Surgery and radiotherapy for symptomatic spinal metastases is more cost effective than radiotherapy alone: a cost utility analysis in a UK spinal center.

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Keywords

Cost, ICER, metastasis, QALY, spine, surgery

Abbreviations

EQ-5D-3L,	EuroQol 5 Dimension 3L measure of health-related quality of life
FCE,	Finished consultant episode

MSCC,	Metastatic spinal cord compression
NHS,	National Health Service
NICE,	National Institute for Health and Care Excellence
PSSRU,	Personal social services research unit
QALY,	Quality adjusted life year

Abstract

Background

Surgery for symptomatic spinal metastases is effective at prolonging ambulation and life, but may appear costly at first glance. We have studied the difference between the cost of surgery and reimbursement received, as well as the cost-effectiveness of surgery in a UK tertiary referral spinal center.

Methods

A cost versus reimbursement and cost-utility analysis was performed in a prospective cohort of patients admitted for surgical treatment of spinal metastases. Outcome measures were health-related quality of life using the EuroQol EQ-5D-3L, Frankel score, quality-adjusted life years (QALYs), treatment and reimbursement costs.

Results

130 consecutive patients were prospectively recruited, of whom 92 had information available for cost and reimbursement comparison, and 100 had information to complete cost utility analysis. Median cost of hospital treatment per patient was £20,752; median reimbursement received was £18,291, with a median shortfall of £1,967. Surgery in addition to radiotherapy over a lifetime horizon was both more effective and less costly than radiotherapy alone, and therefore was found to be cost-effective.

Conclusion

Our results demonstrate that reimbursement to hospitals for surgical management of symptomatic spinal metastases in the UK is broadly in line with costs, and that there was an

overall saving as a result of community care costs being mitigated by patients walking for longer, which is within the expected National Health Service (NHS) threshold. Surgery for metastatic spinal tumors is effective and good value for money.

Funding source

Funding: This work was performed at UCLH, which receives funding from the National Institute for Health Research Biomedical Research Centre. David Choi receives research funding from DePuy Synthes and for other projects from DePuy Synthes, Icotec, and the Wellcome Trust. The researchers work in an independent capacity to the funders.

INTRODUCTION

Spinal metastases occur in up to 75% of the most common cancers, including breast, prostate and lung cancer,[1,2] of which 26% may develop into skeletal related events including pathological fracture and metastatic spinal cord compression (MSCC).[3] In the UK, the National Institute for Health and Care Excellence (NICE) have produced guidelines that promote surgical management in around 70% of patients presenting with symptoms of MSCC.[4,5] These guidelines are supported by Patchell et al (2005), who demonstrated a higher percentage of people able to mobilize, greater longevity of ambulation and better survival following surgical management in conjunction with radiotherapy compared to radiotherapy alone as primary treatment.[6] Despite surgery, MSCC has a significant impact on quality of life and survival,[7] and in tandem there are significant hospital costs associated with the surgical management of symptomatic spinal metastases, which we have previously reported as averaging £16,885 per patient,[8] and when combined with out of hospital costs may be as high as €87,814.[9] Providing good value

healthcare, which is both high quality and affordable is vital to the sustainability of the NHS and other publically funded health care systems.[10] In today's tough economic climate there is an emerging body of literature analyzing the cost-effectiveness of medical interventions to inform process changes that promote efficiency.[11] Clinicians are in the optimal position to develop and deliver changes to practice, maintaining the focus on high quality patient care.

Different financial metrics are available to assist with analysis. We have previously reported the average in-hospital cost of surgically treating symptomatic spinal metastases in one UK center.[8] The difference between this and the reimbursement rate that the hospital receives from the NHS centrally is important at local and national levels; this has not yet been determined in patients with symptomatic spinal metastases. In other conditions, including hip and knee revision surgery, there is a possible shortfall in reimbursement of between £861 and £4566 per patient,[12,13] which was suggested to be largely associated with a more complex patient case-mix than the NHS average in the hospitals studied, with patients requiring more expensive or longer treatment despite receiving the same, nationally-averaged, reimbursement tariff for that patient group. This shortfall requires the departments in question to implement more efficient pathways, or negotiate local variations to the tariff. As an additional incentive for some departments, several tariffs are now reimbursed based on the cost of evidence-based, efficient, patient pathways, rather than national average cost, and future tariffs may be split between health and social care systems.[14]

At a national level, recommendations for healthcare service provision are based on cost utility analysis, balancing cost of treatment with quality and length of life gained following treatment, measured in quality adjusted life years (QALYs).[15] Recommendations by the National Institute for Health and Care Excellence (NICE) have implied an upper limit of £30,000/QALY

for NHS funded treatments,[15,16] although there is considerable debate about the appropriateness of this threshold,[16,17] and a suggestion that populations may be willing to pay more for end of life management than short term health problems.[18] In patients with symptomatic spinal metastases, cost of surgical management over a lifetime horizon has been found to be both more expensive, and more effective than non-surgical management[19,20]; the incremental cost per QALY gained for surgery compared to radiotherapy alone has been estimated at $250,307 by Furlan et al (2012),[19] which is significantly higher than the $50,000 commonly used threshold in the US,[21] whilst Miyazaki et al (2017) estimated it at $42,003.[22] There is a paucity of data in this area,[23] and methodologies differ significantly, giving rise to significant variations in cost effectiveness. The former study looked at medical costs combined with estimated community palliative care costs; these high input homecare costs may be reduced by successful surgical intervention, improving cost effectiveness.

We have studied the cost effectiveness of the surgical treatment of MSCC at one London center and aimed to determine if reimbursement was broadly in line with cost, and the cost effectiveness of surgical treatment of metastatic spine disease.

MATERIALS AND METHODS

Subjects

Consecutive patients were prospectively recruited at a single NHS spinal tertiary referral center in London if they required surgery for symptomatic spinal metastases from any known or unknown primary cancer, verified by intra-operative histology. Patients were recruited between 2009 and 2015. Patients were included in the analysis if they were confirmed as having died, or if they had at least 12 months of follow-up data and were confirmed alive in July 2015 following

a search of records of death, held centrally by Public Health England; those that were alive at time of analysis were allocated a date of death of July 2015 in order to complete the analysis. Exclusion criteria were inability to give written informed consent to participate, and age less than 18 years. Informed consent was obtained from all subjects and ethical approval was granted by the UK National Research Ethics Service.

Outcome measures

Patient demographics, clinical and surgical details were collected during the index admission. Frankel grade and EQ-5D-3L scores were collected pre-operatively, post-operatively, at three, six, twelve months and every 12 months thereafter until death. A utility index suitable to calculating QALYs was calculated from the EQ-5D-3L scores using the UK value set.[24]

Financial analysis

All costs to the hospital, as described previously,[8] as well as tariff reimbursed to the hospital, including the Market Forces Factor, were extracted from the hospital's financial databases for each subject from index admission until death; if still alive, data was collected up to July 2015. Fifty percent of the cost data was used in our previous report[8]; the remainder of the cost data and all the reimbursement data is newly reported here. For each subject, admissions were retained that included a neurosurgical episode, and a manual search reduced admissions to those including neurosurgical treatment of symptomatic spinal metastases using electronic admission details and letters.

Each admission might include more than one finished consultant episode (FCE), for example, medical oncology and neurosurgery. Although costs can be separated into each FCE, reimbursement is usually allocated to the FCE carrying the heavier tariff only, for this reason,

both costs and reimbursements were summed across FCEs for each admission, including critical care costs, to give a fully absorbed admission cost and admission tariff (reimbursement).

Comparison of cost and reimbursement

All costs and reimbursements were adjusted to 2015/16 financial year using the Personal Social Services Research Unit (PSSRU) inflation figures.[25] Data were analyzed at patient level by summing admissions, as spinal centers are likely to treat patients for symptomatic spinal metastases throughout their disease course.

Cost-utility analysis

It is perhaps unethical to repeat a randomized controlled trial (RCT) of surgical treatment vs. non-surgical management of symptomatic spinal metastases due to the superiority of surgical management demonstrated in the RCT by Patchell et al (2005)[6]; as such, it was necessary to model anticipated reimbursements of a matched, non-surgical, radiotherapy-only cohort, as well as expected QALYs. This represents the alternative management strategy to surgery. All data from our subject cohort was initially replicated, to create an identical, model, non-surgical group to be as close as possible to an RCT-style control arm, with the same baseline as the surgical group; survival was reduced to 79%, and ambulation to 11% based on the study by Patchell et al (2005).[6] This was considered to be more robust than comparison with a real world subject group with symptomatic spinal metastases who didn't undergo surgery, as their baseline characteristics are unlikely to match those of the surgery group.[9,22]

It is expected that although the immediate hospital cost of surgically managing symptomatic spinal metastases is high, surgical intervention may mitigate community costs in the future by maintaining ambulation for a longer period, and as a result the community costs

were modeled for both surgical and non-surgical groups using the methods outlined in the MSCC NICE economic analysis.[26] As both hospital reimbursement costs and community care costs were analyzed, this study had an NHS and social care perspective over a lifetime horizon.

Inpatient reimbursement tariff

Reimbursements, rather than costs, were used for the cost utility analysis, as this analysis is more pertinent to commissioning at the national level. All tariffs reimbursed were adjusted to 2015/2016 financial year,[25] and discounting at 3.5% was applied cumulatively to successive years in line with current recommendations by NICE.[15] Reimbursements for inpatient stays, including critical care admissions, were then summed to generate total reimbursement per patient.

Non-surgical management of symptomatic spinal metastases is likely to incorporate radiotherapy treatment.[4] The NICE guidance suggests that this is unlikely to be significantly different to that received by surgical patients.[26] Based on this, radiotherapy costs for the surgical cohort were analyzed, and the average allocated as an 'inpatient reimbursement' to the non-surgical group. This is expected to be an underestimation of costs as initial diagnostic costs in a medical oncology episode were not included.

Community care tariff

The NICE MSCC economic analysis sets out a methodology for calculating community care costs including home care support, community nursing and GP input; these costs are currently not available for direct analysis at the subject level in the same way as hospital reimbursements are. Expected costs are based on the PSSRU's database of community care

183 costs,[25] inflated to the 2015/2016 financial year, and then discounted following the index year as
184 with the hospital costs.[15]

185 For our surgical group, discharge destinations were known (Table 1). Subjects who did
186 not go straight home, or to a nursing home were allocated their eventual destination based on
187 their ability to mobilize at discharge, those that were able to walk (Frankel D or E) were
188 expected to go home, and those that were unable to walk were expected to be cared for at a
189 nursing home. In line with NICE guidance, subjects were expected to continue to be cared for at
190 their discharge location until death.[26]

191 Those who went home were allocated a low cost community tariff for the duration of
192 their ability to walk (£177/week), and a medium cost tariff for the duration that they were unable
193 to walk (£989/ week). Regardless of which tariff they were on at the end of their lives, a high
194 cost tariff was allocated for the final two weeks for palliative care (£1481/week). Packages
195 included increasing levels of social services home care support, as well as increasing levels of
196 community nursing and GP visits. Those that were cared for at a nursing home were allocated a
197 single tier tariff for the period of their survival including nursing care costs, accommodation,
198 ancillary costs and operator profit, regardless of ambulation status (£729/week), (Figure 1).[26]

199 For the model non-surgical group, community care costs were initially calculated for both
200 discharge destination alternatives, as above. For each non-surgical subject, community care cost
201 was calculated as a percentage of home cost, plus a percentage of a nursing home cost, totaling
202 100%. This was dependent on their matched subject's ambulation status at admission (Figure 2).

203 For both groups, we conducted an additional analysis of community costs using the 2008
204 NICE figures for home and nursing home healthcare costs, inflated to 2015/2016, as an

alternative modeling method. This analysis was carried out as a sensitivity analysis to give a range of possible costs, to make the analysis more robust.

QALYs

In the surgical cohort, QALYs from index admission until death, i.e. the lifetime horizon, were calculated using the EQ-5D index gathered during follow-up. On death, patients were allocated an EQ-5D index of zero. QALYs were calculated as the area under the line connecting EQ-5D index points (Figure 3). Subjects who were still alive in July 2015 were pragmatically allocated an EQ-5D index of 0 from that point.

In the non-surgical cohort, QALYs were predicted to remain static initially, as any improvement seen in the surgical group is thought to be related to the surgical intervention. Given the non-surgical group's expected shorter ambulation and lifespan, health utility was modeled as declining from the same time point as the surgical group, with survival being shortened to 79% as discussed previously (Figure 3).[6]

Sensitivity analyses were performed to identify if there would have been a significant change in the results if this method resulted in an under or overestimation of non-surgical QALYs (Figure 3). Sensitivity analysis one represented that the initial analysis underestimated QALYs. QALYs were calculated in this scenario as being maintained at pre-operative levels until the known QALYs from the matched surgical subject became lower than pre-operative levels, and the non-surgical QALY curve was expected to follow that deterioration, with survival being reduced to 79% of the surgical subject. Sensitivity analysis two represented that the initial analysis overestimated QALYs. QALYs were calculated as deteriorating linearly from pre-

operative levels until death at 79% of the surgical patients' survival. For all QALY calculations, discounting was applied to all years after the index year at 3.5% as recommended by NICE.[15]

Statistical analysis

All statistical analysis was carried out in Stata v.12 (Statacorp LP, College Station, TX, USA). Descriptive details were generated for demographics; financial and QALY data included medians and IQR because of skewness of the data; means were generated as recommended by Thompson and Barber (2000)[27] and to enable comparison with other studies. The Wilcoxen signed rank test was used to assess for significant differences in cost and reimbursement, the spearman correlation coefficient was used to analyze relationships between cost per QALY (the Incremental Cost Effectiveness Ratio, ICER) and survival time. Significance level was set at P=.05.

Only subjects with both cost and reimbursement data were used in that comparison analysis and only those with reimbursement and QALY data were used in the cost-utility analysis. Where subjects were unavailable for follow-up of EQ-5D-3L scores, the EQ-5D index was assumed to have improved or deteriorated linearly to the next known point.

RESULTS

During the period of the study, 130 consecutive patients were recruited, of whom 92 had information available to complete cost and reimbursement comparison, and 100 had information available to complete the cost utility analysis.

Inpatient cost and reimbursement analysis

In this group, 47 were male (51.1%) and mean age was 60.6 years (SD 14.0). The majority of patients were not paralyzed at admission (n=64, 69.6%). Median survival was 5.6

months (IQR 2.5-15.9), mean was 9.8 months (SD 9.6). Of the 22 subjects that were still alive at analysis (24%), median length of follow-up was 25.0 months (IQR 23.8-36.1), mean was 27.3 months (SD 9.6).

Median cost per surgical patient was £20,752 (IQR £11,550-£30,825; mean £24,445; SD £17,526), and median reimbursement income received was £18,291 (IQR £17,002-22,089; mean £21,213; SD £13,163), a median shortfall of £1,967 (IQR shortfall £7,387-saving £5,339) (Figure 4). Statistical analysis revealed that the difference between cost and reimbursement was statistically significant (p=.05).

Cost utility analysis

In the surgery group, 49% of subjects were male (n=49), and average age was 59.8 years (SD 14.2). 69 subjects (69%) were able to walk at admission, and 74 subjects (77%) at discharge for a median of 13 months (IQR 4.0, 34.0); of those unable to walk at admission, 13 (44.8%) regained the ability to walk (Table 1 and Figure 5). Median survival was 6.1 months (IQR 2.5, 17.9), mean 10.9 months (SD 11.1); ability to mobilize on discharge had a significant survival advantage, increasing survival to median 7.7 months (IQR 3.9, 19.0), mean 13.0 (SD 11.8). For those still alive, median follow-up was 24.9 months (IQR 12.6, 36.1) mean 24.8 (SD 11.8).

After discounting was applied, median reimbursement tariff for hospital admission was £18,291 (IQR £17,002; 21,768), the mean was £20,950 (SD £12,693), as expected this was higher than the median due to skewness. For patients undergoing post-operative radiotherapy to the same spinal level, the mean reimbursement was £6,338, which was applied to the non-surgical group.

Median community cost was £15,512 for the surgical cohort (IQR £6,440, 29,299), the mean was £21,955 (SD £21,600). All ambulant patients were cared for at home whilst only 23.8% of non-ambulant patients were cared for at home (Table 1). The median total tariff for this group was £35,431 (IQR 25,055, 49,701), mean £42,904 (SD £24,768).

Community care tariffs were modeled for the non-surgical group. 69 patients (69%) were able to walk at admission, and were allocated the home care costs appropriate to their ambulation length and survival. The remaining patients' tariff was comprised 23.8% home care tariff, and 76.2% nursing home tariff (Figure 2). The median community tariff was £38,802 (IQR £13,085-83,893; mean £49,404; SD £43,646), and the median total tariff was £45,141 (IQR £19,423, 90,231; mean £55,743; SD £43,646). The median incremental cost difference was £1,107 more expensive for the surgical group (IQR £38,391 cheaper, £11,702 more expensive), mean £12,839 cheaper for the surgical group (SD £37,896) (Table 2).

The NICE 2008 economic guidance reports that weekly community care tariffs were £91 for an ambulant patient, £1,351 for non-ambulant, £1,918 for a palliative patient and £567 for patients cared for in nursing homes. When inflated to 2015/2016, this resulted in higher community care costs, particularly for non-ambulant patients. The total median tariffs using this approach were £32,002 (IQR £24,357, 42,612; mean £42,819; SD £32,002) for the surgical group, and £62,854 (IQR £22,846, 112,276; mean £76,958; SD £64,220) for the non-surgical group. The median incremental cost difference was £7,069 cheaper for the surgical group (IQR £69,396 cheaper, £10,531 more expensive), mean £34,139 cheaper (SD £63,506) (Table 2).

QALYs were calculated for the surgical group. Health utility scores were available for 99 of 100 subjects at baseline (99%), 60 of 82 subjects alive at three months (73%), 44 of 65

survivors at six months (68%), 38 of 51 survivors at 12 months (75%), 23 of 28 survivors at 24 months (82%), 8 of 14 survivors at 36 months (57%) and 1 of 3 survivors at 48 months (33%). Data was missing where patients were unavailable for follow-up, frequently due to deteriorating health, or where patients were uncontactable. Initial health utility was median 0.33 (0.18, 0.69), mean 0.41 (SD 0.30). The discounted median QALYs were 0.28 (IQR 0.04-0.99) the mean was 0.64 (SD 0.76). For the non-surgical group they were calculated as median 0.13 (IQR 0.02-0.50), mean 0.32 (SD 0.41), with a median incremental QALY difference of 0.09 (IQR 0.01, 0.54; mean 0.32; SD 0.45). The two sensitivity analyses returned QALYs of median 0.17 (IQR 0.02-0.53) and 0.12 (0.02-0.36) respectively with median incremental differences of 0.06 and 0.13, and mean differences of 0.27 and 0.38 (Figure 3).

Surgery is less costly than no surgery based on the mean, and only marginally more costly based on the median, it is also the more effective strategy based on the QALY mean and median, and therefore it must be cost effective as it dominates over no surgery.

The correlations between ambulation time, r=-0.87, or survival time, r=-0.73, and cost per QALY were significant (P<.01 for both), indicating that it is the mitigation of community costs which increases the cost effectiveness of surgery in this patient group (Figure 6).

DISCUSSION

Principle findings

Symptomatic spinal metastases represent a significant clinical and economic burden. Our study is the first in the world to investigate the cost utility of surgical management of symptomatic spinal metastases using prospectively collected health utility data, and the first health utility study for MSCC in the UK. There is a perception amongst surgeons that hospitals

in the UK are under-reimbursed for the work they carry out under the current system; we found a significant median shortfall of £1,967 between the cost of surgery and the reimbursement to the hospital. Our results show that over a lifetime horizon, from the NHS and social care perspective, surgery is less costly and more effective than non-surgical management. This saving is within the expected threshold set by NICE,[15] suggesting surgical management is good value for money, as well as being clinically effective.[6]

Strengths and weaknesses of the study

This study has overcome several hurdles of other health economic studies by completing a prospective study and collecting both cost and health utility data without recourse to searches by HRG coding. However, inputational models were still required to estimate community care costs, as this is not currently collected at the patient level, and to estimate QALY and cost data for a comparative non-surgical cohort. We also recognize that choice of discharge destination is multi-factorial, but chose this method to replicate the NICE economic analysis.[26] A limitation is that the effect of recent advances in radiotherapy techniques that may prolong ambulation or survival may be under-represented, one recent study showed 25% of subjects improved with non-surgical treatment, although there was a mean drop in health utility.[22] These limitations were mitigated where possible by using a conservative estimate of surgical QALYs and non-surgical costs, and performing sensitivity analyses; censoring data from patients who were alive in July 2015 will have resulted in a conservative estimate of cost per QALY, as cost efficiency is strongly correlated with survival time (Figure 6). As this was a single center study, it is possible that some in-hospital costs may have been missed if subjects had further intervention in other hospital Trusts.

335 **Comparison to existing literature**

336 The hospital costs of surgical and radiotherapy management are slightly higher than
337 previously reported by our group (£20,752 vs. £16,885), which is likely to be due the inclusion
338 of oncology admissions attached to neurosurgical episodes.[8] The reimbursement, £18,291, is also
339 higher than other published material: Body et al (2013)[28] reported reimbursement tariffs of
340 €15.048, and a NICE analysis reported likely costs of £13,094 in 2008,[26] these differences are
341 perhaps due to the different methodologies, and changing time periods of the studies.[8,29]

342 A shortfall between cost and reimbursement has been noted in other surgical areas,
343 including hip and knee revision surgery, which have a shortfall of up to £4,566.[12] This was
344 suggested to be a result of a more complex case mix. However, shortfalls may also be due partly
345 to variations in hospital efficiency. The reimbursement tariff is created from an average of costs
346 of admissions for patients undergoing similar procedures across the country, adjusted for market
347 forces, as costs vary throughout the country. Trusts may also negotiate local changes to the tariff
348 in some instances. Other specialist centers suggest that they are able to generate lower costs, and
349 therefore a more beneficial cost: reimbursement ratio, as a result of their frequent management of
350 a specialist patient group, which is possible in this cohort as it is based at a regional center for
351 spinal surgery. It is notable that reimbursement is not expected to directly repay each department
352 pro rata; instead variations are expected across departments, which should balance across a
353 hospital trust.[14]

354 Our calculation showing an overall lifetime saving following surgery in addition to
355 radiotherapy, from the NHS and social care perspective (i.e. the tariff), is significantly lower than
356 the only previous estimate using data with a comparable non-surgical group, by Furlan et al

(2012) of US$250,307 per QALY,[19] as well as an estimate using groups with different baseline characteristics ($42,003 per QALY).[22] Whilst in this study the baseline demographic and clinical measures were similar to those used in Furlan et al.'s study, based on data from Patchell (2005),[6] ambulation and survival length, as well as estimated cost methodology are likely to have contributed to the difference. Median duration of ambulation (152 vs. 122 days) and survival (185 vs. 126 days) were greater in this report; survival time in more recent studies confirms a trend to improving survival time following surgical intervention in this patient group.[22] The discrepancy in cost is also likely to be related to the methodology used; this has previously been reported to be a significant barrier to the comparison of health utility studies.[29] The study by Furlan et al. estimated community care costs based on the cost of palliative care, either at home or at a nursing home; combined hospital and community costs were estimated as mean $583,809 for a surgical patient and $554,323 for a non-surgical patient.[19] The economic guidance by the National Institute for Health and Clinical Excellence2008) used in this study, suggested that it is more likely that some patients will require a lower level of support for the majority of their survival (depending on ambulation status), and only need palliative care in the final weeks of life; this results in a significant difference in the estimation of community care costs and therefore cost per QALY[26]. Our costs of £42,904 for the surgical cohort and £55,743 for the non-surgical cohort are significantly lower, and more closely relate to those of other recent studies; Tipsmark et al (2015) estimated costs of up to €87,814 and €36,616 for surgical and non-surgical groups over a lifetime horizon,[9] whilst Miyazaki et al (2017) estimated costs of $25,770 and $8,615 over one year.[22] Both studies calculated costs using different methodologies, the first was based on an insurance register, the second from medical remuneration points. The mitigation of community care costs as a result of longer survival post-surgery is clearly seen in Figure 6.

The methodology for generating QALYs was also different in our and Furlan et al.'s study.[19] We collected prospective EQ-5D data throughout the subjects' life, whereas Furlan et al. created an estimated health utility generated from interviewing the general population using the time trade-off technique. Furlan et al. used health utilities from the Harvard University Catalogue from the US and the Health Outcomes Data- health utility list from the UK and multiplied by the period of time the patient was affected, which would not take into account deterioration during the lifetime horizon that was demonstrated in our study. Based on a health utility value of 0.388, Furlan et al. described mean QALYs for radiotherapy only as 0.46 (95% 0.06-3.41), mean QALYS for surgery and radiotherapy 0.57 (95% 0.13-2.24). The mean initial health utility in our study pre-operatively was 0.41, whilst mean lifetime QALYS were 0.64 for patients undergoing surgery and 0.32 for patients undergoing radiotherapy only. Miyazaki et al (2017) describe QALYS at one year as 0.433 for their surgical group; that cohort had a lower health status (0.036) and lower level of ambulation (54.8%) at baseline than in our study (0.41 and 69% respectively), furthermore, their patients had tumors with a higher grade of malignancy than in this study, the first two factors are known predictors of quality of life, and the latter is a prediction of survival after surgery,[7,30] and may account for the lower QALYS gained compared to our study.

Implications for clinicians

Our study has demonstrated a small discrepancy between the cost to the hospital and the reimbursement from the government for treating this patient group; we have previously reported that ward cost is the greatest factor in total hospital costs, promoting the implementation of methods to reduce hospital length of stay. Our result shows that surgery in addition to radiotherapy is more effective and less expensive than radiotherapy alone over a lifetime horizon, and despite longer survival, the gain in QALYS following surgery outweighs any costs

from the longer follow-up, particularly as ambulation is prolonged. The cost per QALY is within the implied UK threshold for NHS funding,[15] supporting managers in commissioning surgical services for patients with symptomatic spinal metastases.

Future research

Given the significant initial cost outlay in surgical management compared to non-surgical management, it is vital for cost utility studies in the future to calculate community health care costs as well as hospital costs, as the mitigation of the community costs at the wider health and social care level will have a significant impact on the cost per QALY. Ability to directly extract both health and social care economic data at the patient level will increase the robustness of future studies.[10]

CONCLUSION

Our results demonstrate that reimbursement to a tertiary referral hospital for surgical management of symptomatic spinal metastases in the UK is broadly in line with costs, and that as a result of community care costs being mitigated by a greater percentage of ambulant patients with better quality of life, surgery for MSCC is both effective and good value for money.

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Figure Captions:

Figure 1. Calculation strategy for community care costs for surgical group.

Figure 2. Calculation of community care costs for non-surgical group.

Figure 3. QALY calculations. QALYs were calculated as the area under the curve. Solid line represents patients treated with surgery, and dashed line is non-surgical series with sensitivity analyses (dotted lines).

Figure 4. Admission cost and admission income in GBP. The box shows the 25^{th}, 50^{th} and 75^{th} percentiles, the whiskers encompass values within 1.5 IQR of the closest quartile, outliers are represented as markers.

Figure 5. Ambulation status of patients over time based on Frankel Score: A-C, not walking; D-E, walking.

Figure 6. Cost per QALY correlation with A: survival, r=-0.73, P<.01 and B: ambulation, r=-0.87, P<.01.