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Predictors of Length of Stay Following Shoulder Arthroplasty in a High-Volume UK Centre

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Keywords: Arthroplasties, Shoulder Replacement; Treatment Outcome; Length of Stay

Abstract:

Introduction:

Shoulder arthroplasty rates are increasing in the UK. No data has been published from a UK centre on predictors of length of inpatient stay following shoulder arthroplasty. This study aims to analyse the length of inpatient stay following shoulder arthroplasty in a high volume UK centre and identify predictors of prolonged inpatient stay.

Materials and Methods:

All shoulder arthroplasty cases performed between 2012-2018 were identified. A review of case notes and electronic patient record was completed to identify demographic data, Charlson co-morbidity score, length of inpatient stay and factors associated with length of stay. Multiple linear regression analysis was conducted to determine which factors were independently associated with length of inpatient stay.

Results:

640 shoulder arthroplasty cases were performed in 566 patients. Median length of stay was 2 days. Length of stay was predicted by age, gender, chronic kidney disease, congestive cardiac failure, previous myocardial infarction, intraoperative complication and postoperative transfusion.

Discussion:

Increasing age, female sex, chronic kidney disease, congestive cardiac failure, previous myocardial infarction, intra-operative complication and transfusion were independent predictors of increased length of stay. Strategies to reduce perioperative complication and transfusion, and to optimise renal and cardiac comorbidities may reduce overall length of stay for shoulder arthroplasty patients.

Keywords: Shoulder, arthroplasty, outcome

Introduction:

Rates of primary shoulder arthroplasty have consistently risen year on year over the last decade. In the UK, the National Joint Registry for England, Wales, Northern Ireland and the Isle of Man (NJR) began recording shoulder arthroplasty cases in 2012.(1) 6,526 cases were performed in 2017, this represents a 5.6 fold increase in annual rates of shoulder arthroplasty over the past 20 years.(1,2)

Whilst it is positive that an increasing number of patients have access to the beneficial shoulder specific and overall lifestyle effects of arthroplasty for end-stage glenohumeral arthropathies, (3-5) the rise in demand confers a significant increase in burden on healthcare resources. In the UK, the National Health Service (NHS) has recently experienced a period of unprecedented rising demand with below inflation funding leading to a provider sector deficit of £960million in 2017/18.(6) This has led to increased scrutiny on resource allocation, with elective orthopaedic procedures commonly targeted for healthcare cost savings. In addition to this funding shortfall, seasonal peaks in demand have consistently led to bed shortages and cancellation of elective surgery over the winter months.(7) It is therefore vital for any unit offering shoulder arthroplasty to understand the implications of providing shoulder arthroplasty on the utilisation of inpatient beds.

In the United States of America (USA), several papers have evaluated the length of stay following shoulder arthroplasty and identified predictors of increased length of stay. Dunn et al. analysed 2,004 patients undergoing primary elective total shoulder arthroplasty reporting a mean length of stay of 2.2 days and identifying age, female sex, renal insufficiency and ASA grade of 3 or above as predictive of increased length of stay.(8) In a further study, Menendez et al. analysed 40,869 patients who underwent elective total shoulder arthroplasty, they also

identified age, female sex and renal failure as associated with increased length of stay. In addition, they reported that COPD, pre-operative anaemia, and low volume centres were associated with prolonged inpatient stay.(9)

To date there has been no study of patient and surgical factors associated with increased length of inpatient stay following shoulder arthroplasty in the UK. This study aims to address this evidence gap by reporting the length of inpatient stay following shoulder arthroplasty in a high volume UK centre and identify factors associated with greater length of stay.

Materials and Methods:

A consecutive series of shoulder arthroplasties performed at the host institution, a tertiary referral upper limb unit, between January 2012 and January 2018 was identified. Patients were included if they underwent any form of shoulder arthroplasty, including anatomic total shoulder replacement, reverse total shoulder replacement, hemiarthroplasty and revision procedures for all indications. Patients were excluded if they did not receive a shoulder arthroplasty procedure, no cases were excluded for incomplete data. A review of case notes, electronic patient record, operation notes, anaesthetic charts and discharge summaries was conducted to collect patient demographic data, co-morbidities, details of inpatient stay and date of death. Length of stay was defined as the number of nights spent in an acute inpatient bed. The Charlson co-morbidity index, a validated scoring system used to predict mortality based on a patient's co-morbidities was calculated for each patient.(10)

This study was performed under the jurisdiction of the HRA and their decision making tool indicates that ethical approval is not required for the current study or study design.

Statistical Methods

Descriptive statistical analysis was carried out using Microsoft Excel (Microsoft Corporation, Redmond, Washington, USA.). Multiple linear regression analysis was performed using GraphPad InStat and Prism (GraphPad Software Inc, La Jolla, CA, USA). Significance was determined when $p < 0.05$.

In the multiple linear regression model, independent variables included were age, gender, ASA grade (1-2, 3-4), Charlson co-morbidity index, comorbidities (diabetes, liver failure, malignancy, chronic kidney disease, congestive cardiac failure, myocardial infarction, chronic obstructive pulmonary disease, peripheral vascular disease, cerebrovascular accident, connective tissue disorder and peptic ulcer), trauma or elective surgery, primary or revision surgery, indication for primary surgery (osteoarthritis, cuff tear arthropathy, other), year of surgery (2011-2014, 2015-2017), type of shoulder arthroplasty (hemiarthroplasty, anatomical total shoulder replacement, reverse geometry shoulder replacement), side of operation, hand dominance, anaesthetic (general anaesthetic or general anaesthetic plus regional block), operating surgeon grade (Consultant or training grade), previous surgery (arthroscopic surgery, arthroplasty surgery, open reduction internal fixation), fixation of humeral component (cemented or uncemented), intraoperative complication and postoperative transfusion. Comorbidities of AIDS, dementia and hemiplegia were excluded as there were no cases. Multicollinearity was assessed and addressed where it was a problem ($R^2>0.75$); it was addressed either by grouping variables as described above (e.g. ASA grade and year of surgery) or removal of variables from the model (e.g. day of the week of surgery) until it was no longer a problem ($R^2<0.75$ for all variables).

Results:

During the study period 640 shoulder arthroplasty cases were performed in 566 patients. The mean age at time of surgery was 72 years (SD±10), 451 cases (70%) were performed in female patients. The most common procedure was primary reverse total shoulder replacement (287 cases; 45%) followed by primary anatomic total shoulder replacement (262 cases; 41%) and hemiarthroplasty (36 cases; 6%), 55 revision procedures were undertaken. Of the cases performed 569 (89%) were elective cases, with 71 (11%) due to trauma. The most common indication was osteoarthritis (289 cases, 45%), followed by rotator cuff arthropathy (160 cases; 25%). Demographic details broken down by length of stay for all patients included are provided in Table 1 for illustration of trends.

Table 1. Patient Demographic Data

The median length of stay and a breakdown of median length of stay by patient and surgical factors is shown in Table 2, the mean and standard deviation is also included to allow comparison to published data. The median length of inpatient stay was 2 days (IQR 2-4) and the mean was 4 days (SD+-6), 348 patients stayed for 1 or 2 days, 210 patients stayed between 3-7 days and 82 patients had an inpatient stay of greater than 7 days (see Fig. 1).

Univariate comparisons suggested that patients who required inpatient stays of greater than the median were older (mean age 74yrs vs. 70 yrs), more likely to be female (80% vs. 63%), had a higher Charlson Co-Morbidity Index (4 vs. 3) and were more likely to have undergone surgery for trauma (19% vs. 8%). Analysis of length of stay by patient and surgical factors demonstrated patients over 79yrs had double the length of stay of younger patients (4 days vs. 2 days), female patients had a median length of stay of 3 days vs. 2 days for males and that a Charlson Co-Morbidity Index of 6-9 was associated with a 4 times longer inpatient stay when compared to patients with a score of 0-3.

Table 2. Length of Inpatient Stay by Indicative Patient and Surgical Factors.

Figure 1. Number of patients who stayed for each time period.

The analysis of variance indicated that the multiple regression model did significantly predict length of stay. The length of stay was predicted by the following variables in the model (table 1): age, gender, chronic kidney disease, congestive cardiac failure, previous myocardial infarction, intraoperative complication and postoperative transfusion. None of the other variables independently predicted length of stay.

Table 3. Multiple regression model investigating factors that significantly predict increasing length of inpatient stay following shoulder arthroplasty.

Discussion:

This is the first study to determine factors associated with length of inpatient stay following shoulder arthroplasty in a UK population. We found a median inpatient stay of 2 days (IQR 2-4). 348 (54%) patients achieved discharge in 2 days or less with 83 (13%) patients requiring an inpatient stay of greater than 7 days. The length of stay was predicted by age (p=0.033), gender (p=0.021), chronic kidney disease (p=0.0008), congestive cardiac failure (p=0.035), previous myocardial infarction (p=0.030), intraoperative complication (p=0.014) and postoperative transfusion (p=0.0006) on multivariate analysis.

The 2 day median length of stay reported here is less than the 3 day (IQR 2-5) median length of stay reported by Craig et al. in their study of 51,585 shoulder replacement carried out in the UK between 1998-2017.(2) The 4 day mean length of stay is longer than the figure

reported by Dunn et al. who reported a 2.2 day mean length of inpatient stay in 2,004 primary elective total shoulder arthroplasties, with 91% of patients achieving discharge from hospital in 3 days or less, compared to 67% in this study.(8) Padegimas et al. reported a length of stay of 1.3 days in an orthopaedic specialist hospital, and 1.9 days in a tertiary referral centre when examining 2 groups of 136 patients, matched by baseline characteristics, who underwent primary total shoulder arthroplasty.(11) These figures may not be entirely comparable though as these cases were all primary procedures, performed electively, and it is common practice in the USA for elective orthopaedic patients to be discharged to a rehabilitation facility prior to home. Length of stay is also influenced in our institution by day case procedures being prioritised for early positioning on the operating list, with arthroplasty often undertaken later in the day.

In a study of 40,869 patients who underwent elective primary total shoulder arthroplasty, Menendez et al. identified increasing age, female sex, renal failure, congestive heart failure, COPD and anaemia as factors associated with prolonged length of inpatient stay.(9) Dunn et al. also identified increasing age, female sex, chronic renal disease and higher co-morbidity scores as predictive of prolonged length of stay in his cohort of 2,004 patients.(8) The associations identified in this study between prolonged inpatient stay and increasing age, female sex, chronic renal failure and congestive cardiac failure are consistent with these previous findings. Previous myocardial infarction, intra-operative complication and post-operative transfusion independently predicting prolonged length of stay has not been reported previously.

Kim et al. examined the use of the Charlson Comorbidity Index and the Elixhauser Comornidity Measure in 90,491 patients who underwent primary elective total shoulder

arthroplasty between 2002-2014 in Cleveland, Ohio. (12) They reported both measures to be good predictors of postoperative complication, prolonged inpatient stay, discharge to a rehabilitation facility and death.(12) Whilst the Charlson Comorbity Index was higher in patients with prolonged inpatient stay in this study, the Charlson score was not significantly associated with prolonged inpatient stay on multivariate analysis, so our findings do not support this Kim et al's finding. However the Charlson co-morbidity index is made up of individual scores for co-morbidities, some of which were found to be independent predictors of prolonged length of stay, so our data suggest the effect on length of stay appears to arise from the individual co-morbidities rather than the overall Charlson Index.

The limitations of this paper are that this was a retrospective study based on case note and medical record review and the numbers may have been too small to detect all significant associations on multivariate analysis.It must be stated that the numbers are small when compared to large national population level studies from the USA. These cases were performed in a high-volume UK centre so may not be generalisable to all UK centres performing shoulder arthroplasty. The study here is designed to demonstrate an association between considered variables and outcomes, but is not able to definitively prove causation.

Conclusion:

This study reports the first data on length of stay following shoulder arthroplasty in a UK centre and the factors associated with prolonged inpatient stay. The findings are consistent with previously published work that increasing age, female sex, chronic renal failure and congestive cardiac failure are all associated with prolonged inpatient stay following total shoulder arthroplasty. Previous myocardial infarction, intra-operative complication and post-

operative transfusion were also identified and predictors of prolonged inpatient stay. This study provides useful single centre data in a UK population, and could be used in planning resource allocation for centres undertaking shoulder arthroplasty. This study also highlights the need for a larger in depth population level study of length of inpatient stay, and the factors associated with prolonged inpatient stay, in patients undergoing shoulder arthroplasty in the UK.

Word count: 2083

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Figure 1. Number of patients who stayed for each time period

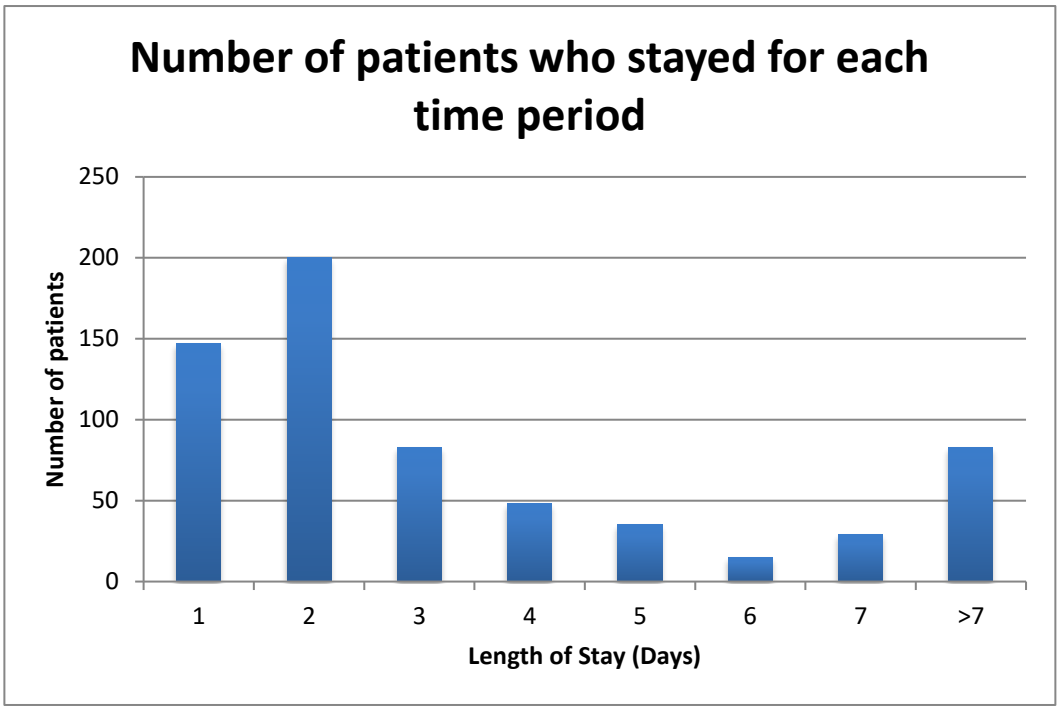

Table 1. Patient Demographic Data by Length of Stay

	All Patients	Length of Stay		
		<3 days	3-7 days	>7 days
Number	640	348	210	82
Age				
Mean (SD)	72 (+-10)	70 (+-10)	73 (+-9)	77 (+-9)
Min	24	24	31	42
Max	95	89	95	93
Gender				
Male	189	129	45	15
Female	451	219	165	67
ASA				
1	52	40	12	0
2	314	197	95	22
3	265	109	101	55
4	9	2	2	5
Charlson Index				
Median (IQR)	3 (2-4)	3 (2-4)	4 (3-5)	4 (4-5)
Procedure				
Anatomic	262	178	72	12
Reverse	287	125	108	54
Hemi	36	20	10	6
Revision	55	25	20	10
Indication				
OA	297	193	86	18
RA	36	23	9	4
Cuff arthropathy	160	69	64	27
AVN	18	11	5	2
Trauma	22	7	8	7
Trauma sequelae	49	20	17	12
Revision	55	25	20	10
Infection	3	0	1	2
Elective vs Trauma				
Elective	569	321	185	63
Trauma	71	27	25	19
Side				
Right	351	173	132	46
Left	289	175	78	36
Previous Surgery				
Yes	95	48	35	12
No	545	300	175	70

Table 2. Length of Inpatient Stay by Patient and Surgical Factors

All Patients	**Length of Stay (Days)**
Median (IQR)	2 (2-4)
Mean (SD)	4 (+/-6)
Range	0-71
Age (Years)	**Median Length of Stay (IQR)**
<60	2 (1-3)
60-69	2 (1-3)
70-79	2 (2-4)
>79	4 (2-8)
Gender	
Male	2 (1-3)
Female	3 (2-5)
ASA	
1	2 (1-2)
2	2 (1-4)
3	3 (2-7)
4	8 (3-23)
Charlson Score	
0-3	2 (1-3)
3-6	4 (2-7)
6-9	8 (4-15)
Procedure	
Anatomic	2 (1-3)
Reverse	3 (2-7)
Hemi	2 (2-6)
Revision	3 (2-5)
Indication	

Elective	2 (2-4)
Trauma	3 (2-8)
Previous Surgery	
Yes	2 (2-4)
No	2 (2-5)

Table 3: Multiple regression model investigating factors that significantly predict increasing length of inpatient stay following shoulder arthroplasty.

Variable	Multiple regression model estimate	95% confidence interval	t value	p value
Age	0.137	0.011 to 0.263	2.141	0.0327
Gender	1.091	0.165 to 2.018	2.314	0.0210
ASA 1-2 or 3-4	-0.861	-1.820 to 0.098	1.763	0.0784
Charlson Score	-0.340	-1.549 to 0.870	0.5519	0.5812
Diabetes	0.566	-1.226 to 2.358	0.6207	0.5350
Liver failure	-3.815	-14.220 to 6.589	0.7201	0.4717
Malignancy	1.299	-0.306 to 2.905	1.589	0.1125
CKD	3.727	1.565 to 5.889	3.386	0.0008
CCF	2.581	0.186 to 4.977	2.116	0.0348
MI	2.672	0.265 to 5.078	2.180	0.0296
COPD	0.843	-1.097 to 2.782	0.8533	0.3938
PVD	2.621	-2.131 to 7.372	1.083	0.2792
CVA	-0.560	-3.140 to 2.020	0.4265	0.6699
Connective tissue	0.836	-1.051 to 2.722	0.8700	0.3846
Peptic ulcer	0.738	-2.155 to 3.632	0.5012	0.6164
Trauma or elective	1.341	-0.566 to 3.247	1.381	0.1678
Primary or revision	-0.281	-0.642 to 0.084	<0.001	>0.9999
Indication: OA	-0.872	-2.531 to 0.787	1.032	0.3025
Indication: cuff tear arthropathy	-0.098	-1.841 to 1.646	0.110	0.9123
Year 2011-4 or 2015-7	-0.473	-1.365 to 0.419	1.042	0.2980
Hemiarthroplasty	-0.069	-0.711 to 0.573	<0.001	>0.9999
Anatomical TSR	-2.399	-8.721 to 4.021	<0.001	>0.9999
Reverse TSR	-2.871	-9.121 to 3.379	<0.001	>0.9999
Side	-0.150	-0.984 to 0.684	0.352	0.7247
Hand dominance	1.585	-0.220 to 3.390	1.724	0.0852
Anaesthetic (GA vs. GA+block)	-0.551	-1.859 to 0.756	0.828	0.4081
Operating surgeon grade	0.088	-0.867 to 1.042	0.180	0.8572
Previous arthroscopy	0.315	-1.366 to 1.997	0.368	0.7129
Previous ORIF	-1.619	-5.139 to 1.901	0.903	0.3667
Previous arthroplasty	-2.739	-5.626 to 0.148	1.863	0.0630
Humeral fixation	-0.364	-1.604 to 0.878	0.575	0.5654
Intraoperative complication	1.903	0.393 to 3.412	2.476	0.0136
Postoperative transfusion	3.888	1.671 to 6.106	3.444	0.0006