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Clinical study

Factors influencing extended hospital stay in patients undergoing metastatic spine tumour surgery and its impact on survival

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ABSTRACT

Metastatic spine tumour surgeries (MSTS) are indicated for preservation or restoration of neurological function, to provide mechanical stability and pain alleviation. The goal of MSTS is to improve the quality of life of the patients with spinal metastases and rarely for oncological control which is usually achieved by adjuvant therapies. Hence outcome measures such as length of stay (LOS) and rate of complications after MSTS are important indicators of quality but there is limited literature evidence for the same. We carried out a retrospective study to determine the incidence and the factors influencing normal (nLOS) and extended length of stay (eLOS) after MSTS. Data of 220 consecutive patients who underwent MSTS between 2005 and 2015 were retrieved from hospital electronic records. The preoperative, intraoperative and postoperative variables, discharge destinations as well as socioeconomic factors were analyzed. eLOS defined as positive when the LOS exceeded the 75th percentile for this cohort, was the key outcome indicator. Univariate and multivariate logistic regression analyses were performed to determine the predictive factors of eLOS. The overall median LOS was 7 days (1–30 days) and 55 patients had eLOS (LOS $\geq$ 11 days). Multivariate analysis revealed that significant variables independently associated with eLOS were instrumentation >9 spinal segmental levels (OR 2.89, 95% CI 1.1–7.5, $p = 0.032$) and presence of postoperative complications (OR 3.68, 95% CI 1.85–7.30, $p < 0.001$). Metastatic tumours other than breast, prostate and lung have lesser risk of eLOS (OR 0.31, 95% CI 0.14–0.70, $p = 0.004$). Survival estimates show that patients with eLOS have shorter survival than patients with nLOS (Crude HR 1.81, 95% CI 1.13–2.89, $p = 0.003$).

1. Introduction

Surgery forms one leg of a tripod in comprehensive management of metastatic spine disease (MSD); the others being; radiotherapy (RT), chemotherapy (CT)/hormonal therapy (HT) [1]. The goals of metastatic spine tumour surgery (MSTS) include preservation or restoration of neurologic function, providing mechanical stability, pain alleviation and rarely oncologic control. The decision for surgery is influenced by multiple factors-patient's responsiveness to non-operative measures, estimated post-operative life expectancy, potentially achievable post-operative quality of life and surgery related costs [2]. In addition to considering physical suitability for operative treatment, it is also important to ensure that health care cost and postoperative recovery does not outweigh its potential benefits. Length of stay (LOS) is one such key factor to measure cost-effectiveness, quantify operative success and give a meaningful outcome measure that can be a potential target for quality improvement activities [3,4].

LOS can be influenced by clinical or non-clinical causes, however increased length of hospital stay results increased financial burden, resource strain and affect delivery of efficient and quality health care [5]. Thus, understanding the factors affecting extended

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LOS (eLOS) will aid in addressing factors causing prolonged hospital stays much earlier in course of hospital admission. This will result in optimizing health care service delivery and provide an opportunity for patients to make an informed decision regarding surgery. Patients with spinal metastases are elderly and high-risk patients with a shorter predicted survival. Hence, deeper understanding of the factors influencing eLOS will allow both physicians and patients alike to better weigh the cost-effectiveness and risk-benefit of MSTS. Literature supports studies evaluating the factors determining eLOS in patients undergoing elective surgeries for spinal [6–9] and other surgical disciplines [5]. However, there is a paucity of literature estimating LOS in patients undergoing MSTS.

With this background, we aimed to examine the factors influencing eLOS in patients undergoing MSTS by generating a multivariate model accounting for potential confounding factors which can be either preoperative, intraoperative and/or postoperative variables, as well as socioeconomic factors. We also looked at the impact of eLOS on the survival of the patients after MSTS.

2. Materials and methods

All patients who underwent MSTS at a single tertiary institution between 2005 and 2015 were identified. Ethics approval was obtained from institutional review board. Indications for surgery were neurological deficit, spinal instability, intractable pain or combination of the above. We excluded patients who underwent only vertebro/kyphoplasty, revision surgery, or those who died during hospital stay. Data were retrieved by hospital electronic records [Computerized Patient Support System (CPSS) & Cluster Shared Patient Record System (CPRS)].

The data collected were demographics, ECOG score for preoperative general condition, BMI, preoperative haemoglobin, preoperative radiotherapy and comorbidities categorized by Charlson comorbidity index [10]. The socioeconomic status of the patient was evaluated indirectly using the class of admission. To account for discrepancy in admission class due to bed availability, the final bed class at time of discharge was used for analysis. The tumour characteristics were assessed by origin of spinal metastases and disease status (visceral/vertebral metastases, cord compression and pathological fracture). The extent of cord compression was graded using Bilsky's scale [11]. The operative variables included were type of surgical approach, number of vertebral levels instrumented and/or decompressed, operative time, perioperative blood loss and transfusion. Postoperative variables recorded were complications and LOS. Major complications were defined as any organ space infection, wound complications or complications requiring reoperations, septic shock, deep vein thrombosis, respiratory complications (pneumonia, unplanned intubation, pulmonary embolism), cardiac complications (myocardial infarctions, cardiogenic shock), acute renal failure and urinary tract infections. Minor complications were superficial wound infections, episodes of hypotension, hypercalcemia, pyrexia of unknown origin, asymptomatic atrial fibrillation or ventricular tachycardia.

Depending on the primary tumour, the patients were stratified into 4 groups: lung, breast, prostate, and others [renal, haematological (myeloma/lymphoma), gastrointestinal, hepatocellular, nasopharyngeal, thyroid and others]. This is because of similar patterns of perioperative outcomes between these tumours and hence they were grouped to make meaningful statistical conclusions. The patients were stratified into 4 groups depending on surgical approaches: Types I) Posterior instrumentation without decompression; II) Posterior instrumentation with decompression III) Posterior instrumentation with partial corpectomy; IV) Posterior or Anterior total or near total corpectomy with reconstruction [12,13]. In our classification, type II and type III surgery is equivalent to posterior approach mentioned in Holmen et al study [14] while type IV included anterior or combined procedures. We also classified level of instrumentation into 3 groups namely <6, 6–9 and >9 levels instrumented; level of decompression into 3 groups namely 0, 1–2, $\geq$3 levels decompressed. The rationale of choosing 3 groups of instrumentation levels is as follow: <6 levels of instrumentation usually is carried out for 1–2 levels of tumour involvement; 6–9 levels of instrumentation usually is carried out for 1–2, rarely $\geq$ 3 levels of non-contiguous tumour involvement; >9 levels of instrumentation would comprise of $\geq$ 3 levels of decompression which could be contiguous or non-contiguous.

2.1. Definition of outcome measure

Length of hospital stay (LOS) was determined in days from the date of index surgery to the date of discharge, transfer to postoperative radiotherapy/oncology services or transfer to home care or community hospital, whichever came first. The outcome of interest was eLOS, a binary variable that we defined as positive when the LOS was >75th percentile for this cohort. The 75th percentile LOS was chosen as a cutoff to account for normal variations in LOS and differing practices of surgeons towards discharging patients, however still capturing patients with abnormal eLOS. It was determined that the effects of outliers on the results would be increased if the cutoff for eLOS was at a greater percentile or if LOS was treated as a continuous variable for analysis [6].

2.2. Statistical analysis

Statistical analyses were performed using STATA Stata/SE14.0 (College Station, Texas, USA) with the assumption of a two-sided test with 5% significance level. Continuous variables with approximately normal distribution were summarized by mean and standard deviation. The difference between the extended and normal length of stay groups was compared by the independent two-sample *t* test. The univariate logistic regression was employed to study the association between a continuous variable and the outcome (extended vs. normal length of stay), which was measured by the crude odds ratio (OR) and its 95% confidence interval (CI). Categorical variables were summarized by count and percentage in the overall patients, patients with normal and extended length of stay respectively. The association between a categorical variable and the outcome was studied by the Fisher's exact test. The corresponding crude OR and its 95% CI were obtained. Variables showing strong association with the outcome (with $p < 0.05$) were selected for the multivariable logistic regression. A backward variable selection procedure with a removal criterion of $p > 0.05$ was implemented to obtain the final model. Lastly, the discriminative ability of the final model was evaluated by the receiver-operating characteristics curve with estimated area under curve and its 95% CI. Association between readmission, length of stay and overall survival was tested by the Log-rank test.

3. Results

A total of 220 patients who underwent MSTS were included in the final analysis. Table 1 summarizes median LOS and distribution of patients with eLOS for each demographic, oncological, operative characteristics and socioeconomic status. Categorical variables are presented as numbers and percentages and continuous variables as means ± standard deviation or median and range, depending on the distribution of data. The overall median LOS was 7 days (1–30 days) (Fig. 1). The 75th percentile LOS was 10.5 days and hence $\geq$11 days was considered as eLOS. The mean age was

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