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FULL TITLE

The management and cost of surgical site infection in patients undergoing surgery for spinal metastasis

RUNNING TITLE

Cost of SSI after spinal tumour surgery

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SUMMARY

Background

Surgical site infection (SSI) is a serious potential complication of spinal surgery. SSI can impact significantly on in-patient hospitalisation and the costs associated with extra care.

Aim

To investigate the management of patients experiencing SSI following surgery for spinal metastatic tumours, and to estimate the costs associated with SSI in this context.

Methods

Patients experiencing SSI following spinal tumour surgery at a large spinal surgery centre between January 2009 and December 2012 were identified. Existing case notes were reviewed and patient and procedural data, details of the infection and treatment interventions were collected. A bottom-up approach to calculating costs associated with infection was used for patients experiencing SSI and compared with a quasi-random sample of similar patients without SSI.

Findings

The mean cost of treating patients with SSI was significantly greater than costs associated with those without SSI ($p=0.019$). Mean cost of in-patient hospital stay was 60% higher in patients with SSI compared to those without SSI ($p=0.004$). In-patient hospital stay alone accounted for 59% of total costs. Return to theatre was the second most costly intervention overall, accounting for 38% of costs, and was the most expensive single intervention involved in the treatment of SSI.

Conclusion

SSI significantly increases healthcare costs for patients undergoing surgery for spinal metastasis, with prolonged in-patient hospitalisation and return to theatre for wound management being major contributors. The actual total cost to society derived from SSI in this patient group is likely to be far beyond just the direct costs to healthcare providers.

Key Words

Cost; Metastasis; Spine; Surgical site infection.

INTRODUCTION

Surgical site infection (SSI) is a common complication of surgery, accounting for approximately 16% of all healthcare acquired infections in England (1). SSI occurs in approximately 10 to 20% of patients who undergo surgery for secondary (metastatic) spinal tumours (2-6), which is considerably higher than the average of 4% for all surgical procedures (7). Aside from the significant morbidity associated with SSI and a substantive effect on patient survival (8), the impact on patients' quality of life and the challenge to the care team, there is an undoubtable negative impact on the health service through elevated costs due to this complication (9, 10). Recently, one study provided a comprehensive overview of the economic burden of SSI to healthcare organisations (10), which included spinal surgery as a surgical category. However, there are no published reports which estimate the costs of SSI in spinal tumour patients specifically.

Given the increased success of treatments in prolonging the life of many patients with cancer, the number of individuals affected by spinal metastasis is likely to grow, leading to a corresponding rise in surgical cases. This not only puts services under greater pressure to provide the initial surgical and medical care to this increased number of patients, but potentiates a significant problem with respect to complications such as SSI.

The aim of this study was to describe the current management of patients with SSI who have undergone surgery for spinal metastases at a large tertiary referral centre, in order to estimate the economic costs associated with this complication in this patient group.

METHODS

This was a sub-study of an ethically approved case note review of adult patients (aged ≥ 18 years) who had undergone surgical treatment for spinal metastatic tumours at Salford Royal NHS Foundation Trust (SRFT) between 1st January 2009 and 31st December 2012 (6). Patients experiencing SSI over this four year period were identified and patient and procedural data, details of the infection and treatment interventions were collected. A comparator group consisting of a quasi-random sample of 23 metastatic spinal tumour patients without SSI (operated on within the same time period) was included. This comparator group consisted of every fifth patient (when ordered by date of operation).

Definition of SSI

The presence or absence of a SSI (superficial or deep) was defined using the criteria set out by Public Health England (11), which is largely based on the definitions published by the Centers for Disease Control and Prevention (CDC) and the work of Horan et al. (12). SSIs were classified by the SSI surveillance nurse for the neurosurgery department, as per standard routine for the reporting of SSIs through the hospital SSI Surveillance Service.

Data Collection

Data were collected from existing patient case notes and associated medical records (e.g. medical images) and were anonymised prior to analysis; no contact with patients or relatives was required for additional data collection. It was assumed that all patients who experienced SSI were treated for the infection at the tertiary referral centre where they underwent their operation, though in practice this may not be the case if some were treated in primary care or other healthcare settings. In addition to demographic data, American Society of Anesthesiologists (ASA) grade was obtained as a measure of health status and Revised Tokuhashi Score (RTS) as a measure of prognosis (8).

Determination of Costs

A bottom-up approach to calculating costs associated with infection was used for patients experiencing SSI and compared with a quasi-random sample of similar surgical metastatic spinal tumour patients without SSI, on a patient-by-patient basis. The bottom-up approach was used given the low number of SSI cases in the data set, meaning that the data could be interrogated at a closer level to provide a more detailed perspective than a top-down method. The bottom-up approach provides a greater level granularity and versatility, and is a more robust method of estimating benefits to those commissioning services where savings need to be made (13)(UK Centre for Social Impact Bonds, 2013).

Costs were provided independently by the finance department of the hospital. Costs for in-patient hospital stay were calculated for all patients, based on the current rate (as of 2014) of one night's stay for each ward (e.g. intensive care unit; high dependency unit; spinal unit) on which a patient was resident. Additionally, for patients with SSI, costs associated with assessments or interventions directly related to SSI were calculated on an individual basis, in order to accurately reflect the treatment of each in-patient. These included referral to clinical microbiology (i.e. sending of samples to central laboratory and receipt of test results), antibiotic treatment, return to theatre, additional wound care interventions (e.g. negative pressure wound therapy, NPWT), and other wound-specific assessments (e.g. wound ultrasound scan). Thus, the cost of each of these additional components was assumed to be zero for patients without SSI. Costs associated with wound dressings, out-patient clinic visits and community care (e.g. GP consultations and community nurse visits) were not included in the analysis.

Statistical Analysis

Patients with and without an SSI were compared at baseline in terms of key demographic and health variables to verify that groups were reasonably matched at baseline. Total costs and stay costs for both groups were summarised descriptively. Independent samples t-tests were used to assess the significance of the difference of total costs and stay costs between groups in unadjusted models. Factorial analysis of variance (ANOVA) was conducted on corresponding adjusted models correcting for controlling factors and covariates shown to be imbalanced at baseline. In both cases a Bonferroni correction was applied to the significance level to reflect the multiple comparison testing being undertaken. Models with and without controlling variables were compared using the adjusted-R² statistic.

RESULTS

Seventeen patients (seven females and 10 males) experienced SSI (14 superficial and three deep) out of a total of 152 patients undergoing surgery for spinal metastasis over the four year study period, representing a rate of 11.2%. Mean age at operation of those with SSI was 63.5 years (standard deviation (SD) 11.0 years). All except two SSIs were identified as in-patients. Those identified as out-patients returned to the hospital for management of SSI. The mean interval between operation and confirmation of infection was 12 days (SD 7 days). The mean duration of in-patient hospitalisation for patients with SSI was 32 days (SD 15.0 days), compared to 17 days (SD 11.0 days) for those without infection.

Assessment of degree of matching of cases and controls revealed that cases and controls were well matched on age, body mass index (BMI), ASA and RTS scores, with no substantive differences between SSI and non-SSI patients on any of these variables. A gender imbalance was observed; with 10 out of 17 SSI cases being male (58.8%); and 9 out of 23 non-SSI patients being male (39.1%).

Management of SSI

Thirteen patients were documented to have been administered with antibiotic treatment for SSI. Four patients were returned to theatre for irrigation and debridement of the wound, on between one and 10 occasions. Four patients underwent treatment with NPWT, three of which were indwelling negative pressure devices (re-applied between two and eight times) and one which involved a topical negative pressure system (one single application).

Thirteen combinations of micro-organism were cultured from wound swabs, twelve of which included staphylococcus species. One patient's wound was culture negative but met other criteria indicative of SSI. A full list of cultured organisms is presented in Table 1.

Associated costs

Unit costs associated with hospital stay and treatment interventions for the whole group are summarised in Table 2. The cost of treatment of the 17 patients calculated in this study was £217,416 (mean £12,789, SD £12,511), compared with £108,852 for 23 patients without SSI (mean £4,733, SD £3,797). Mean cost of in-patient hospital stay was 60% higher in patients with SSI (£7,594, SD £3,540) compared to those without SSI (£4,733, SD £3,797). Independent samples t-tests conducted on total costs indicated that costs associated with SSI patients were significantly greater than non-SSI patients, with a correction for degrees of freedom due to inequality of

variances ($t_{18,2} = 2.57$; $p = 0.019$). Independent samples t-tests conducted on length of stay costs indicated that costs associated with SSI patients were significantly greater than non-SSI patients ($t_{38} = 2.42$; $p = 0.020$). Both values remain significant at the 5% significance level when applying the Bonferroni correction for multiple comparisons.

Adjusted- R^2 statistics were revealed to be 0.162 for the total costs model and 0.111 for the length of stay costs model, indicating that the models were adequate fits to the data, with the model for total costs being rather better.

In-patient hospital stay alone accounted for 59% of total costs. Return to theatre was the second most costly intervention overall, accounting for 38% of costs, and was the most expensive single intervention involved in the treatment of SSI. NPWT, referral to microbiology, antibiotic treatment and other interventions (e.g. wound ultrasound scanning), combined, comprised less than 3% of the costs associated with SSI.

Further analysis was conducted using gender as a controlling variable, to account for the baseline gender imbalance between cases and controls. A factorial ANOVA conducted on total costs found group (i.e. SSI or non-SSI) to be significantly associated with the outcome, controlling for gender ($F_{1,36} = 9.27$; $p = 0.004$). The controlling variable gender and the group-gender interaction were not significantly associated with the outcome. A factorial ANOVA conducted on stay costs found group to be significantly associated with the outcome, controlling for gender ($F_{1,36} = 9.21$; $p = 0.004$). The controlling variable gender was also significantly associated with the outcome ($F_{1,36} = 6.28$; $p = 0.017$). The group-gender interaction was not significantly associated with the outcome. All inferences of significance were not affected by the application of the Bonferroni correction for multiple comparisons. Adjusted- R^2 statistics were revealed to be 0.153 for the total costs model controlling for gender and 0.246 for the stay costs model controlling for gender, indicating that the models were adequate fits to the data, with the model for stay costs being rather better. Hence the unadjusted model is preferred for total costs, and the adjusted model is preferred for length of stay costs.

DISCUSSION

The economic costs associated with treatment of patients experiencing SSI after surgery for spinal metastasis are significantly higher than those without SSI. The major cost associated with SSI is related to duration of in-patient stay, representing 60% of total costs in this study. The main increase in total costs is attributable to patients with SSI being hospitalised by around 90% longer, causing them to be 60% more costly than those without SSI. This appears to be the case whether other factors are controlled for or not.

Furthermore, this study indicates that the need to return patients to theatre for wound management is likely to occur in around a quarter of all cases with SSI. Significant time and resources are required to bring patients back to the operating room, posing a substantial financial burden to the service, not least because this process is often required several times for a single patient with SSI. Additional surgical procedures also necessitate additional general anaesthesia, which itself is another risk to the patient, and recovery from each additional procedure prolongs the length of time a patient must stay in hospital. More costly wound dressings and management systems such as NPWT are generally only implemented after the onset of wound complications in spinal surgery patients (14), further adding to the costs associated with treating this complication. NPWT has previously been recommended for use only in cases without malignant disease with the exception of its use in palliative care (15), where it has successfully been used following spinal surgery (16). Whilst antibiotic treatment accounts for only a small proportion of the direct costs associated with SSI, increased antibiotic usage may contribute to the development of more resistant microbial species, costing money and lives in the longer term. As the World Health Organization highlights, the development of antibiotic resistance is likely to make surgical procedures more dangerous than they have traditionally been perceived to be, given that antibacterial drugs used to prevent SSI are becoming less effective (17).

Based on an estimated 4,000 metastatic spinal cord compression cases being treated within England and Wales annually (18), with approximately 20% of these being treated surgically (Richards, personal communication) and an infection rate of 11% (6), it is projected that approximately 90 patients per year would experience SSI. Assuming a typical cost for the treatment of SSI similar to that determined in this study, an estimated *minimum* of £1.1 million is incurred annually for this patient group alone. This does not include the costs incurred through primary care services (e.g. community nurse visits and GP appointments) and therefore should be viewed as an underestimate of the real resources needed to treat this complication. Furthermore, while SSIs were identified in both in- and out-patients, readmission rate *per se* was not included as an outcome of this study.

Readmission also has significant financial implications, with an estimated £1.6 billion being spent annually on those readmitted to hospital within one month of discharge (19). SSI is one of the main causes of readmission in surgical patients (20), yet the UK 'payment by result's guidance states that healthcare providers should not be reimbursed for readmissions which are judged to have been avoidable, and this includes SSIs (1). Therefore, those hospitals which conduct high-quality, rigorous surveillance of SSIs (and which therefore are more likely to identify more cases of infection) are likely to be penalized within the current surveillance service (21). This further exacerbates the cost to the service which provides the initial surgical treatment.

The human and societal costs associated with SSI should also not be overlooked. While the informed consenting process for surgery should involve a discussion around the risk of SSI, very few patients appear to be concerned about this complication prior to their operation (21). However, the impact on the quality of life of patients, families and carers who do experience SSI is likely to be substantial. This is perhaps magnified in spinal tumour patients given the clinical implications of SSI after this type of surgery (i.e. the potential of surgical failure leading to spinal instability, significant pain, loss of sensory and motor function and disability). Previously it has been estimated that healthcare costs only account for 10% of the overall costs of SSI to the wider economy (22), which would include loss of earnings of patients and carers, and reductions in productivity through absence from work (21). Ways of reducing the number of SSIs occurring in the first instance are therefore highly desirable. Preventative measures such as the use of evidence-based care bundles have shown some promise (23, 24). However, while this approach aims to drive up efficiency in the peri-operative phase, the Institute for Healthcare Improvement (IHI) suggests that any potential benefit in terms of clinical outcome **may** only be demonstrated if all of the bundle components are strictly adhered to (25). It could also be suggested that the principles of basic care should be applied first before any extra (and potentially costly) interventions are introduced. That being said, given the urgent nature of some types of surgical cases and the potential for catastrophic outcomes were SSI to occur, it could be argued that interventions which may have the potential to reduce the infection rate by any substantial degree – despite them being more costly from the outset – may be warranted. A full economic analysis in future studies of such interventions would help to determine whether the initial outlay on systems such as NPWT – which have shown promise in stimulating wound healing and preventing SSI in some scenarios (14, 26, 27) – is cost-effective in the longer term, if used in patients at high risk of wound complications. **Indeed, any prospective full economic study should assess costs relating to all aspects of care including out-patient and community services (something which was beyond the scope of the current investigation) in order to count the full financial cost of SSI.**

Hypothetically, if an intervention costing on average £200 per week (such as incisional NPWT) were used for up to one week immediately post-operatively in *all* 152 patients who underwent surgery for spinal metastasis during the current study, a total of £30,400 would be spent on all patients. Evidence suggests that the SSI rate after spine surgery could be reduced by around 30% if this technique were implemented routinely (26), meaning that five fewer patients may have suffered SSI over the four year study period presented in our current study. This would translate into a saving of approximately £38,000 in costs associated with in-patient stay alone. While this net saving may be low (just £7,600), this calculation does not include the costs associated with additional treatments (including costly returns to theatre), primary care, and the immeasurable benefits to quality of life for the patient, family and carer. Scaling this up further across England and Wales over a one year period, treating all 800 patients with the more expensive intervention for one week would cost £160,000. A reduction of 30% in patients suffering SSI would mean the figure of 90 would drop to 63, reducing the in-patient hospitalisation bill by £205,038, resulting in a net saving of £45,038. Again, this differential does not include costs other than those associated with length of in-patient stay.

While this study is limited to the investigation of a relatively small group of patients, one of its strengths lies in its inclusion of all SSIs in those undergoing surgery for metastatic spinal tumours which occurred over a four year period at a major UK spinal centre. Though representing relatively few patients in terms of absolute numbers, this itself has enabled an accurate, bottom-up estimation of costs associated with each individual patient to be made, giving a realistic representation of the bigger picture, albeit an underestimate.

CONCLUSIONS

SSI significantly increases healthcare costs for patients undergoing surgery for spinal metastasis, with prolonged in-patient hospitalisation being a major contributor. Return to theatre for wound management is a costly intervention required in approximately a quarter of these patients. The actual total cost to society derived from SSI in this patient group is likely to be far beyond just the direct costs to healthcare providers. Because of this, the introduction of interventions which demonstrate efficacy in preventing SSI and can be shown to be cost effective are certainly warranted.

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