The influence of pre-operative factors on the length of in-patient stay following primary total hip replacement for osteoarthritis

A MULTIVARIATE ANALYSIS OF 2302 PATIENTS

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We analysed which pre-operative factors could be used to predict the length of in-patient stay following unilateral primary total hip replacement undertaken for osteoarthritis. Data were collected prospectively from 2302 patients undergoing primary total hip replacement over a nine-year period. The relationships between the various pre-operative factors and length of stay were studied separately using either Student's t-test or Pearson's correlation, and then subjected to multiple linear regression analysis.

The mean length of stay was 8.1 days (median 7; 3 to 58). After adjusting for the effects of other pre-operative factors, younger age, male gender, higher combined Harris hip function and activity score, higher general health perception dimension of the Short-Form 36 score, and non-steroidal anti-inflammatory drug use were all found to be significantly associated with a reduced length of stay.

Primary total hip replacement (THR) is one of the most common surgical procedures, with approximately 202 000 performed in the United States and 62 000 in the United Kingdom per year.¹⁻³ By 2030, it is estimated that 572 000 primary THRs will be carried out annually in the United States alone.⁴ It is also one of the most cost-effective operations performed, with a high Quality of Life Adjusted Year (QUALY) index despite being associated with a relatively high initial average cost of \$35 000.¹

Since the 1970s clinical pathways have been used with the primary aim of improving the quality of in-patient care and patient satisfaction following THR. Previous studies examining the role of clinical pathways have shown that it is possible to reduce the length of stay and costs in acute care facilities while still safeguarding standards of patient safety and maintaining the same discharge goals.^{5,6}

Factors shown to increase the length of stay following primary THR include increased age,⁷⁻¹¹ female gender,⁷⁻⁹ high body mass index (BMI),¹¹⁻¹⁴ smoking,¹³⁻¹⁵ low hip scores,^{16,17} not being married, and African-American ethnicity.¹⁸ However, these studies were retrospective and either involved small numbers, focused on a limited number of variables, or were not subject to robust statistical analysis. A more recent multivariate analysis of 712 patients¹⁹ has also demonstrated a correlation between the length of stay and age, gen-

der, marital status, medical comorbidities, American Society of Anaesthesiologists (ASA) grade and pre-operative level of haemoglobin.

It would be useful to be able to predict which factors affect the length of stay following THR. This would allow units to improve patient flow and thereby increase efficiency by optimising the case-mix and staffing levels in all related departments. Furthermore, more accurate information could be given to patients pre-operatively, enabling better management of patient expectation. We hypothesised that there are a number of pre-operative factors that would predict the length of in-patient stay following a unilateral primary THR. In order to test this hypothesis we carried out a multiple logistic regression analysis on data collected over a nine-year period.

Patients and Methods

Our dedicated elective orthopaedic unit consists of a 28-bed ward attached to an operating suite that runs 17 half-day operating sessions per week. Approximately 300 primary THRs are performed per annum on an almost exclusively Caucasian population. Since January 1998 prospective data have been collected on all patients undergoing primary THR. Specialist nurses interview each patient during the pre-assessment appointment and prospectively enter data into a Microsoft Excel database. Further data are collected during the in-patient stay and following discharge. Apart from

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length of stay, no other post-operative data were analysed in our study, with length of stay defined as the number of post-operative nights before discharge.

During the period of the study a total of 17 surgeons performed or supervised the operations, although on average there were only eight surgeons involved in a given year. All surgeons used a standard anterolateral approach, and all components were cemented. Charnley all-polyethylene acetabular components (DePuy, Leeds, United Kingdom) were used in all cases, and either Charnley (DePuy) or Lubinus SPII femoral components (Link, Hamburg, Germany) were used.

Every patient followed the same clinical pathway post-operatively with mobilisation the day after surgery. Routine blood tests were taken on the first and fourth days. Patients were discharged back to their pre-operative residence when they were deemed to be able to function independently, transfer safely, manage stairs if appropriate, and had a dry wound. There was no physiotherapy service at the weekend and no wound drains were used. Thromboembolic prophylaxis was not standardised throughout the study period. Initially this involved the use of graduated compression stockings, with anti-thrombotic drugs being prescribed according to surgeon preference. Since 2004 routine use of low molecular weight heparin for a total of ten days post-operatively has been adopted with patients completing the course at home. Patients deemed at high risk of thromboembolic disease are given 2.5 mg s/c of fondaparinux sodium (GlaxoSmithKline, Uxbridge, United Kingdom) eight hours post-operatively, and the once daily for four weeks.

We identified 2547 consecutive patients over the nine-year period from 1 January 1998 to 1 January 2007. Exclusion criteria were bilateral simultaneous THR (99 patients), a diagnosis other than primary osteoarthritis (137 patients), and patients who had died during the initial admission for THR (nine patients). The remaining 2302 patients were anonymised and entered into the study.

The pre-operative factors that were recorded included age, gender, BMI, date of operation, surgeon, pre-operative haemoglobin, Harris hip score (HHS),^{20,21} Short-Form 36 (SF-36) score,²² Scottish Index of Multiple Deprivation,²³ knee pain, back pain, contralateral hip pain, ischaemic heart disease, diabetes mellitus, other medical comorbidities, smoking and use of pre-operative aspirin or non-steroidal anti-inflammatory drugs (Table I).

From the HHS we extracted the combined function/activity dimension, which takes into account whether patients had a limp or used a walking aid, their walking distance, the ability to use public transport, to use stairs and to put on socks, and the length of time they are able to sit without pain. This permitted a score between 0 and 47 to be generated. From the SF-36 score we calculated the general perception dimension from responses to four statements: 'I seem to get sick a little easier than other people', 'I am as healthy as anybody I know', 'I expect my

health to get worse' and 'My health is excellent'. Patients were required to indicate how strongly they agreed or disagreed with each statement, and a total score of between 0 and 100 was calculated.

The Scottish Index of Multiple Deprivation is a government tool for identifying local concentrations with multiple deprivations across 6000 small areas in Scotland. It is generated from a postcode and produces a ranking index by weighting the sum of a series of seven domains: current income, employment, health, education, skills and training, geographic access to services, housing and crime.

Ischaemic heart disease and diabetes mellitus were analysed individually. Other comorbidities grouped together for analysis included peripheral vascular disease, hypertension, osteoporosis, phlebitis, previous thromboembolic disease and malignancy. Other musculoskeletal pathology involving the knees, the contralateral hip and the lumbar spine were graded by the patient as normal, abnormal or disabling.

Statistical analysis. Data analysis was performed retrospectively by an independent statistician using SPSS 15 software (SPSS Inc., Chicago, Illinois). The mean length of stay was 8.1 days (median 7.0, 3 to 58). This indicated that the data were highly skewed, and so the statistical analysis was based on the logarithm of length of stay, which had an approximately symmetrical distribution. The relationship between each factor and length of stay was analysed separately using the *t*-test or Pearson's correlation. Multiple linear regression was used to analyse the effect of each significant factor adjusted for others. Because of the logarithmic transformation, the coefficients from this model convert to percentage differences in length of stay between the categories of each factor. Statistical significance was assumed when a *p*-value of < 0.05 was obtained.

Results

The pre-operative factors that were not significantly associated with the length of stay included BMI, Scottish index of multiple deprivation score, and disabling knee, back or contralateral hip pain. A number of pre-operative factors were found to be highly significant predictors of length of stay when subjected to univariate analysis, but were not significant after multivariate analysis; these included smoking, ischaemic hip disease, diabetes mellitus, pre-operative aspirin use, the pre-operative haemoglobin level and overall SF-36 score (Table I).

Multivariate logistic regression revealed that length of stay was significantly associated with age at the time of operation, gender, pre-operative use of non-steroidal anti-inflammatory drugs (NSAIDs), surgeon performing the operation, the day of the week and the year of surgery, the combined function/activity dimension of the HHS, and the general health perception dimension of the SF-36 score (Table I).

Table I. Statistical analyses of the influence of various factors on length of stay

Factor ^a	Number of patients	Mean length of stay (days)	Univariate p-value	Multivariate p-value
Age (yrs)				
< 60	376	6.5		
60 to 70	788	7.1	< 0.001	< 0.001
70 to 80	839	8.7		
> 80	299	11.5		
Gender				
Male	843	7.5	< 0.001	< 0.001
Female	1459	8.5		
BMI [†]				
< 18.5	19	9.1	0.46	(‡)
18.5 to 25	602	8.3		
25 to 30	878	7.9		
30 to 40	696	8.2		
> 40	27	8.2		
Day of operation				
Sunday	18	9.3	< 0.001	0.001
Monday	655	8.1		
Tuesday	303	8.3		
Wednesday	434	8.2		
Thursday	558	8.2		
Friday	317	7.8		
Saturday	17	7.2		
Year of admission				
1998 to 1999	456	8.8	< 0.001	0.008
2000 to 2001	471	8.2		
2002 to 2003	446	8.1		
2004 to 2005	552	8.2		
2006 to 2007	377	7.2		
Knees [†]				
Normal	1771	8.1	0.60	(*)
Abnormal	158	8.4		
Disabling	354	8.1		
Back [†]				
Normal	1568	8.1	0.83	(*)
Abnormal	210	8.2		
Disabling	510	8.1		
Other musculoskeletal problems [†]				
Normal	1955	8.2	0.13	(*)
Abnormal	140	7.9		
Disabling	194	7.7		
Medical comorbidities [†]				
Yes	1061	7.6	< 0.001	0.12
No	1234	8.6		
Ischaemic heart disease [†]				
Yes	324	9	< 0.001	0.59
No	1971	8		
Diabetic [†]				
Yes	158	9.1	0.002	0.06
No	2137	8.1		
NSAIDs [†]				
Yes	1011	7.6	< 0.001	< 0.001
No	1284	8.5		

Table I. Continued

Factor [†]	Number of patients	Mean length of stay (days)	Univariate p-value	Multivariate p-value
Aspirin [†]				
Yes	520	8.7	< 0.001	0.07
No	1775	8		
Smoker [†]				
Current	321	7.3	< 0.001	0.08
Never	1133	8.3		
Ex	742	8.1		
Pre-operative haemoglobin level (g/l)				
< 12	291	9.6	< 0.001	0.28
12 to 13	471	8.3		
13 to 14	679	8.1		
> 14	861	7.6		
Consultant code [†]				
1	111	8.4	< 0.001	< 0.001
2	251	8.1		
3	196	9.3		
4	211	8.5		
5	242	8.2		
6	253	8.4		
7	547	8		
12	200	7.9		
14	138	6.4		
Other	125	7.8		
Scottish Index of Multiple Deprivation [†]				
1	242	8.2	0.33	(*)
2	338	8.2		
3	373	8.4		
4	381	8.3		
5	293	8.3		
Harris hip score (total) [†]				
0 to 34	487	9.6	< 0.001	0.67
35 to 44	634	8.3		
45 to 54	625	7.6		
55 to 100	515	7.1		
Harris hip score (pain) [†]				
0	7	9.7	< 0.001	0.44
10	1585	8.4		
20	679	7.5		
30	27	7.1		
44	2	8.5		
Harris hip score (function and activity) [†]				
0 to 19	571	9.4	< 0.001	< 0.001
20 to 25	473	8.3		
26 to 31	593	7.9		
32 to 47	637	7		
Harris hip score (movement) [†]				
0 to 3	467	8.3	0.02	0.08
4 to 6	397	8.4		
7	1028	8.1		
8 to 9	383	7.7		
SF-36 physical functioning [†]				
0	409	9.8	< 0.001	0.87
5 to 10	540	8.4		
15 to 20	505	7.8		
> 25	814	7.3		

Table I. Continued

Factor*	Number of patients	Mean length of stay (days)	Univariate p-value	Multivariate p-value
SF-36 role physical†				
0	1525	8		
25	93	7.6		
50	67	7.1	0.001	0.12
75 to 100	88	7.1		
SF-36 Pain†				
0	123	9.1	< 0.001	0.81
11 to 22	1182	8.2		
33	461	7.9		
44 to 100	503	7.8		
SF-36 general health perception†				
0 to 49	160	9.2		
50 to 60	288	8.3		
70 to 89	1064	8.3	< 0.001	0.003
90 to 100	748	7.5		
SF-36 vitality†				
0 to 25	431	8.6		
30 to 40	491	8.6		
45 to 60	693	8	< 0.001	0.58
65 to 100	646	7.5		
SF-36 social role functioning†				
0 to 22	488	8.9		
33 to 44	539	8.2		
56 to 67	400	8.1	< 0.001	0.43
78 to 100	839	7.6		
SF-36 emotional role functioning†				
0	322	8		
33	37	6.9		
67	25	8	0.98	(*)
100	1390	7.9		
SF-36 mental health†				
0 to 60	474	8.6		
64 to 76	570	8.1		
80 to 88	707	7.9	< 0.001	0.22
92 to 100	510	7.9		
SF-36 combined health†				
0	119	8.4		
25	448	8.8		
50	1587	7.9	< 0.001	0.28
75 to 100	113	8		

* BMI, body mass index; NSAIDs, non-steroidal anti-inflammatory drugs; SF-36, short-form 36

† some missing data

‡ not included in multivariate analysis as not significant on univariate analysis

The 95% confidence limits for the effect sizes of each highly significant independent factor, expressed as a percentage difference from either a reference category or the calculated mean of each factor, are presented in Table II.

Discussion

The results confirm our hypothesis that there are a number of independent pre-operative factors that can be used to

predict the length of stay following a unilateral primary THR. Most of our findings confirm those of earlier studies, particularly the relationships between increased length of stay and older age^{7-11,16,24-26} and female gender.⁷⁻⁹ Oldmeadow, McBurney and Robertson²⁷ have shown that several factors, including age, gender and locomotor function, could predict the destination of the patient after discharge from hospital. They devised a formula to calculate

Table II. The 95% confidence limits for effect sizes of highly significant factors adjusted for one another

Factor*	95% confidence limits†
Age	
Increase of ten years‡	14 to 17
Gender	
Female vs male	4 to 10
HHS function/activity score	
Increase of 10 units§	-8 to -5
SF-36 GHP	
Increase of 10 units¶	-2 to -1
NSAIDs	
Present vs absent	-8 to -3
Consultant	
Code 3 vs code 7	5 to 19
Year of admission	
Increase of ten years	-15 to -4
Day of operation	
Tuesday vs Monday	2 to 14

* HHS, Harris hip score; SF-36, short-form 36; GHP, general health perception; NSAIDs, non-steroidal anti-inflammatory drugs

† expressed as a percentage of median stay

‡ from mean age of population

§ from means score in population (0 to 47)

¶ from mean score in population (0 to 100)

the risk of extended in-patient rehabilitation, but their predictive factors were generated through literature review and expert opinion. Additionally the group they studied was small (520 patients) and included those undergoing all types of hip and knee arthroplasty, including primary and revision, and hemiarthroplasty of the hip. Thus, only tentative comparisons between the papers can be drawn.

We believe that two significant factors identified by our study have not been previously reported. There was a significant association between a high SF-36 general health perception score and shorter length of stay, which may reflect increased motivation and expectation in this group. The combined function/activity dimension of the HHS was also strongly associated with the length of stay. For example, a patient scoring seven points would be expected to stay between 20% and 28% longer than a matched patient scoring the maximum of 47 points. Although they used a different measure, Husted et al¹⁹ reported an association between the pre-operative use of a walking aid and an increased length of stay. This is consistent with our finding, the use of a walking aid being one of the criteria in the validated HHS function/activity assessment.

The requirement for regular NSAID medication pre-operatively was also associated with a significantly shorter length of stay, and we wondered if this contributed to reduced post-operative pain and swelling in this group.

We also noted a significant association between the surgeon and the length of stay, but this could include variations in surgical technique, operating schedule, anaesthetic technique and pre-operative counselling. However, it is impossible to explore this further within the limitations of the study design.

Some of the negative findings in our study were surprising. Several previous studies have shown that high BMI,¹¹⁻¹⁴ smoking^{13,15} and diabetes mellitus²⁴ are all associated with an increased length of stay, but no such association was identified in our study. Conversely, our series demonstrated a trend that smoking was actually associated with a reduced length of stay ($p = 0.008$), and there was only a trend towards increased length of stay in diabetic patients after multivariate analysis ($p = 0.06$). A large multivariate analysis¹³ on the impact of tobacco use and obesity in patients undergoing THR identified that these factors were associated with an increase in the complication rate but were not related to an increased length of stay.

The day of surgery did not influence the length of stay, as we had anticipated. In common with many institutions no physiotherapy services were available at the weekend. Previous authors¹⁹ have suggested that for this reason, surgery at the end of the week can lead to an increased length of stay. However, we found the shortest length of stay occurred in those patients undergoing surgery on a Friday. More analysis of this is needed before conclusions can be drawn.

We believe this study has several strengths. The length of stay of a large number of well-defined patients has been analysed using prospectively gathered data. However, we acknowledge the limitation that the database was not set up primarily to study the length of stay. Consequently, we did not have complete information relating to social circumstances, cognitive scores, objective measures of locomotor function or details of anti-coagulation with warfarin. Furthermore, data from multiple centres and from a more ethnically diverse population would have added to the strength of this study.

Further work will hopefully validate a simple scoring system which will predict the length of in-patient stay. Although the length of stay itself may not actually be reduced, an improvement in efficiency and patient flow through the hospital might result from advanced knowledge of the requirement for resources. Patient satisfaction and exceptions might also be better managed with more accurate forecasting of the likely length of stay. Obviously, intra- or post-operative complications will increase the length of stay, but these generally cannot be foreseen and their effects are currently the subject of a separate research project by our unit.

In conclusion, younger age, male gender, higher combined Harris hip function and activity score, higher general health perception dimension of SF-36 score and NSAID use are all significantly associated with reduced length of stay following primary THR for osteoarthritis.

All patients gave informed consent to participate in the study, and the study was approved by the Fife NHS institutional review board. The authors would like to thank specialist arthroplasty nurses Mrs A. Simpson, L. McComiskie and S. Wilson for maintaining the database. Thanks also to Dr R. Elton for providing the statistical analysis.

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