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The financial burden of reverse shoulder arthroplasty for proximal humerus fractures

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Aims

The purpose of this study was to evaluate the cost of reverse shoulder arthroplasty (RSA) for patients with a proximal humerus fracture, using time-driven activity based costing (TDABC), and to compare treatment costs with reimbursement under the Healthcare Resource Groups (HRGs).

Methods

TDABC analysis based on the principles outlined by Kaplan and a clinical pathway that has previously been validated for this institution was used. Staffing cost, consumables, implants, and overheads were updated to reflect 2019/2020 costs. This was compared with the HRG reimbursements.

Results

The mean cost of a RSA is £7,007.46 (£6,130.67 to £8,824.67). Implants and staffing costs were the primary cost drivers, with implants (£2,824.80) making up 40% of the costs. Staffing costs made up £1,367.78 (19%) of overall costs. The total tariff, accounting for market force factors and high comorbidities, reimburses £4,629. If maximum cost and minimum reimbursement is applied the losses to the trust are £4,828.67.

Conclusion

RSA may be an effective and appropriate surgical option in the treatment of proximal humerus fractures; however, a cost analysis at our centre has demonstrated the financial burden of this surgery. Given its increasing use in trauma, there is a need to work towards generating an HRG that adequately reimburses providers.

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Introduction

Evaluating value in health economics is defined as achieving a health-related outcome relative to the cost of achieving that outcome. In the last ten years value has become a key driver in NHS treatments, both for NHS England and for treatment providers. This has been fueled by the pressures of austerity, an ever ageing population, and increasingly expensive medical drugs and technologies.[1]

In the UK, service providers are reimbursed for specific treatments based on tariffs that are calculated from national cost estimates, generally determined by a costing tool. In the NHS the costing tool is the Patient Level Information Costing System (PLICS).[2] Information is submitted annually from trusts to the Department of Health, which then sets the tariff for all hospitals in England. Tariffs are attributed to Healthcare Resource Groups (HRGs) and are commonly a number of similar treatments that are grouped together.[3] For patients with a proximal humerus fracture who have an inpatient episode and undergo surgical management, the HRG would encompass all surgical treatment methods.

In recent years the use of the reverse shoulder arthroplasty (RSA) for proximal humerus fractures has become an increasingly popular method of treatment.[4] In trauma, it is commonly used in fractures with severe comminution, those that are

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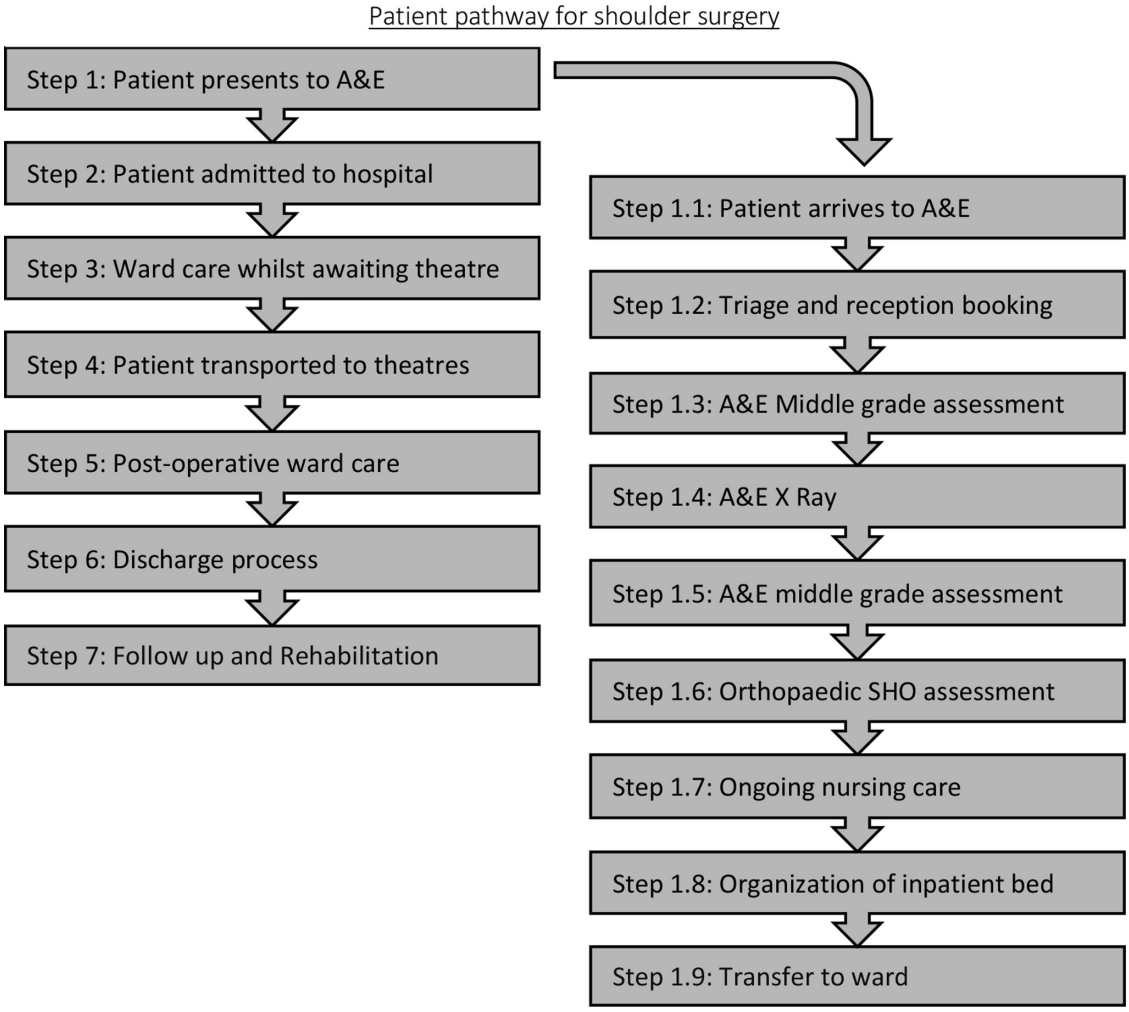

Fig. 1

Pathway showing breakdown of one stage of the patient pathway. This was used to calculate staffing costs within the pathway and identify materials used. A&E, accident and emergency; SHO, senior house officer.

indicative of humeral head ischemia, and in the elderly osteoporotic population.[5] Within our institution practice has changed to see the use of RSA instead of hemiarthroplasty for part fractures. While there is some evidence to support its use, most shoulder surgeons are looking to results from the Proximal fracture of the humerus: Evaluation by randomization 2 (PROFHER 2) trial to help further guide practice.[6] Knowing the cost implications of specific implants will be useful when considering these results and may well influence clinicians' final decisions.

Cost analysis using time-driven activity based costing (TDABC) for shoulder fracture has previously shown that hemiarthroplasty on average runs at a loss against the tariff set as of 2014.[7] Implant costs are one of the highest cost drivers in this estimate; therefore, given the greater prosthesis cost, it was postulated that the reverse will show even greater losses when evaluating current national reimbursement against an updated 'bottom-up' costing analysis.

The primary objective of this study is to estimate the cost of reverse arthroplasty by using TDABC. The secondary objective is to establish what the institutional financial burden of treatment is likely to be when comparing treatment costs to reimbursement.

Methods

This analysis was based upon a TDABC methodology using the principles outlined by Kaplan,[7,8] by mapping a clinical pathway for the determined population. The pathway was then discussed with all stakeholders within the inpatient episode and validated using the Delphi technique.[7]

This study was performed from the perspective of an English NHS hospital. In the English NHS there is a purchaser-provider split, where health services are commissioned by organizations called Clinical Commissioning Groups (CCGs) distributed regionally across the country. These organizations buy services, including

Table I. Breakdown of costs of reverse shoulder arthroplasty with minimum, maximum, and mean values.

Costs (GBP £)	Minimum	Maximum	Mean
Staffing			
A&E	39.73	92.71	63.78
Ward	113.61	610.04	257.55
Theatre	603.86	1,916.73	1,046.45
Consumables			
Implant	2,824.80	2,824.80	2,824.80
Sterilization	132.02	132.02	132.02
Drugs	42.49	52.01	45.66
All consumables (including implant and sterilization)	3,491.78	3,505.78	3,491.78
Estates/overheads	1,839.20	2,647.40	2,102.46
Total cost of procedure*	6,130.67	8,824.67	7,007.46

*Total cost calculated by total of above costings plus adjustment for length of stay.

orthopaedic trauma care, from NHS hospitals, which operate with a financial and governance structure that is independent of the CCGs. Within hospitals, staff employment is based on a national payscale while consumables and medications are normally acquired through the NHS Supply Chain, an organization that purchases and delivers supplies to hospitals across the country. Procurement of implants is done by individual hospitals and there is a growing consensus that this should be done at a national level and with more transparency.[9]

Once the pathway was validated, individual costing for staffing, consumables, and estates costs were calculated to produce a total cost of treatment. Regarding reimbursement, the current single HRG includes treatment for the entirety of the inpatient journey, from time of emergency admission to operative treatment until discharge from ward. There is a separate HRG for the patient's Accident and Emergency (A&E) episode.

The patient pathway on which this costing model was based has been previously developed for surgical treatment of a proximal humerus fracture but did not include treatment with a RSA in its final analysis.[7] Figure 1 shows the seven major steps of the patient pathway, which have then been broken down into further detailed steps to determine staff time, consumables used, and drug costs. This model has been used with updated values to reflect 2019 financial data. Staffing costs have been based on 2019 NHS payscales, and consumable costs including laboratory tests and implant costs were updated to 2019 figures. HRGs and Market Force Factors (MFFs) were calculated from 2019 financial data.

Consumable costs were obtained from suppliers' prices as invoiced to the trust. The previous study looked at overhead costs from the estates and facilities departments for all non-clinical cost. This was rediscussed with our finance and estates team and their calculation was 30% overheads for treatment costs. All previous staff units of time were costed from 2019 NHS payscales.[10] Minimum, mean, and maximum cost were calculated taking into account banding, seniority, and clinical excellence points achieved.

The patient population included those with 3- or 4-part fractures,[11] American Society of Anesthesiologists (ASA) grade 3 or less,[12] and who were independently mobile. A sample of nine patients who met these criteria from an 18-month period, who had undergone a RSA for acute proximal humerus fractures, were used to update the model. This allowed mean send time, mean theatre time, and mean length of stay (LOS) to be determined and applied to our costing model. Overall maximum, minimum, and mean costs were calculated based on staffing costs, consumables, and adjusted for LOS and theatre times.

Ethical approval or informed consent was not required for this study. No statistical analysis or statistical software was used for this data.

Results

The previous methodology had eight major steps from A&E to outpatient rehabilitation (Figure 1). For the purpose of this study we excluded the outpatient follow-up and rehabilitation. This worked on the basis of a patient having a four-day admission (Day 1, admission; Day 2, theatres; Day 3, Post-op; Day 4, discharge). Of the nine patients we reviewed who had reverse arthroplasty for fracture at our centre, the mean LoS postoperative was three days (one to five). To calculated the maximum costing, we repeated step 5 to cost three days on the ward. To calculate the minimum costing, the ward day (step 5) was removed with the exception a postoperative radiograph and its review by a surgeon, and a consultant review was added to step 6.

The mean overall cost for a RSA was £7,007.46 (£6,130.67 to £8,824.67). Implant and theatre consumables comprised the greatest part of the overall costs at £3,278.14, making up 47% of the overall costs. Staffing costs made up £1,367.78 (19%) of overall costs. Drugs and estate/overhead costs made up the rest. "Estates" is an estimate of water, electricity, maintenance, and non-clinical ward costs provided by our finance team, calculated at 30%. Table I shows the breakdown of the various costs and the variation from maximum to minimum costings.

Using tariff codes VB08Z and HT53C the estimated reimbursement for this episode would have been £3,829 (Table II). The MMF for this trust is 1.2268, which means the tariff is raised to £3,996. A large proportion of those patients getting RSAs were noted to be ASA grade 3. These patients are therefore likely to have two to three comorbidities, thereby becoming HT53B and incurring an increase in tariff of £4,629.

Table II. Healthcare Resource Group codes for 2019/2020 with costs and adjustments for market force factors.

Reimbursement type	HRG name	HRG code	Price (GBP £)
A&E episode	Emergency Medicine, Category 2 Investigation with Category 1 Treatment	HB08Z	155
Orthopaedic admission and surgical treatment	Major Shoulder Procedures for Trauma, 19 years and over, with CC Score 2 to 3	HT53B	3,619
	Major Shoulder Procedures for Trauma, 19 years and over, with CC Score 1	HT53C	3,102
Overall reimbursement adjusted for MFF* (minimum; maximum)	N/A	N/A	3,996; 4,629

*Imperial NHS Trust market force factor = 1.2268.
A&E, accident and emergency; CC, complexity and comorbidity; HRG, Healthcare Resource Group; MFF, market force factor; N/A, not applicable

Even with the highest tariff reimbursement and the lowest cost estimate the trust would lose £1,501.67 per episode. If maximum cost and minimum reimbursement are applied this goes up to £4,828.67.

Discussion

The results of our study have shown the financial burden at an institutional level, where treatment costs far exceed national reimbursement. The implications of this for hospitals across the UK are important because RSA is becoming an increasingly popular choice of treatment for complex proximal humerus fracture in an older population.[4] Data from the National Joint Registry shows that there is an increased use of the reverse prosthesis year-on-year, and its application far exceeds the use of both total shoulder arthroplasty and hemiarthroplasty for shoulder fractures.[13] Clinicians, key opinion leaders in shoulder surgery, and policy makers need to reflect on both the clinical effectiveness and health economics of its use for proximal humerus fractures.

To date there is one published Level 1 study that compares reverse with nonoperative treatment for 3- and 4-part proximal humerus fractures.[14] There were only 59 patients included in this trial, and when comparing these to the 250 patients included in PROFHER, there is a clear risk of type 2 error; the failure of the authors to find a significant difference between the two treatment methods may reflect the small number of trial participants rather than true clinical equipoise. The authors of the PROFHER trial concluded that among patients with a displaced proximal humerus fracture involving the surgical neck, there was no difference between surgical and non-surgical treatment in patient-reported outcomes at two years.[15] None of the surgically treated patients in PROFHER received a RSA and only 4% of patients included had a 4-part fracture. These aspects of the trial have limited the applicability of its findings for decision-making in elderly patients with more complex fractures and fracture dislocations.

There are clinical scenarios, such as fracture dislocations and head split fractures, where there is less controversy over the benefits of operative treatment over nonoperative treatment, and selection of an appropriate surgical management has been the focus of clinical research. Over the last few years there has been a growing body of evidence that RSA is superior to plate fixation and hemiarthroplasty for proximal humerus fracture management among elderly patients.[16,17] Previously published research from our unit on cost analysis in this field examined the financial implications for hospitals of fixation and hemiarthroplasty within the English NHS. The policy implications of the findings of that 2016 publication are limited by the increasing uptake of reverse for the management of shoulder fractures.[13] The ongoing PROFHER 2 trial will look more specifically at 3- and 4-part fractures, and has three arms comparing nonoperative treatment, RSA, and hemiarthroplasty. The trial is aiming to recruit 380 patients. The results of PROFHER 2, which are expected in 2023, are likely to impact decision-making for surgeons.[6] We have defined the current financial burden of RSA in proximal humerus fracture management based on updated treatment costs and HRG reimbursement, and these findings are particularly relevant at a time when RSA forms part of a treatment arm to a multicentre randomized trial (PROFHER 2) that many hospitals across England are participating in. While reverse remains a recognized part of the surgical armamentarium for managing shoulder fractures, it is important that the current HRG appropriately reimburses hospitals.

Currently HRGs are determined by national data being fed back to NHS England through Patient Level Information and Costing System (PLICS).[18] This is a relatively new development, having been implemented over the past few years. Previously costing was determined via a 'top down' method. The descriptions for the HRGs, as shown in Table II, are very broad. A "major shoulder operation", as previously published research from our institution demonstrated, has the potential to include a number of different procedures with the range of treatment costs.[7] These surgical interventions will be applied to the same HRG. These results have shown the reverse is 54% more expensive than that of hemiarthroplasty and yet this is not accounted for within the HRGs. This disparity between treatment costs and reimbursement is not a new observation within orthopaedics or the UK health service. It has previously been reported that revision surgery in both

hips and knees places a substantial financial burden on hospitals due to reimbursement falling short of actual treatment costs.[19,20] The HRGs are subject to change, and a number of organizations and key opinion leaders feed into this decision-making along with patient costing data.[21]

The implant cost accounts for the largest single expenditure in the inpatient episode. The implant cost is likely to vary considerably between institutions. This study has not discussed which implant was used as our costs are negotiated confidentially with the manufacturer. A UK government report on hip prosthesis purchasing showed it was not possible to estimate the variation in cost, and a large number of trusts were unable to give an exact figure for procurement costs.[22] This observation applied to practices across the UK and is therefore very hard for the HRGs to take into account. One potential approach would be to have a national purchasing system with complete transparency. This would allow for further uplift on tariffs where there is variation in prosthesis type for cases of increasing surgical complexity. National purchasing would also potentially allow for volume-based discounting but may have an impact of surgeons' implant choice.

The second largest cost driver is estates. At our institution this was accounted for at 30%, but this will vary across institutions. Variation in overheads is determine by the MFFs, which is accounted for on a location basis. It incorporates staffing costs, infrastructure, land, business rates, and 'other factors'.[23] The variation between the lowest (Cornwall NHS Trust = 1) and the highest (University College London = 1.2976) is large, but questions remain about its accuracy predicting variation in cost drivers such as infrastructure cost and procurement practices. When the MMF is calculated, land and buildings account for 3.1% of costs. In an older institution such as ours, maintenance of buildings and cost of land must have a higher proportion than other trusts.

The third biggest factor is theatre time, which will vary depending on complexity of the case, theatre efficiency, and human factors. Within this cost, the largest proportion comes with staffing costs of the operating theatre. There is strong evidence that demonstrates a clear relationship between surgical volume and operating time.[24] It is feasible that as the volume of RSA increases, operating time and therefore treatment costs will also be reduced.

TDABC has three main limitations when costing a procedure. Firstly, it does not take into account any delays in treatment or theatre delays which may drive costs up. This would include if the patient was discharged between presentation and operation; although total time in hospital would be similar, outpatient costs would likely become an additional cost. To mitigate this, the current study used a representative cohort of patients for our institution to determine minimum or maximum surgical times and LoS that may be associated with these delays. Secondly, TDABC cannot look at any long-term rehabilitation and healthcare needs for these patients, however this is not accounted for in the HRGs. Thirdly, it does not provide a methodology for indirect costs. If these were excluded then the second largest cost driver in treatment would be excluded. Overheads will vary between trusts and this is reflected in the HRG in the fixed MFF for each trust. We acknowledge that defining the error of margin for overheads would be a useful way of understanding the accuracy of the analysis, however to date there is no published methodology that has defined an approach for this. What is clear is that among all the existing costing models in healthcare, TDABC is the most accurate approach to providing treatment estimates.[25]

In summary, RSA is a commonly used surgical treatment for select elderly patients with proximal humerus fractures, however a cost analysis at our centre has demonstrated the financial burden of providing this surgery. It is likely that in the UK, reimbursement from the national tariff is likely to fall short of actual treatment costs. Given its increasing use in trauma surgery, there is a need to work towards generating a HRG that adequately reimburses providers.

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- S. Sabharwal: Originated the study idea and methodology, Wrote the manuscript.
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- P. Reilly: Originated the study idea, Edited the manuscript.

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