBM) is the primary malignant.[1,10] The focus of this research was on estimating the impact and costs of gliomas and meningiomas neurosurgical treatment in patients in a huge tertiary teaching hospital in Brazil.

Methods

We analyzed all patients with the main hypothesis of brain tumor who underwent surgery between January 2008 and December 2019. For cost analysis, a small period was considered due to changes in the record system. Results will be presented in two parts.

All study procedures were conducted in accordance with the ethical standards of the institutional and national research committee and the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This project was previously approved by the local institutional Human Ethics Research Committee. Statistical tests were used to analyze the quantitative and qualitative variables.

Cost calculation of the entire procedure was determined through a detailed evaluation of surgical material, operating room, human labor, drugs, blood products, parenteral nutrition, imaging examinations,

laboratory tests, days of hospitalization, and physiotherapy. The value was initially calculated in the Brazilian reais and later converted to US dollars (this conversion was performed using the February 06, 2021, exchange rate in which US$ 1 equals R$ 5.37). After data collection, a free R software (version 3.3.0) and IBM SPSS version 20 software were used to perform the statistical analysis. We used the following parameters: mean, median, standard deviation, minimum, and maximum for summarizing the quantitative variables. For categorical variables, absolute and relative frequencies (%) were applied. Fisher's exact test was used to evaluate the association between categorical variables. For comparing two groups considering quantitative variables, the unpaired Mann–Whitney U-test was used, and for comparing more than two groups, the nonparametric Kruskal-Wallis test was chosen. Spearman's correlation coefficient was used to evaluate the linear correlation between two quantitative variables.

A detailed literature review performed in the PubMed database was performed aiming at comparing results and describing associations.

Results

The results are presented in two categories: general epidemiology of the whole period and cost analysis of a small period.

General Epidemiology

A total of 1279 patients underwent brain tumor microsurgery between January 2008 and December 2019. We used the neurosurgery department database. We excluded nineteen patients who had an initial hypothesis of brain tumor not confirmed in the histological analysis. The remaining 1260 patients with brain tumors were analyzed. Remarkably, we excluded patients with brain tumors not submitted to any neurosurgical procedure. The predominant age range was between 56 and 65 years (22.5%).

The study sample included 322 glioma and 225 meningioma patients. Glioma and meningioma were the two primary tumors more frequently comprising 43.48% of all tumors in this period. High-grade gliomas comprised 75.75% of all diffuse gliomas. Metastatic tumors were responsible for 21.5%. Besides, we divided them into the following tumors: craniopharyngiomas, adenomas, medulloblastomas, schwannomas, and other tumors (Graphic 1).

Cost Evaluation

After December 2016, the medical record system changed and became more complete, with more details. Before this period, a retrospective cost analysis had several biases. Therefore, for cost analysis, we considered only patients operated after this change. We included only adult patients (>18 years). Furthermore, endoscopic procedures were excluded from cost evaluation; only microsurgery was considered. The predominant age range was between 46 and 55 years (23.3%).

After December 2016, 217 patients with meningiomas and gliomas underwent neurosurgical procedures. A statistically significant sample ($p < 0.05$) was evaluated, 139 patients. Only patients operated by the

authors JCEV and JLVA were included seeking a more homogenous sample. However, due to incomplete data, 37 were excluded. Hospitalization cost analysis was performed on 102 patients. Among them, 44.43% had high-grade gliomas, 40.39% meningiomas, and 19.18% low-grade gliomas (Graphic 2).

The mean cost of these patients was R$ 22.372 (U$ 4.166). Costs were greater in meningioma patients; however, this association was not statistically significant (p = 0.246). For most surgeries, operating room (Graphic 3) and ICU costs represented the largest proportion of the total cost (29.24% and 24.95%, respectively). Patients between 66 and 75 years had the greatest cost (mean of U$ 5.756,61); however, the age difference concerning costs was not statistically significant (p = 0.787) (Graphic 4).

Eighteen patients (45%) with meningioma had skull base lesions, and the infection rate among them was greater than that among nonskull base patients. Considering the whole group, infections were more common in high-grade glioma patients (55.5%)

In 8 glioma patients, awake craniotomy was performed. It had the lowest cost; however, this association was not significant (p = 0.538). If patients presented with any thromboembolic complications, costs were higher, but this association was not significant (p = 0.308).

The average period of hospitalization was 12 days (Graphic 5). The mean ICU period was 3.8 days; however, the ICU costs were higher than neurosurgery ward. Nonelective patients had a greater length of stay (LOS).

The mortality rate was 12.7%. Only one patient had an elective procedure, and 92.3% of deaths occurred in urgent neurosurgeries. Eighteen patients had some types of infection, and 44% of them died.

Discussion

The treatment priorities of a brain tumor patient are quality of life (QOL) and overall survival (OS). High neurosurgical costs could impact public health, even if patients have medical insurance. Comparing costs of different countries helps to better understand weak points and how to improve them.[11]

Documenting costs for neurosurgical care is important for resource allocation, with healthcare sector planning, as well as exploring the benefit of adopting cost-saving interventions, and also helps clinical research aiming at improving patients QOL.[12]

The cost of neurosurgical intervention is the sum of direct and indirect costs. Direct costs can be attributed to a specific service or procedure, while indirect costs are costs that cannot. Identification of patients groups or interventions with higher associated treatment costs may be beneficial in efforts to decrease the overall financial burden. Strategies to reduce cost may require different approaches depending on the procedure type.[13,14] Because of this, we did not compare the costs of microsurgery and endoscopy in this evaluation; each type of procedure has several different particularities. Providing a cheaper but effective treatment not only improves economy but also QOL and OS.

LOS is a useful measure of healthcare quality. In addition to influencing patient care, an increase in LOS is associated with higher healthcare costs.[15,16] Postoperative LOS of 14 or more days has been associated with increased frequency of surgical site infections (SSI) and a rise in healthcare costs of up to 300%.[15] In this series, the mean LOS was 12 days. The smaller LOS was 3 days of an elective procedure. Several patients admitted to the emergency department (ER) were not immediately operated, as was done in elective procedures in which patients were at home and admitted only when properly prepared for surgery. With prolonged LOS, the complication rate increased including infections and thrombosis.[17] This series only evaluated adult patients; for children, analysis characteristics are different.[15]

Due to the need for improving patient outcomes and reducing costs, the concern of developing safe and effective standards in postoperative care emerged, and advances have been achieved.[7,18] In 1994, Engelmann and colleagues introduced the concept of “Fast-Track Surgery” to optimize postoperative recovery.[17] Many neurosurgical centers still adopt an in-patient postoperative care with a mean of 4 days after craniotomy for safety reasons, even in cases with no perioperative complications. As we confirmed in this paper, the hospitalization period is associated with greater costs, especially in ICU (Fig. 7).

Shorter hospital LOS has been associated with decreased complication rates, fewer hospital-acquired infections, and lower costs.[17] Due to concerns for postoperative complications, neurosurgeons could be hesitant to discharge patients on the same day or 1 day after craniotomy. Most severe postoperative sequelae occur within 24 hours after surgery. Observing patients overnight should limit the number of complications developing after discharge. With the evolution of surgical technology, instrumentation, monitoring techniques, and increased proficiency in anesthesia, patients are now receiving improved perioperative care with shorter operative duration and shorter recovery times and times to discharge.

In this study, ICU LOS was considered the second factor responsible for the increased costs. A study revealed that the cost differential between the ICU and neuro-transitional care unit is U$1504 per day.[19] Perhaps some postoperative brain tumor patients could be monitored in a semi-intensive unit and this could decrease costs.[13] Qualification of health professionals for a more dynamic and effective patient approach could be an alternative, and earlier and safer discharge could become more common.[20,21]

This study also revealed that emergency procedures are related to greater hospitalization days, infections, deaths, and total costs. In this scenario, patients did not have proper surgical preparation. Several of them had noncontrolled arterial hypertension, diabetes mellitus, and obesity and were smokers. Rarely brain tumors required surgery in an emergency, usually when they cause hydrocephalus, huge midline shift, or edema. Unfortunately, as we discussed, five billion people do not have access to safe, affordable surgical, and anesthesia care when needed[1] and only get health assistance when they are severely compromised, especially in low-income and lower-middle-income countries. Better patient preparation and fewer emergency procedures are a reasonable option for cost reduction.

Although awake surgery was not statistically significantly associated with smaller costs, this result had bias due to the small number of awake procedures in this series.[22] Several studies described a shorter LOS in patients undergoing awake craniotomies.[16] Some tools have been shown to improve outcomes with decreased complications.[11,23-25] For the selected cases, awake neurosurgery improved functional outcomes with small LOS. The preparation of a multidisciplinary team is required for awake surgery.

In the postoperative period, infections and thromboembolic events are responsible for great morbidity, mortality, and costs.[26] SSI incidence in neurosurgery is low and most readmissions occur within 30 days.[26-28] Broad-spectrum antibiotics are expensive, so careful surgical preparation should be encouraged.[29,30]

Concerning the histological type and costs, meningiomas had a greater cost; however, this association was not significant. For skull base meningiomas, procedures are longer, recovery is slower[31,32], and infection rate was greater than that in nonskull base meningiomas. Among the meningioma group, skull base localization had greater costs. In this series, all patients were submitted for microsurgery; endoscopic procedure costs and complications are different and not considered.

Regarding gliomas, LGG predominates in younger patients with faster recovery and shorter hospitalization, which did not happen to HGG, especially GBM.[33-35] GBM was the most common tumor in this cost evaluation with 22.75% of incidence. It is an aggressive, high-grade brain tumor associated with a significant clinical burden.[36] In most series, nearly half of adult primary malignant brain tumors are GBM. According to the Central Brain Tumor Registry of the United States, the average annual age-adjusted incidence of GBM is 3.2 cases per 100,000 people.

Health economics in GBM is a subject of rising interest, as in many other cancers, but there is only limited knowledge on cost-effectiveness and other economic aspects of different therapies for recurrent GBM.[33] It is important to know the treatment impact of this disease worldwide.

A high proportion of patients with GBM have emergency department visits (32%) and hospitalizations (28%) in the 6 months after diagnosis, indicating the substantial healthcare resource burden associated with GBM.[36] Emergency neurosurgical approaches were required many times as documented in this paper.[26] Mortality rate was greater in emergency patients (92.3%). Only one elective patient died in this series: an elderly female patient with several comorbidities, initial Karnofsky Performance Scale of 40, and a giant olfactory groove meningioma who died of a refractory septic shock due to pneumonia. Adjuvant therapy is not discussed here but is also responsible for more treatment costs.

Limitations

This study has several limitations. Results of a retrospective cost analysis from a single-center, mixed case index academic practice may not apply to all centers depending on the proportion of cases. This paper did not consider the cost of neurooncological patients who did not undergo neurosurgery.

Conclusions

Interest in cost analysis comparisons in the neurosurgical field has recently increased. Neurosurgical procedures are highly driven by technology, often require extensive workup, and can result in prolonged hospital stays because of the morbidity of neurologic injury even when the procedures are performed without surgical complications.[13] Optimization of resources, especially trying to reduce the LOS and postoperative infections, seems to be an excellent alternative for cost saving and better outcomes.

Declarations

Funding – The authors did not receive support from any organization for the submitted work.

Conflicts of interest/Competing interests – The authors have no conflicts of interest

Availability of data and material – All data are available with the authors. This publication is part of a post-graduating research approved by an Ethics committee and analyzed by an statistic.

Code availability - free R software (version 3.3.0) and IBM SPSS version 20 software were used to perform the statistical analysis

Authors' contributions:

Aline L Campos Paiva – study design, data collection, writing, editing and review

João L Vitorino-Araujo - study design and review

Renan M Lovato – data collection and review

Guilherme H Ferreira da Costa – data collection and review

José C Esteves Veiga - study design and review

Ethics approval: Santa Casa of São Paulo Ethics committee approval – this study is a part of a post-graduating research

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Figures

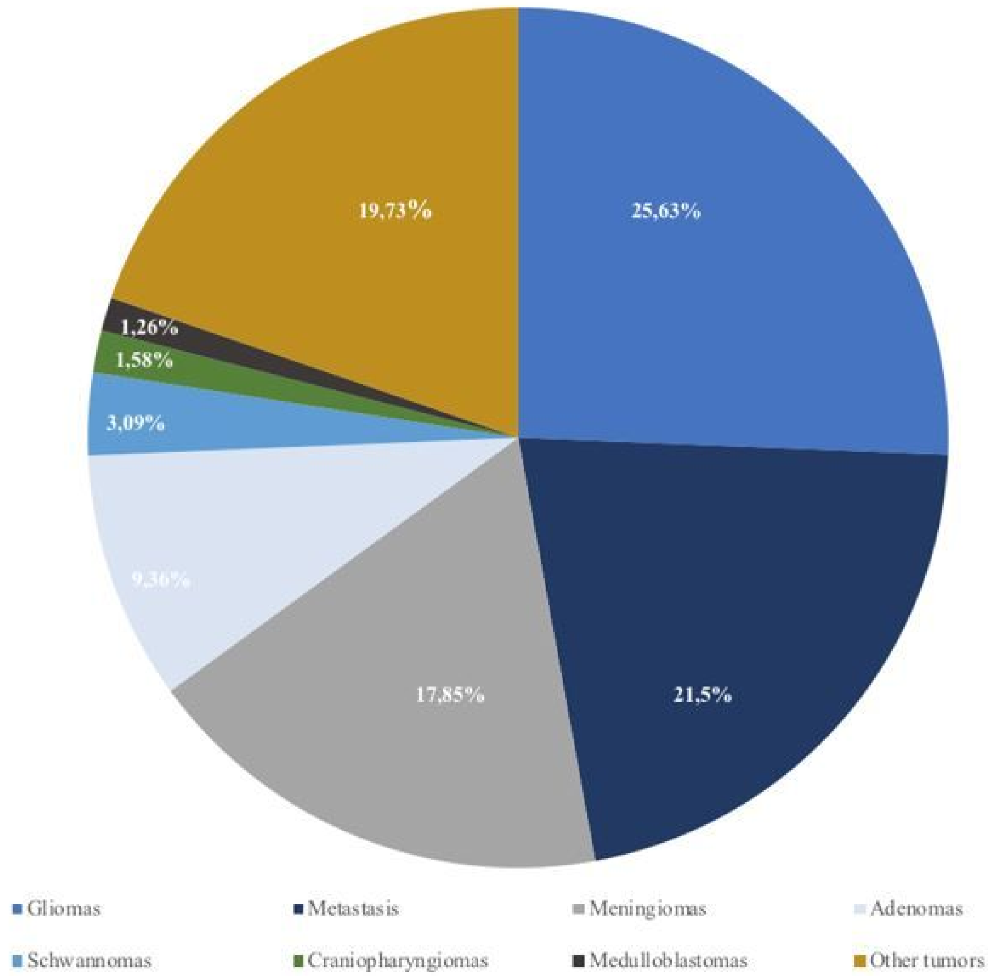

Figure 1

Brain Tumors Histology Incidence

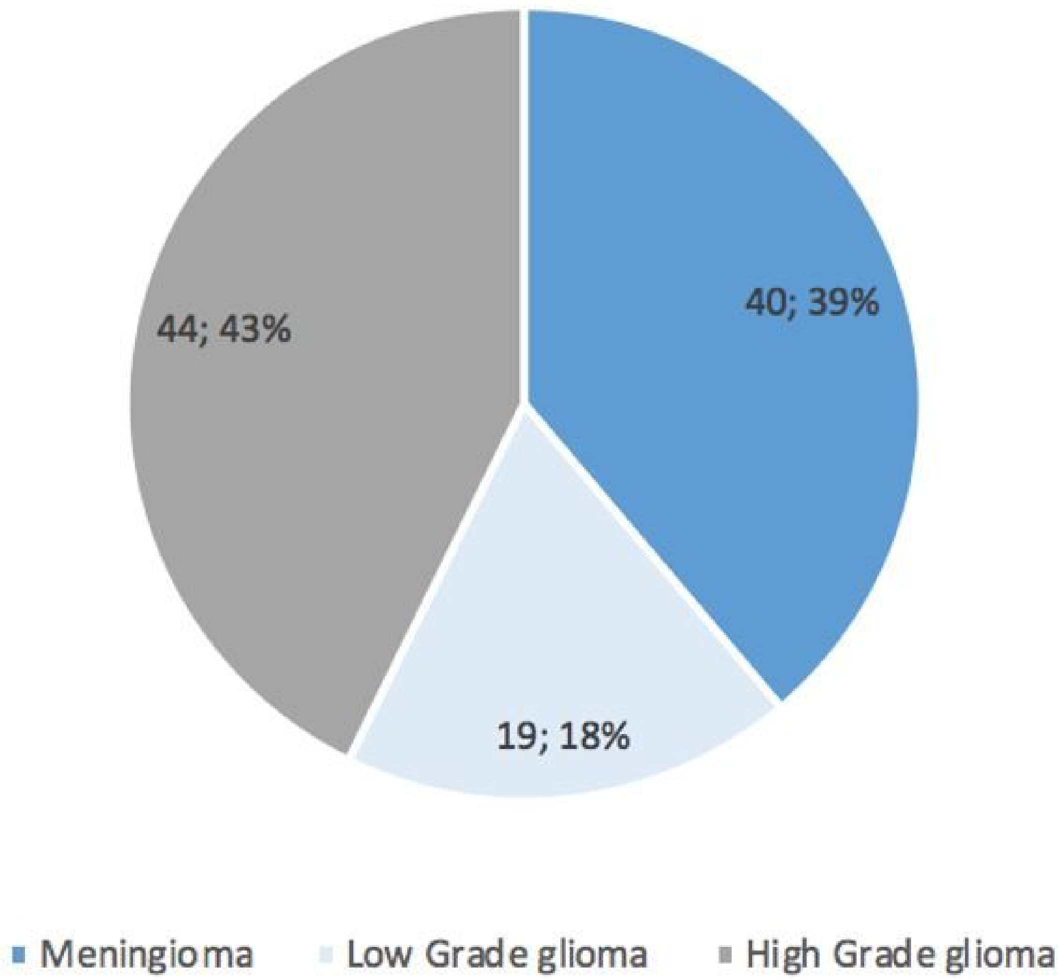

Figure 2

Histological classifications of cost-analysis sample

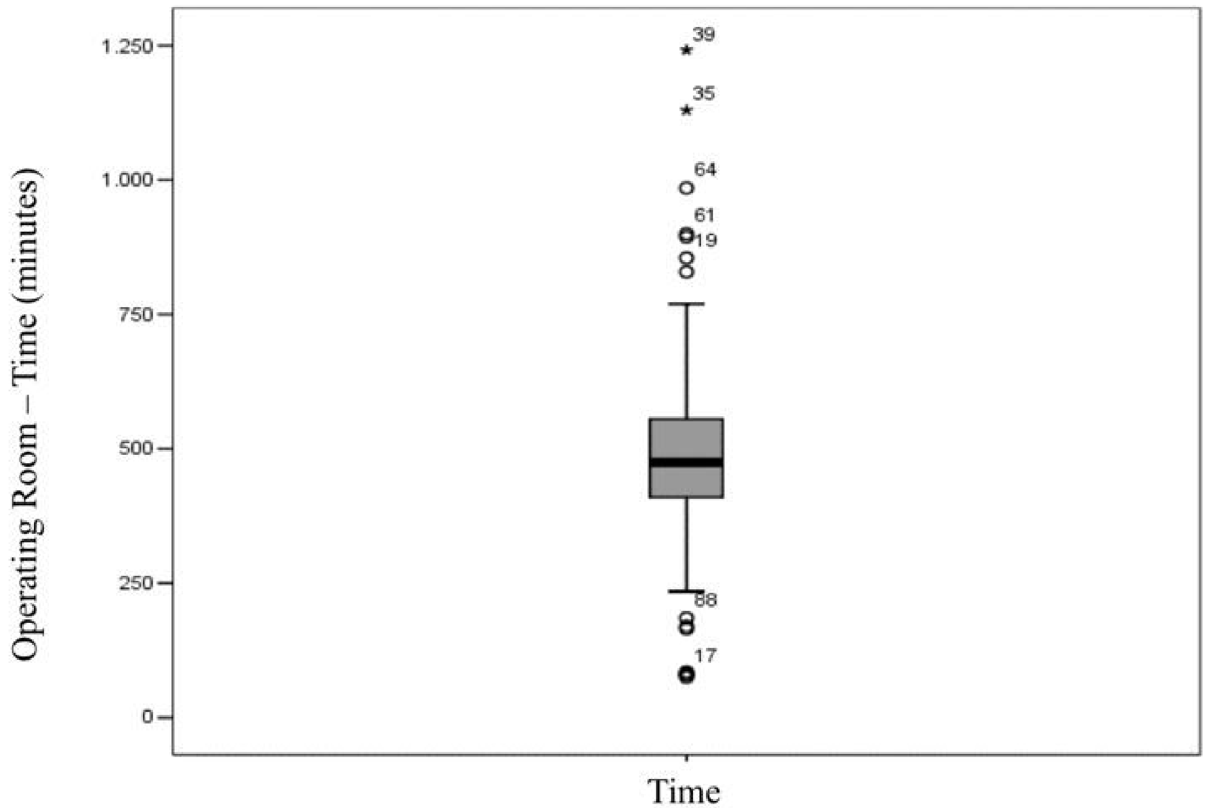

Figure 3

OR time in minutes

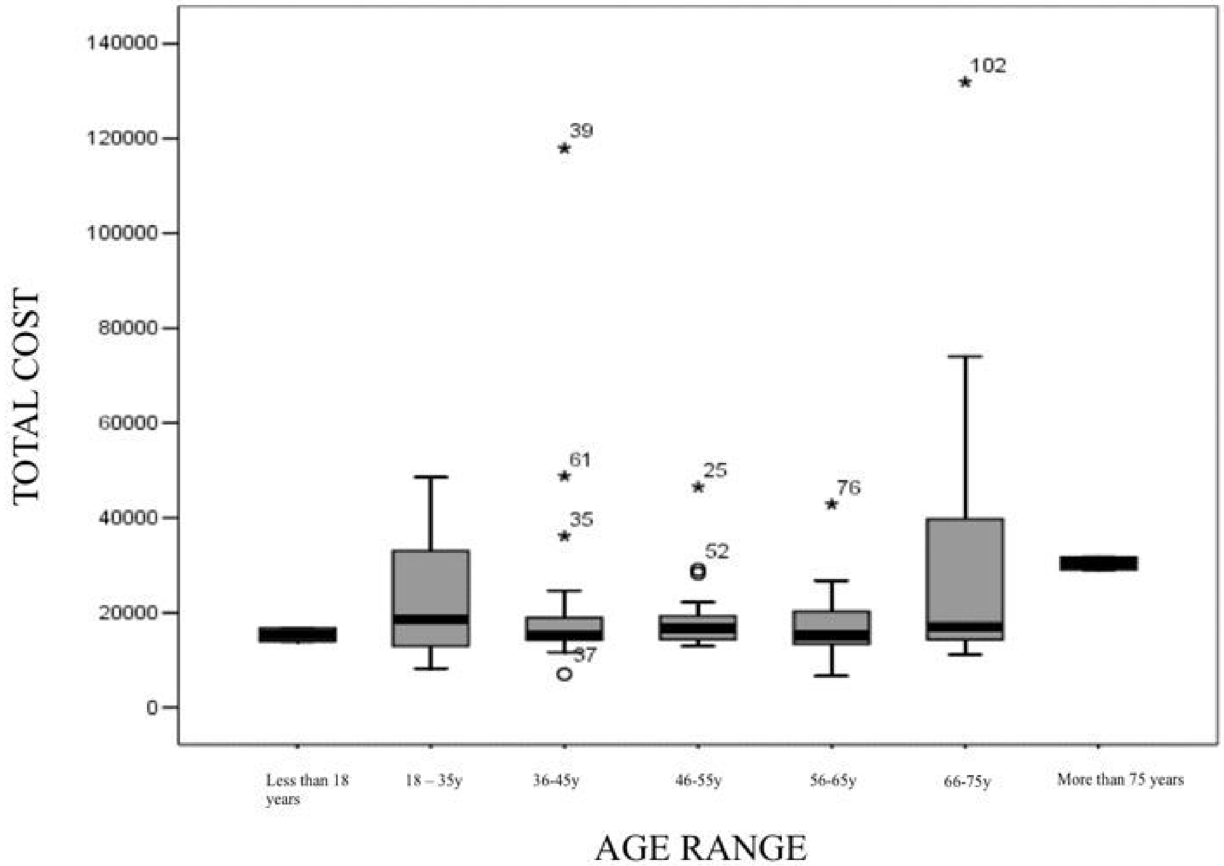

Figure 4

Age Range X Total Cost

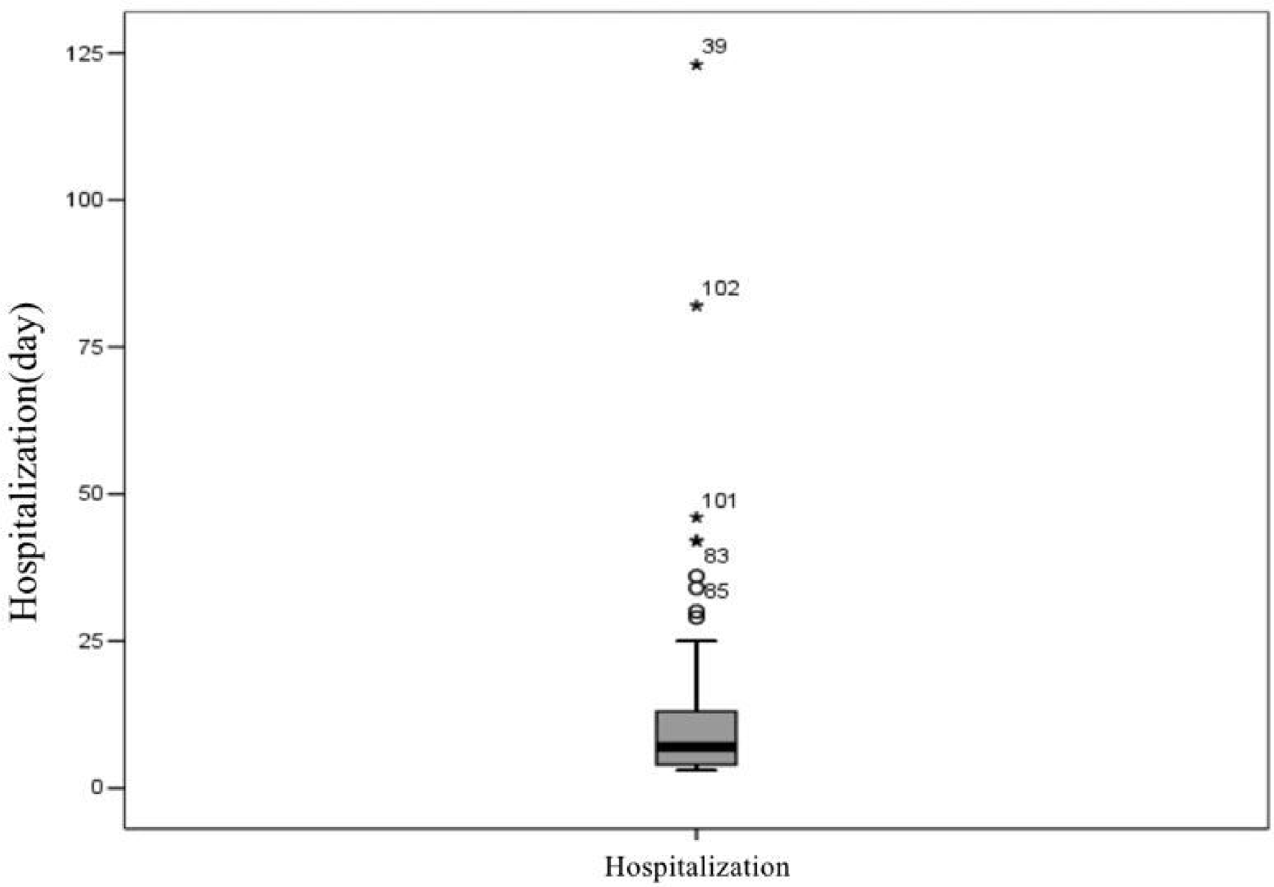

Figure 5

Length of stay (LOS): ICU and neurosurgical ward