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Does Achieving the Best Practice Tariff Improve Outcomes in Hip Fracture Patients?

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Abstract (299 words)

Objectives: To determine if the introduction of the best practice tariff (BPT) has improved outcomes for older people with hip fracture at organisational or individual levels.

Setting: A single university teaching hospital

Participants: 2,541 patients aged over 60 admitted with a neck of femur fracture between 2008 and 2010 and from 2012 to 2014 were included, to create two cohorts of patients, before and after the introduction of BPT. The post-BPT cohort was divided into two groups, those who achieved the criteria and those who did not.

Primary and Secondary Outcome Measures: Primary outcomes of interest were differences in mortality across cohorts. Secondary analysis was performed to identify associations between individual BPT criteria and mortality.

Results: There was no significant difference in 30-day mortality after the introduction of BPT (8.3% pre-BPT vs 10.0% post-BPT; p = 0.128). Neither was there a significant reduction in length of stay (15 days (IQR 9-21) pre-BPT vs 14 days (IQR 11-22); p=0.236). However, the introduction of BPT was associated with a reduction in the time from admission to theatre (median 44hours pre-BPT (IQR 24-44) vs 23hours post-BPT (IQR 17-30); p<0.005). 30-day mortality in those who achieved BPT was significantly lower (6.0% vs 21.0% in those who did not achieve-BPT; p < 0.005). There was a survival benefit at one year for those who achieved BPT (28.6% vs 42.0% did not achieve-BPT; p<0.005). Multivariate logistic regression revealed that of the BPT criteria, AMT monitoring and expedited surgery were the only BPT criteria that significantly influenced survival.

Conclusion: The introduction of the BPT has not led to a demonstrable improvement in outcomes at organisational level, though other factors may have confounded any benefits. However, patients where BPT criteria are met appear to have improved outcomes. It is not possible to ascribe causation to this association.

Strengths and limitations of this study

- Prospectively collated, quality controlled data used
- Large patient cohort
- Long study period potential confounder
- Potential type two-error despite large sample size
- An observational study hence conclusions are limited

Introduction

Hip fractures are an ever-increasing public health burden. The latest UK data report average 30 day mortality of 8%.(1) One year mortality rates are reported between 10-30% with a significantly reduced quality of life amongst those who survive.(2-4) Acute hospital and overall length of stay are 15.7 and 20.3 days respectively and just over half of patients return to their original residence within 30 days.(5)

Hip fractures mostly, though not exclusively, occur in older people with significant medical and social co-morbidity.(3, 4) Hip fracture carries a significant socio-economic burden costing £1-2 billion per year in the UK.(6) Despite improvements in fracture prevention, due to changing demographics, the numbers of hip fractures are predicted to be more than 100,000 per year by 2020.(7)

The poor outcomes and wide variations in standards of care led, in April 2010, to the UK Department of Health introducing a financial incentive to English National Health Service (NHS) hospitals. This essentially meant that the 'base' payment made to hospitals for hip fracture care was reduced, but there was additional funding for meeting all of a set of defined process measures: the 'Best Practice Tariff' (BPT).(8) The Best Practice Tariff criteria were based on national guidance and expert opinion and was intended to drive improvements in processes of care from admission to discharge, where there was evidence of sub-optimal practice and where changes in process were felt likely to have the biggest impact.(9) The criteria are detailed in table 1 and included prompt surgery and the involvement of an orthogeriatrician. The expectation was that patient outcomes would improve as well as reducing length of stay and care costs.(10)

Table 1: Best Practice Tariff Criteria

	Best Practice Tariff Criteria (11)
1	Time to surgery with 36 hours from arrival in the A&E department to the start of anaesthesia (or from time of diagnosis if an admitted patient)
2	Admitted under the joint care of a consultant geriatrician and consultant orthopaedic surgeon
3	Admitted using an assessment protocol agreed by geriatric medicine, orthopaedic surgery and anaesthesia
4	Peri-operative assessment by geriatrician in the perioperative period (within 72hours of admission)
5	Post-operative geriatrician guided multi-professional rehabilitation team
6	Fracture prevention assessments (falls and bone health)
7	Two abbreviated mental test (AMT) scores performed and all the scores recorded in the NHFD with the first test being carried out prior to surgery and the second post-surgery but within the same spell

* Failure of criteria 3 reflects a lack of documentary evidence that the agreed multi-disciplinary assessment process was used.

Upon the introduction of BPT, the base tariff, payable irrespective of whether the BPT criteria were met, was reduced by £110. However, should all the BPT criteria be met then an additional payment would be made of £445.(8) Subsequent changes to the tariff system have increased this price differential to £1,333(11) With a potential uplift of over £1000 per patient, and compliance monitored via the National Hip Fracture Database, implementation of the hip fracture BPT criteria has been widespread.(1, 5) Current BPT achievement rates are around 63%, 100% compliance is not expected, as some patients will inevitably not be fit for surgery within 36 hours of admission.(5) Yet increased compliance is often considered to correlate with an increase in quality of care.(5, 11, 12)

However, there is limited evidence that increased compliance with BPT has led to improved patient outcomes. There are several published audits demonstrating reduced length of stay following increased compliance of the BPT, however length of stay is multifactorial and these results were confounded by changes in service provision at reporting hospitals which supported BPT compliance.(12, 13) A single study directly assessed the effects of implementing the BPT on mortality, but was unable to demonstrate any survival benefit.(14) Although there has been an improvement in outcomes that parallels the introduction of BPT it is not possible to distinguish the possible effects of BPT from more generic improvements in care.

The aim of this study is to determine if the introduction of the BPT has improved outcomes for the hip fracture population and whether achieving the BPT affects an individual's outcome.

Method

This is an observational cohort 'before and after' study. The study was conducted using prospectively collected, anonymised patient data from the Nottingham Hip Fracture Database.

Inclusion and exclusion criteria

The Nottingham Hip Fracture database (15, 16) is a prospectively collected, quality controlled dataset based on the European Standardised Audit of Hip Fractures in Europe (SAHFE) process.(17) Retrospective analysis was performed on two cohorts of patients admitted with a fractured neck of femur to the Queen's Medical Centre. The pre-BPT cohort was from April 2008 until April 2010 and the post-BPT cohort from April 2012 to April 2014. The period between April 2010 and 2011 where BPT was introduced was excluded *a priori* in order to avoid confounding as the BPT criteria were subsequently changed in 2011. (Table 1)

Patients were divided *a priori* into three groups:

1. Admissions before the implementation of BPT
2. Admissions after the extended BPT was implemented in 2011 who met the BPT criteria
3. Admissions after extended BPT implementation but did not achieve the BPT criteria.

Several of the BPT criteria were not collected prior to introduction of BPT so it was not possible (or appropriate) to split the pre-BPT cohort into 'achievers' and 'non-achievers'.

Any patient aged under 60, managed non-operatively or who sustained a further hip fracture during the time of the study was excluded.

Mortality and admission data were collected for all patients. Mortality data is provisioned by the Office for National Statistics; the last update of mortality data was June 2015 and all data are censored at that point.

Variables

Demographic, physiological, operative and admission data were collected for all patients. The Nottingham Hip Fracture Score (NHFS) was prospectively calculated for all patients as part of routine clinical practice. The NHFS is a weighted seven-factor frailty score specific to hip fracture: age; cognitive function on admission (Abbreviated Mental Test Score <7); not living at home; sex (male); haemoglobin < 100g L^{-1}; previous malignancy; >1 comorbidity (stroke/transient ischemic attack; cardiovascular disease; diabetes; previously diagnosed renal disease). It has previously been shown to predict 30-day post hip fracture mortality.(21-23) The NHFS is a quantitative assessment of the physiological state of the patient and has been shown to be an accurate predictor of thirty-day mortality and length of hospital stay both within the UK and internationally.(16, 18-21)

Statistical Analysis

The primary outcomes were:

Differences in mortality in the two cohorts: pre-BPT and post-BPT; and differences in mortality in the achievers and non-achievers in the post-BPT cohort. The primary analysis was performed using 30-day mortality, assessed using chi-squared tests; complementary analysis was performed using Cox proportional hazards model.

Secondary analyses were performed using multivariate logistic regression to identify associations between individual BPT criteria and 30-day mortality.

Data was analysed using SPSS statistics programme version 23. Categorical variables are presented as proportions. Ordinal variables are presented as mean or median with interquartile range (IQR) as appropriate. Groups were compared with Chi-squared, Student's t-test or Mann-Whitney U test as appropriate. A p value of less than 0.05 was considered significant. Multivariate logistic regression was performed to identify factors that influenced patient outcomes with 30-day mortality: backward entry, factors with univariate $p < 0.10$ included and $p < 0.05$ as criterion for keeping factors in the model.

Formal power analysis was not performed as the sample size is fixed by the nature of the dataset.

Results

2,917 patients were admitted with a hip fracture during the study period. 174 were excluded due to sustaining more than one hip fracture; 79 were managed non-operatively; and 123 were aged under 60. This left 2,541 patients for analysis of which 1,364 were before BPT was introduced and 1,177 after BPT. 314 of the 1177 did not achieve the BPT criteria. Patient characteristics and admission data are summarised in table 2. As previously reported the population characteristics changed over time with more patients admitted from their own home, but an increase in medical complexity demonstrated by an increase in patients with multiple co-morbidity, reduction in mobility independence and an increase in average NHFS.(4)

Table 2: Patient characteristics and admission data

Patient Characteristics	Prior to BPT	After BPT	P Value	Achieved BPT	Did not Achieve BPT	P Value
N	1364	1177		863	314	
Median Age Years (IQR)	83 (77-88)	84 (78-89)	0.469	83 (78-89)	82 (77-88)	=0.186
Gender Male:Female	336:1028	306:871	0.430	200:663	106:208	**<0.005**
30-day mortality N (%)	113 (8)	118 (10)	0.128	52 (6)	66 (21)	**<0.005**
Median AMT (IQR)	8 (4-10)	8 (4-10)		8 (4-10)	8(4-10)	
Mean AMT (SD)	6.71 (3.74)	6.73 (3.69)	0.826	6.74 (3.65)	6.68 (3.80)	0.85
Median NHFS (IQR)	4 (4-6)	4 (4-6)		4 (4-6)	4 (4-6)	
Mean NHFS (SD)	4.61 (1.47)	4.72 (1.45)	**0.026**	4.69 (1.42)	4.88 (1.54)	**<0.005**
Mean Admission Hb (SD)	123.8 (1.83)	123.3 (1.78)	0.435	124.0 (1.75)	121.0 (1.87)	**0.03**
Median Admission Hb (IQR)	12.5 (10.5-14.5)	12.3 (10.3-14.3)				
Malignant Fracture (%)	163 (12)	165 (14)	0.121	105 (12)	60 (19)	**0.03**
Median length of stay (IQR)	15 (9-21)	14 (9-19)	0.236	18 (4-24)	18 (3-29)	0.328
Median time: admission to theatre (hours)(IQR)	44 (23.6-64.4)	23 (17-30)	**<0.005**	21 (16-27)	41 (27-55)	**<0.005**
Residence						
Nursing home (%)	151 (11)	98 (8)		74 (8.6)	24 (7.6)	
Own home (%)	931 (68)	869 (74)		625(72)	244 (78)	
Warden aided/residential home (%)	264 (19)	208 (18)	**0.001**	45 (5)	45 (14)	0.08
Hospital inpatient (%)	6 (0)	0 (0)				
Rehab facility (%)	0 (0)	2 (0)				
Other (%)	9 (0)	2 (0)		0 (0)	1 (0)	
Number of Comorbidities						
<2 (%)	916 (67)	675 (57)	**0.000**	508 (59)	167 (53)	0.08
≥2 (%)	448 (33)	502 (43)		355(41)	147 (47)	
Living alone prior to fracture (%)	613 (45)	496 (42)	0.126	363 (42)	133 (42)	0.56
Walking ability prior to fracture						
Independent outdoors (%)	668 (49)	549 (47)		404 (47)	145 (46)	
Accompanied outdoors (%)	231 (17)	213 (18)		161 (19)	52(17)	
Independent indoors (%)	247 (18)	169 (14)	**0.002**	127 (15)	42 (13)	0.377
Accompanied indoors (%)	76 (6)	67 (6)		47 (5)	20 (6)	
Unable/transfer only (%)	26 (2)	25 (2)		13 (2)	11 (4)	
Not stated (%)	116 (9)	154 (13)		110 (13)	44 (14)	

There was no statistically significant difference in 30-day mortality between the pre-BPT cohort and the post-BPT cohort (113/1364 (8.3%) pre-BPT vs 118/1177 (10.0%) post-BPT; p = 0.128). Survival analysis showed no difference between the two cohorts either (p = 0.22), figure 1. NHFS increased from 4.61 (1.47) (mean (SD)) in the pre-BPT cohort to 4.74 (1.45) post-BPT (p=0.026).

There was no significant reduction in length of stay 15 days (IQR 9-21) pre-BPT vs 14 days (IQR 11-22); p=0.236) between the two cohorts. The median time from admission to the emergency department to theatre was significantly reduced in the post-BPT cohort (44hours pre-BPT (IQR 24-44) vs 23hours post-BPT (IQR 17-30); p<0.005). The proportion of patients being operated on within 36 hours of admission was also significantly higher (485/1364, 36% pre-BPT vs 974/1177, 84% post-BPT; p<0.005).

Within the post-BPT cohort, the 30-day mortality was significantly lower in those who achieved BPT (52/863 (6%) vs 66/314 (21%) in those who did not achieve-BPT; p < 0.005). Survival analysis showed a significant long term survival benefit for those who achieved BPT (figure 2, p<0.005). One year mortality for those who achieved BPT was 28.6% (196/863), in comparison to 42.0% (132/314) for those who did not achieve-BPT (p<0.005).

Univariate analysis of patient characteristics, their NHFS and the individual NHFS components was performed to identify potential variations between the two groups to explain the difference in mortality rate. Those who did not achieve the BPT criteria had higher NHFS scores, had higher rates of malignancy, were more likely to be male and had lower haemoglobin levels.(table 1)

Univariate analysis of BPT criteria revealed that time to surgery, orthogeriatrician review, post-operative AMT monitoring, MDT rehabilitation plus falls and bone protection assessment were negatively associated with 30-day mortality (i.e. not achieving these criteria was associated with greater 30-day mortality).(table 3) Multivariate logistic regression revealed that of the BPT criteria, AMT monitoring and expedited surgery were the only factors that were significantly associated with survival both at 30-days and at one year.(table 4)

Table 3: Results of univariate analysis of BPT criteria as predictors for 30-day mortality

	Survived 30-days	Did not Survive 30-days	Odds Ratio (OR)	OR 95% Confidence Interval		p
				Lower	Upper	
Time to Surgery	886/1059	85/118	0.503	0.326	0.776	**<0.005**
MDT Admission Protocol	1046/1055	115/118	0.330	0.088	1.236	0.11
AMT pre-op	1034/1059	116/118	1.402	0.328	5.996	0.48
Orthogeriatrician review within 72hours	1052/1058	110/118	0.078	0.027	0.230	**<0.005**
AMT post-op	1013/1059	81/118	0.099	0.061	0.162	**<0.005**
MDT guided rehabilitation	1023/1057	85/114	0.097	0.057	0.168	**<0.005**
Falls assessment	1039/1058	103/118	0.126	0.062	0.255	**<0.005**
Bone protection assessment	1038/1059	102/118	0.129	0.065	0.255	**<0.005**

a. An Odds Ratio of <1 infers that achieving the criterion was associated with an improved rate of survival

Table 4: Results of multivariate logistic regression of BPT criteria as predictors for 30-day and 1 Year mortality

	30-day Mortality			1 Year Mortality		
	B	S.E	Sig.	B	S.E	Sig.
Time to Surgery	-.641	.249	**.010**	-.639	.169	**.000**
MDT Admission Protocol	-1.162	.812	.153	-1.347	.700	.0.54
AMT pre-op	2.391	.932	**.010**	2.031	.716	**.005**
Orthogeriatrician review within 72hours	-.988	.777	.204	.393	.768	.609
AMT post-op	-1.740	.393	.000	-.642	.355	.071
MDT guided rehabilatation	-1.234	.446	.006	-.819	.400	.041
Falls assessment	-.474	.939	.614	.003	.831	.997
Bone protection assessment	.715	.946	.450	-1.077	.771	.162
Constant	.438	1.039	.673	.895	.954	.348

ime to Surgery, MDT Admission Protocol, AMT pre-op, Orthogeriatrician review within 72hours, AMT post-op, MDT guided rehabilatation, Falls assessment, Bone protection assessment

The commonest cause for failing to meet BPT criteria was a delay in surgery, occurring in approximately a third of cases. All patients were admitted under the joint care of a geriatrician and orthopaedic surgeon. The breakdown of BPT failure and delay to surgery are summarised in tables 5 and 6.

Table 5: Breakdown of failure to meet BPT criteria

Criteria	N (%)
Time to Surgery	100 (32)
AMT post-op	83 (26)
MDT based rehabilatation	63 (20)
Bone protection assessment	37 (12)
Falls assessment	34 (11)
AMT recorded pre-op	27 (9)
Orthogeriatrician review with 72 hours	14 (4)
MDT admission assessment	12 (4)
Admission under joint care of Surgeon and Geriatrician	0 (0)

Table 6: Causes in delay to surgery of over 36 hours

Cause	N (%)
Lack of resources*	640 (59)
Medically Unfit	200 (18)
Awaiting investigations	157 (15)
Deranged Coagulation	57 (5)
Other	28 (3)

*"lack of resources" is a broad coding category that can include: a delay due to a caseload with a higher NCEPOD classification (22), theatre staff availability and unexpected theatre delays such as prolonged operating time

Discussion

The introduction of BPT was not associated with a reduction in mortality or length of hospital stay in our hip fracture population. However, at a patient level, failure to achieve BPT was associated with

significantly poorer survival. Consistent with NHFD data, delay to surgery is the most common reason not to meet the BPT criteria, despite a significant reduction in the average time from admission to theatre.

The data concerning the impact of BPT are inconsistent. Some studies have reported a temporal association between implementation of BPT and improved outcomes;(12, 13) other studies have not demonstrated a change, though this may have been due to inadequate power.(14) In Wales, which provides data to the National Hip Fracture Database but does not have a BPT mechanism, there have been modest temporal reductions in mortality over a similar time period. As this is an observational study we are not able to distinguish association and causation. Despite Nottingham having one of the largest hip fracture units in England, combined with a long-standing high-quality clinical database, the analysis is probably underpowered to demonstrate a clinically achievable difference at an organisational level. Of note, mortality in the post-BPT cohort was non-significantly greater than in the pre-BPT cohort. Conversely, the data do support an association at individual level between meeting BPT criteria and outcome.

Patients in the post-BPT cohort were more frail as demonstrated by a significantly higher NHFS, and individual criteria associated with worse outcome such as male sex, anaemia and malignancy were all more common in the post-BPT cohort.(23) This may have negated any benefit as a cohort from the introduction of BPT due to the population having a poorer physiological state, and hence worse outcomes despite improvements in peri-operative care. Should this failure of BPT to improve outcomes is real and not a type 2 error, then the clinical practice of individual units at the time of its introduction should be considered. The BPT encourages best practice that was already recommended by several national bodies. Expedited surgery and MDT based rehabilitation were also strongly promoted to prior to its introduction. Hence many of the BPT criteria may have already been implemented within the department and hence introducing BPT would have only improved monitoring of these processes rather than significantly changing the pre-existing model of care.

Failure to achieve BPT at an individual level was associated with poorer outcomes. This suggests that either meeting some or all of the BPT criteria matters or that patients who fail to meet them have pre-existing conditions that are associated with poorer outcomes – or a combination of the two. Those who failed to meet the BPT criteria had a worse NHFS and possessed factors known to adversely affect survival such as being male, anaemia and malignancy. However, the difference in NHFS is relatively small and unlikely to account for all the observed difference in mortality. The two BPT criteria associated with poorer outcomes were delay to surgery and post-op assessment of cognition.

A delay to surgery was also the most common reason behind not meeting the BPT, those who did not achieve BPT took twice as long to receive surgery (41hrs vs 21hrs, p = 0.004). This is despite a significant reduction in the time to surgery after the introduction of BPT (median time to theatre 44hours pre-BPT vs 23hours post-BPT, P<0.005). Expedited surgery is known to be associated with improved survival.(24-26) However, this may be a reflection of the underlying medical co-morbidity requiring optimisation prior to surgery rather than a direct benefit of early surgery itself.

Previous studies have demonstrated no increase in mortality when surgery is delayed up to four days when the delay is not due to medical co-morbidities.(27) A delay to surgery of over 36 hours was not associated with an increased NHFS (mean NHFS 4.63, time to theatre <36 hours vs mean

NHFS 4.72, time to theatre over 36 hours; p=0.08) and the commonest cause for a delay to theatre was a lack of resources rather than the patient being medically unfit.(table 5) This, along with an increased NHFS in the post-BPT cohort, may explain why the reduction in time to theatre was not associated with a reduction in mortality.

The association between poor outcome and failure to record an abbreviated mental test (AMT) score postoperatively was an unexpected finding. We regard this result as hypothesis generating and it may be a spurious finding. As with delay to surgery there may be patient factors resulting a failure to document the AMT, or there be an impact on care resulting from this omission, such as missed diagnoses. Patients without a documented AMT may have been clearly confused; both pre-existing cognitive impairment and delirium are known risk factor for poorer outcome.(28-30)

Anecdotally, an AMT is omitted when the patient is critically unwell or on an end of life pathway, which might explain the association between 30-day mortality and AMT monitoring. However, the median time to death in those patients who died and missed an AMT was 308 days (IQR 4-708), which perhaps makes this less likely.

The length of stay in hospital did not significantly vary between cohorts, it is known to be multi-factorial hence the lack of improvement is likely to reflect the availability of medical, nursing and social services to provide support after discharge in a population with low physiological reserve, as well as the post-operative recovery.

The quality and accuracy of the data used in this study is of a high standard; a dedicated audit team prospectively maintain the electronic database which is cross checked for inaccuracy and has previously been shown to have an error rate of <3%.(26) However, despite this, there are limitations to this study. The time over which the data was collected introduces potential confounders, as changes in other aspects of care are likely to have occurred. During this time period our major trauma network was activated which may have both positive and negative effects on aspects of hip fracture care. However other centres have reported no changes in hip fracture care from becoming a major trauma centre.(31) The introduction of the BPT is likely to have resulted in a gradual change in practice along with a period of adjustment to the new protocol where the reported results may not reflect actual practice. We attempted to account for this by omitting the year after its introduction from the data.

Conclusion

The introduction of the BPT has not led to a demonstrable improvement in outcomes across our hip fracture population. However, during this time period the patients with hip fractures have become significantly more frail with more co-morbidities.(4) There does appear to be a benefit to individual patients associated with achieving BPT. The survival benefit from achieving BPT is potentially due to selection bias, as patients with less co-morbidities are less likely to have acute medical problems that would delay surgery or affect their recovery. It may also be that the process of care makes a difference to outcome.

Legends

Figure 1: Kaplan-Meier survival analysis comparing long-term survival before and after the introduction of BPT

Figure 1: Kaplan-Meier analysis of long-term survival comparing those who achieved BPT criteria against those who did not

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Competing Interests Statement

The authors have read and understood the BMJ policy on declaration of interests and declare that we have no competing interests

Authors Contribution

1. Ben Oakley: data and statistical analysis, data interpretation, manuscript preparation
2. Jessica Nightingale: data collation and analysis
3. Christopher Moran: study design, data interpretation, manuscript review
4. Iain Moppett: study design, statistical analysis, data interpretation, manuscript review

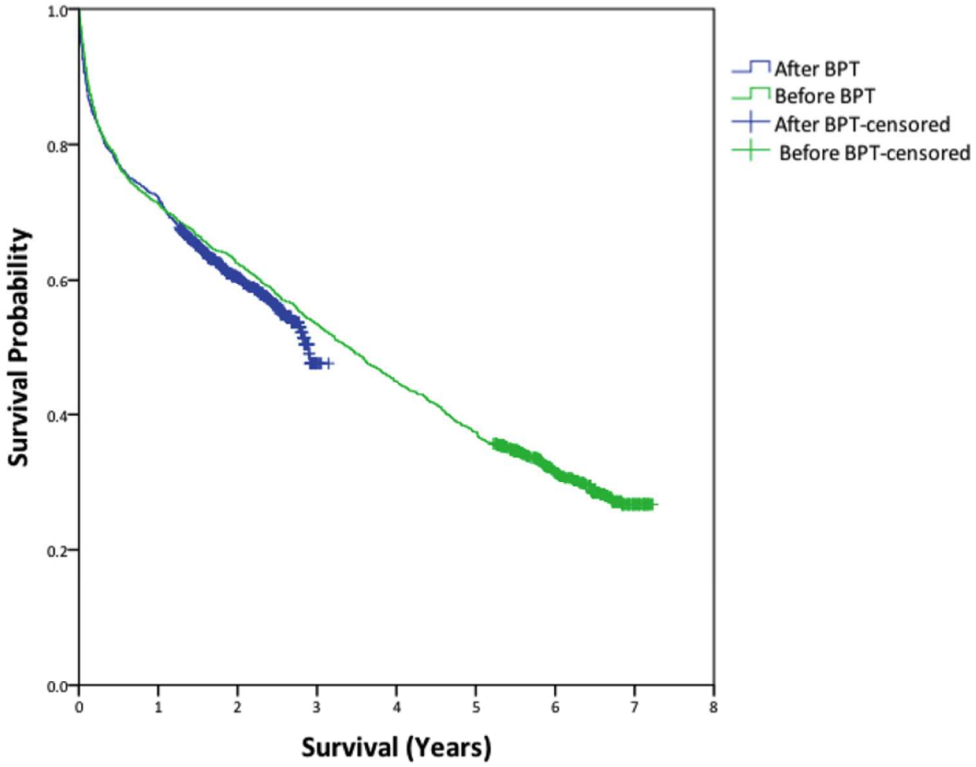
Data Sharing Statement

All data is available upon request to the authors.

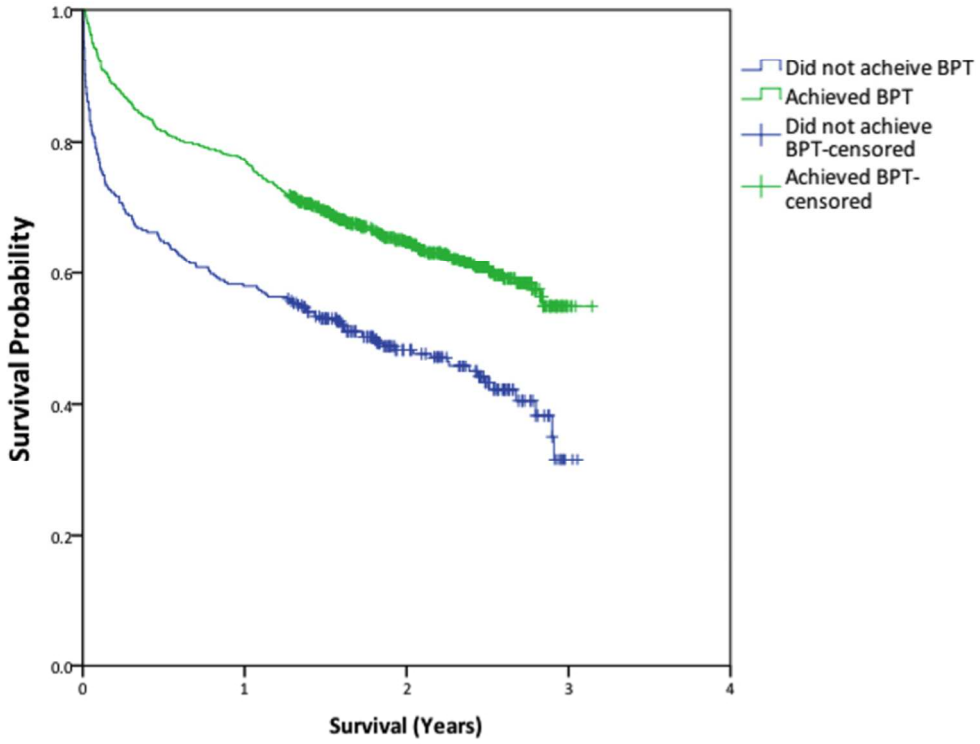
References

1. Royal College of Physicians. National Hip Fracture Database (NHFD) annual report 2014. 2014. Available from: http://www.nhfd.co.uk/2014report
2. Griffin XL, Parsons N, Achten J, Fernandez M, Costa ML. Recovery of health-related quality of life in a United Kingdom hip fracture population. The Warwick Hip Trauma Evaluation--a prospective cohort study. The bone & joint journal. 2015;97-b(3):372-82.
3. Cooper C, Campion G, Melton LJ, 3rd. Hip fractures in the elderly: a world-wide projection. Osteoporosis international : a journal established as result of cooperation between the European Foundation for Osteoporosis and the National Osteoporosis Foundation of the USA. 1992;2(6):285-9.
4. Baker PN, Salar O, Ollivere BJ, Forward DP, Weerasuriya N, Moppett IK, et al. Evolution of the hip fracture population: time to consider the future? A retrospective observational analysis. BMJ open. 2014;4(4):e004405.
5. Royal College of Physicians. National Hip Fracture Database (NHFD) annual report 2015. 2015. Available from: http://www.nhfd.co.uk/2015report.
6. Lawrence TM, White CT, Wenn R, Moran CG. The current hospital costs of treating hip fractures. Injury. 2005;36(1):88-91.
7. Holt G, Smith R, Duncan K, Hutchison JD, Reid D. Changes in population demographics and the future incidence of hip fracture. Injury. 2009;40(7):722-6.
8. Department of Health. Payment by Results Guidance for 2010-2011. 2010. Available from: http://webarchive.nationalarchives.gov.uk/20130107105354/http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_112284
9. The care of patients with fragility fracture ("Blue Book"). British Orthopaedic Association, September 2007. Available from: http://www.bgs.org.uk/index.php?option=com_content&view=article&id=338
10. Royal College of Physicians. Best Practice Tariff (BPT) for Fragility Hip Fracture Care User Guide. 2010. Available from: http://www.www.nhfd.co.uk.
11. Department of Health. Payment by Results Guidance for 2013-2014. 2013. Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/214902/PbR-Guidance-2013-14.pdf
12. Hawkes D, Baxter J, Bailey C, Holland G, Ruddlesdin J, Wall A, et al. Improving the care of patients with a hip fracture: a quality improvement report. BMJ quality & safety. 2015;24(8):532-8.
13. Khan SK, Weusten A, Bonczek S, Tate A, Port A. The Best Practice Tariff helps improve management of neck of femur fractures: a completed audit loop. British journal of hospital medicine (London, England : 2005). 2013;74(11):644-7.
14. Khan SK, Shirley MD, Glennie C, Fearon PV, Deehan DJ. Achieving best practice tariff may not reflect improved survival after hip fracture treatment. Clinical interventions in aging. 2014;9:2097-102.
15. Maxwell MJ, Moran CG, Moppett IK. Development and validation of a preoperative scoring system to predict 30 day mortality in patients undergoing hip fracture surgery. British journal of anaesthesia. 2008;101(4):511-7.
16. Moppett IK, Parker M, Griffiths R, Bowers T, White SM, Moran CG. Nottingham Hip Fracture Score: longitudinal and multi-assessment. British journal of anaesthesia. 2012;109(4):546-50.
17. Parker MJ, Currie CT, Mountain JA, Thorngren K-G. Standardized audit of hip fracture in Europe (SAHFE). Hip Int 1998; 8: 10-15.
18. Marufu TC, Mannings A, Moppett IK. Risk scoring models for predicting peri-operative morbidity and mortality in people with fragility hip fractures: Qualitative systematic review. Injury.46(12):2325-34.
19. Karres J, Heesakkers NA, Ultee JM, Vrouenraets BC. Predicting 30-day mortality following hip fracture surgery: Evaluation of six risk prediction models. Injury.46(2):371-7.

20. White SM, Moppet IK, Griffiths R, Johansen A, Wakeman R, Boulton C, Plant F, Williams A, Pappenheim K, Majeed A, Currie CT, Grocott MPW. Outcomes after anaesthesia for hip fracture surgery. Secondary analysis of prospective observational data from 11 085 patients included in the UK Anaesthesia Sprint Audit of Practice (ASAP 2). Anaesthesia. 2016; In press.
21. Marufu TC, White SM, Griffiths R, Moonesinghe R, Moppett IK. Comparison of the Nottingham Hip Fracture Score (NHFS) with the Surgical Outcome Risk Tool (SORT) in predicting 30-day mortality after hip fracture surgery. Anaesthesia. 2016; In press.
22. National Confidential Enquiry into Patient Outcome and Death. The NCEPOD Classification of Intervention. 2004. http://www.ncepod.org.uk/pdf/NCEPODClassification.pdf.
23. Potter LJ, Doleman B, Moppett IK. A systematic review of pre-operative anaemia and blood transfusion in patients with fractured hips. Anaesthesia. 2015;70(4):483-500.
24. Colais P, Di Martino M, Fusco D, Perucci CA, Davoli M. The effect of early surgery after hip fracture on 1-year mortality. BMC geriatrics. 2015;15:141.
25. Simunovic N, Devereaux PJ, Sprague S, Guyatt GH, Schemitsch E, Debeer J, et al. Effect of early surgery after hip fracture on mortality and complications: systematic review and meta-analysis. CMAJ : Canadian Medical Association journal = journal de l'Association medicale canadienne. 2010;182(15):1609-16.
26. Wiles MD, Moran CG, Sahota O, Moppett IK. Nottingham Hip Fracture Score as a predictor of one year mortality in patients undergoing surgical repair of fractured neck of femur. British journal of anaesthesia. 2011;106(4):501-4.
27. Moran CG, Wenn RT, Sikand M, Taylor AM. Early mortality after hip fracture: is delay before surgery important? The Journal of bone and joint surgery American volume. 2005;87(3):483-9.
28. Heruti RJ, Lusky A, Barell V, Ohry A, Adunsky A. Cognitive status at admission: does it affect the rehabilitation outcome of elderly patients with hip fracture? Archives of physical medicine and rehabilitation. 1999;80(4):432-6.
29. van Dortmont LM, Douw CM, van Breukelen AM, Laurens DR, Mulder PG, Wereldsma JC, et al. Outcome after hemi-arthroplasty for displaced intracapsular femoral neck fracture related to mental state. Injury. 2000;31(5):327-31.
30. Zakriya K, Sieber FE, Christmas C, Wenz JF, Sr., Franckowiak S. Brief postoperative delirium in hip fracture patients affects functional outcome at three months. Anesthesia and analgesia. 2004;98(6):1798-802, table of contents.
31. Wong K, Rich J, Yip G, Loizou C, Hull P. Management of hip fractures pre- and post-Major Trauma Centre activation. Injury. 2015;46(10):1975-7.



Kaplan-Meier survival analysis comparing long-term survival before and after the introduction of BPT
Figure 1
77x61mm (300 x 300 DPI)



Kaplan-Meier analysis of long-term survival comparing those who achieved BPT criteria against those who did not
Figure 2
82x66mm (300 x 300 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	2-4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4,5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	4,5
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	Not matched
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4,5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*4,5*
Bias	9	Describe any efforts to address potential sources of bias	4
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5
		(*b*) Describe any methods used to examine subgroups and interactions	5
		(*c*) Explain how missing data were addressed	prospective
		(*d*) If applicable, explain how loss to follow-up was addressed	Not applicable
		(*e*) Describe any sensitivity analyses	Not applicable

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5
		(b) Give reasons for non-participation at each stage	5
		(c) Consider use of a flow diagram	Not used
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6
		(b) Indicate number of participants with missing data for each variable of interest	Not missing
		(c) Summarise follow-up time (eg, average and total amount)	5
Outcome data	15*	Report numbers of outcome events or summary measures over time	6
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	7
		(*b*) Report category boundaries when continuous variables were categorized	6
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	7
Discussion			
Key results	18	Summarise key results with reference to study objectives	8
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	9
Generalisability	21	Discuss the generalisability (external validity) of the study results	9,10
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	11

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Does Achieving the Best Practice Tariff Improve Outcomes in Hip Fracture Patients? An Observational Cohort Study

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Keywords: hip fracture, trauma, elderly, best practice tariff

Abstract (299 words)

Objectives: To determine if the introduction of the best practice tariff (BPT) has improved survival of the elderly hip fracture population, or if achieving BPT results in improved survival for an individual.

Setting: A single university-affiliated teaching hospital

Participants: 2,541 patients aged over 60 admitted with a neck of femur fracture between 2008 and 2010 and from 2012 to 2014 were included, to create two cohorts of patients, before and after the introduction of BPT. The post-BPT cohort was divided into two groups, those who achieved the criteria and those who did not.

Primary and Secondary Outcome Measures: Primary outcomes of interest were differences in mortality across cohorts. Secondary analysis was performed to identify associations between individual BPT criteria and mortality.

Results: The introduction of BPT did not significantly alter overall 30-mortality in the hip fracture population (8.3% pre-BPT vs 10.0% post-BPT; p = 0.128). Neither was there a significant reduction in length of stay (15 days (IQR 9-21) pre-BPT vs 14 days (IQR 11-22); p=0.236). However, the introduction of BPT was associated with a reduction in the time from admission to theatre (median 44hours pre-BPT (IQR 24-44) vs 23hours post-BPT (IQR 17-30); p<0.005). 30-day mortality in those who achieved BPT was significantly lower (6.0% vs 21.0% in those who did not achieve-BPT; p < 0.005). There was a survival benefit at one year for those who achieved BPT (28.6% vs 42.0% did not achieve-BPT; p<0.005). Multivariate logistic regression revealed that of the BPT criteria, AMT monitoring and expedited surgery were the only BPT criteria that significantly influenced survival.

Conclusion: The introduction of the BPT has not led to a demonstrable improvement in outcomes at organisational level, though other factors may have confounded any benefits. However, patients where BPT criteria are met appear to have improved outcomes.

Strengths and limitations of this study

- Large patient cohort
- Long study period potential confounder
- Potential type two-error despite large sample size
- An observational study hence conclusions are limited

Introduction

Hip fractures are an ever-increasing public health burden; the numbers of hip fractures are predicted to be more than 100,000 per year by 2020.(1-3) The latest UK data reports an average 30 day mortality of 7.1%.(4) One year mortality rates are reported between 10-30% with a significantly reduced quality of life amongst those who survive.(3-5) Acute hospital and overall length of stay are 16.4 and 21.1 days respectively and just over half of patients return to their original residence within 30 days.(4)

Hip fractures mostly, though not exclusively, occur in older people with significant medical and social co-morbidity.(2, 3) Hip fracture carries a significant socio-economic burden costing £1-2 billion per year in the UK.(6)

The poor outcomes and wide variations in standards of care led, in April 2010, to the UK Department of Health introducing a financial incentive to English National Health Service (NHS) hospitals. This essentially meant that the 'base' payment made to hospitals for hip fracture care was reduced, but there was additional funding for meeting all of a set of defined process measures: the 'Best Practice Tariff' (BPT).(7) The Best Practice Tariff criteria were based on national guidance and expert opinion and was intended to drive improvements in processes of care from admission to discharge, where there was evidence of sub-optimal practice and where changes in process were felt likely to have the biggest impact.(8) The criteria are detailed in table 1 and included prompt surgery and the involvement of an orthogeriatrician. The expectation was that patient outcomes would improve as well as reducing length of stay and care costs.(9)

Table 1: Best Practice Tariff Criteria

	Best Practice Tariff Criteria (10)
1	Time to surgery with 36 hours from arrival in the A&E department to the start of anaesthesia (or from time of diagnosis if an admitted patient)
2	Admitted under the joint care of a consultant geriatrician and consultant orthopaedic surgeon
3	Admitted using an assessment protocol agreed by geriatric medicine, orthopaedic surgery and anaesthesia
4	Peri-operative assessment by geriatrician in the perioperative period (within 72hours of admission)
5	Post-operative geriatrician guided multi-professional rehabilitation team
6	Fracture prevention assessments (falls and bone health)
7	Two abbreviated mental test (AMT) scores performed and all the scores recorded in the NHFD with the first test being carried out prior to surgery and the second post-surgery but within the same spell

* Failure of criteria 3 reflects a lack of documentary evidence that the agreed multi-disciplinary assessment process was used.

Upon the introduction of BPT, the base tariff, payable irrespective of whether the BPT criteria were met, was reduced by £110. However, should all the BPT criteria be met then an additional payment

would be made of £445.(7) Subsequent changes to the tariff system have increased this price differential to £1,333(10) With a potential uplift of over £1000 per patient, and compliance monitored via the National Hip Fracture Database, implementation of the hip fracture BPT criteria has been widespread. Current BPT achievement rates are around 63%, 100% compliance is not expected, as some patients will inevitably not be fit for surgery within 36 hours of admission.(4) Yet increased compliance is often considered to correlate with an increase in quality of care.(4, 10-12)

However, there is limited evidence that increased compliance with BPT has led to improved patient outcomes. There are several published audits demonstrating reduced length of stay following increased compliance of the BPT, however length of stay is multifactorial and these results were confounded by changes in service provision at reporting hospitals which supported BPT compliance.(11, 12) A single study directly assessed the effects of implementing the BPT on mortality, but was unable to demonstrate any survival benefit.(13) Although there has been an improvement in outcomes that parallels the introduction of BPT it is not possible to distinguish the possible effects of BPT from more generic improvements in care.

The aim of this study is to determine if the introduction of the BPT has improved outcomes for the hip fracture population and whether achieving the BPT affects an individual's outcome.

Method

This is an observational cohort 'before and after' study. The study was conducted using prospectively collected, anonymised patient data from the Nottingham Hip Fracture Database.

Inclusion and exclusion criteria

The Nottingham Hip Fracture database (14, 15) is a prospectively collected, quality controlled dataset based on the European Standardised Audit of Hip Fractures in Europe (SAHFE) process.(16) Retrospective analysis was performed on two cohorts of patients admitted with a fractured neck of femur to the Queen's Medical Centre. The pre-BPT cohort was from April 2008 until April 2010 and the post-BPT cohort from April 2012 to April 2014. The period between April 2010 and 2011 where BPT was introduced was excluded *a priori* in order to avoid confounding as the BPT criteria were subsequently changed in 2011 (table 1).

Patients were divided *a priori* into three groups:

1. Admissions before the implementation of BPT
2. Admissions after the extended BPT was implemented in 2011 who met the BPT criteria
3. Admissions after extended BPT implementation but did not achieve the BPT criteria.

Any patient aged under 60, managed non-operatively or who sustained a further hip fracture during the time of the study was excluded.

Mortality and admission data were collected for all patients. Mortality data is provisioned by the Office for National Statistics; the last update of mortality data was June 2015 and all data are censored at that point.

Variables

Demographic, physiological, operative and admission data were collected for all patients. The Nottingham Hip Fracture Score (NHFS) was prospectively calculated for all patients as part of routine clinical practice. The NHFS is a weighted seven-factor frailty score specific to hip fracture: age; cognitive function on admission (Abbreviated Mental Test Score <7); not living at home; sex (male); haemoglobin < 100g L^{-1}; previous malignancy; >1 comorbidity (stroke/transient ischemic attack; cardiovascular disease; diabetes; previously diagnosed renal disease). It has previously been shown to predict 30-day post hip fracture mortality. The NHFS is a quantitative assessment of the physiological state of the patient and has been shown to be an accurate predictor of thirty-day mortality and length of hospital stay both within the UK and internationally.(15, 17-20)

Statistical Analysis

The primary outcomes were:

Differences in mortality in the two cohorts: pre-BPT and post-BPT; and differences in mortality in the achievers and non-achievers in the post-BPT cohort. The primary analysis was performed using 30-day mortality, assessed using chi-squared tests; complementary analysis was performed using Cox proportional hazards model.

Secondary analyses were performed using multivariate logistic regression to identify associations between individual BPT criteria and 30-day mortality.

Data was analysed using SPSS statistics programme version 23. Categorical variables are presented as proportions. Ordinal variables are presented as mean or median with interquartile range (IQR) as appropriate. Groups were compared with Chi-squared, Student's t-test or Mann-Whitney U test as appropriate. A p value of less than 0.05 was considered significant. Multivariate logistic regression was performed to identify factors that influenced patient outcomes with 30-day mortality: backward entry, factors with univariate $p < 0.10$ included and $p < 0.05$ as criterion for keeping factors in the model.

Formal power analysis was not performed as the sample size is fixed by the nature of the dataset.

Results

2,917 patients were admitted with a hip fracture during the study period. 174 were excluded due to sustaining more than one hip fracture; 79 were managed non-operatively; and 123 were aged under 60. This left 2,541 patients for analysis of which 1,364 were before BPT was introduced and 1,177 after BPT. 314 of the 1177 did not achieve the BPT criteria. Patient characteristics and admission data are summarised in table 2. As previously reported the population characteristics changed over time with more patients admitted from their own home, but an increase in medical complexity demonstrated by an increase in patients with multiple co-morbidity, reduction in mobility independence and an increase in average NHFS.(3)

Table 2: Patient characteristics and admission data

Patient Characteristics	Prior to BPT	After BPT	P Value	Achieved BPT	Did not Achieve BPT	P Value
N	1364	1177		863	314	
Median Age Years (IQR)	83 (77-88)	84 (78-89)	0.469	83 (78-89)	82 (77-88)	=0.186
Gender Male:Female	336:1028	306:871	0.430	200:663	106:208	**<0.005**
30-day mortality N (%)	113 (8)	118 (10)	0.128	52 (6)	66 (21)	**<0.005**
Median AMT (IQR)	8 (4-10)	8 (4-10)		8 (4-10)	8(4-10)	
Mean AMT (SD)	6.71 (3.74)	6.73 (3.69)	0.826	6.74 (3.65)	6.68 (3.80)	0.85
Median NHFS (IQR)	4 (4-6)	4 (4-6)		4 (4-6)	4 (4-6)	
Mean NHFS	4.61	4.72	**0.026**	4.69	4.88	**<0.005**
Mean Admission Hb (SD)	123.8 (1.83)	123.3 (1.78)	0.435	124.0 (1.75)	121.0 (1.87)	**0.03**
Median Admission Hb (IQR)	12.5 (10.5-14.5)	12.3 (10.3-14.3)				
Malignant Fracture (%)	163 (12)	165 (14)	0.121	105 (12)	60 (19)	**0.03**
Median length of stay (IQR)	15 (9-21)	14 (9-19)	0.236	18 (4-24)	18 (3-29)	0.328
Median time: admission to theatre (hours)(IQR)	44 (23.6-64.4)	23 (17-30)	**<0.005**	21 (16-27)	41 (27-55)	**<0.005**
Residence						
Nursing home (%)	151 (11)	98 (8)		74 (8.6)	24 (7.6)	
Own home (%)	931 (68)	869 (74)		625(72)	244 (78)	
Warden aided/residential home (%)	264 (19)	208 (18)	**0.001**	45 (5)	45 (14)	0.08
Hospital inpatient (%)	6 (0)	0 (0)				
Rehab facility (%)	0 (0)	2 (0)				
Other (%)	9 (0)	2 (0)		0 (0)	1 (0)	
Number of Comorbidities						
<2 (%)	916 (67)	675 (57)	**0.000**	508 (59)	167 (53)	0.08
≥2 (%)	448 (33)	502 (43)		355(41)	147 (47)	
Living alone prior to fracture (%)	613 (45)	496 (42)	0.126	363 (42)	133 (42)	0.56
Walking ability prior to fracture						
Independent outdoors (%)	668 (49)	549 (47)		404 (47)	145 (46)	
Accompanied outdoors (%)	231 (17)	213 (18)		161 (19)	52(17)	
Independent indoors (%)	247 (18)	169 (14)	**0.002**	127 (15)	42 (13)	0.377
Accompanied indoors (%)	76 (6)	67 (6)		47 (5)	20 (6)	
Unable/transfer only (%)	26 (2)	25 (2)		13 (2)	11 (4)	
Not stated (%)	116 (9)	154 (13)		110 (13)	44 (14)	

There was no statistically significant difference in 30-day mortality between the pre-BPT cohort and the post-BPT cohort (113/1364 (8.3%) pre-BPT vs 118/1177 (10.0%) post-BPT; p = 0.128). Survival analysis showed no difference between the two cohorts either (p = 0.22), figure 1. NHFS increased from 4.61 (1.47) (mean (SD)) in the pre-BPT cohort to 4.74 (1.45) post-BPT (p=0.026).

There was no significant reduction in length of stay 15 days (IQR 9-21) pre-BPT vs 14 days (IQR 11-22); p=0.236) between the two cohorts. The median time from admission to the emergency department to theatre was significantly reduced in the post-BPT cohort (44hours pre-BPT (IQR 24-44) vs 23hours post-BPT (IQR 17-30); p<0.005). The proportion of patients being operated on within 36 hours of admission was also significantly higher (485/1364, 36% pre-BPT vs 974/1177, 84% post-BPT; p<0.005).

Within the post-BPT cohort, the 30-day mortality was significantly lower in those who achieved BPT (52/863 (6%) vs 66/314 (21%) in those who did not achieve-BPT; p < 0.005). Survival analysis showed a significant long term survival benefit for those who achieved BPT (figure 2, p<0.005). One-year mortality for those who achieved BPT was 28.6% (196/863), in comparison to 42.0% (132/314) for those who did not achieve-BPT (p<0.005).

Univariate analysis of patient characteristics, their NHFS and the individual NHFS components was performed to identify potential variations between the two groups to explain the difference in mortality rate. Those who did not achieve the BPT criteria had higher NHFS scores, had higher rates of malignancy, were more likely to be male and had lower haemoglobin concentrations (table 1).

Univariate analysis of BPT criteria revealed that time to surgery, orthogeriatrician review, post-operative AMT monitoring, MDT rehabilitation plus falls and bone protection assessment were negatively associated with 30-day mortality (i.e. not achieving these criteria was associated with greater 30-day mortality; table 3). Multivariate logistic regression revealed that of the BPT criteria, AMT monitoring and expedited surgery were the only factors that were significantly associated with survival both at 30-days and at one year (table 4).

Table 3: Results of univariate analysis of BPT criteria as predictors for 30-day mortality

	Survived 30-days	Did not Survive 30-days	Odds Ratio (OR)	OR 95% Confidence Interval		p
				Lower	Upper	
Time to Surgery	886/1059	85/118	0.503	0.326	0.776	**<0.005**
MDT Admission Protocol	1046/1055	115/118	0.330	0.088	1.236	0.11
AMT pre-op	1034/1059	116/118	1.402	0.328	5.996	0.48
Orthogeriatrician review within 72hours	1052/1058	110/118	0.078	0.027	0.230	**<0.005**
AMT post-op	1013/1059	81/118	0.099	0.061	0.162	**<0.005**
MDT guided rehabilitation	1023/1057	85/114	0.097	0.057	0.168	**<0.005**
Falls assessment	1039/1058	103/118	0.126	0.062	0.255	**<0.005**
Bone protection assessment	1038/1059	102/118	0.129	0.065	0.255	**<0.005**

a. An Odds Ratio of <1 infers that achieving the criterion was associated with an improved rate of survival

Table 4: Results of multivariate logistic regression of BPT criteria as predictors for 30-day and 1 Year mortality

	30-day Mortality			1 Year Mortality		
	B	S.E	Sig.	B	S.E	Sig.
Time to Surgery	-.641	.249	**.010**	-.639	.169	**.000**
MDT Admission Protocol	-1.162	.812	.153	-1.347	.700	.0.54
AMT pre-op	2.391	.932	**.010**	2.031	.716	**.005**
Orthogeriatrician review within 72hours	-.988	.777	.204	.393	.768	.609
AMT post-op	-1.740	.393	.000	-.642	.355	.071
MDT guided rehabilatation	-1.234	.446	.006	-.819	.400	.041
Falls assessment	-.474	.939	.614	.003	.831	.997
Bone protection assessment	.715	.946	.450	-1.077	.771	.162
Constant	.438	1.039	.673	.895	.954	.348

ime to Surgery, MDT Admission Protocol, AMT pre-op, Orthogeriatrician review within 72hours, AMT post-op, MDT guided rehabilatation, Falls assessment, Bone protection assessment

The commonest cause for failing to meet BPT criteria was a delay in surgery, occurring in approximately a third of cases. All patients were admitted under the joint care of a geriatrician and orthopaedic surgeon. The breakdown of BPT failure and delay to surgery are summarised in tables 5 and 6.

Table 5: Breakdown of failure to meet BPT criteria

Criteria	N (%)
Time to Surgery	100 (32)
AMT post-op	83 (26)
MDT based rehabilitation	63 (20)
Bone protection assessment	37 (12)
Falls assessment	34 (11)
AMT recorded pre-op	27 (9)
Orthogeriatrician review with 72 hours	14 (4)
MDT admission assessment	12 (4)
Admission under joint care of Surgeon and Geriatrician	0 (0)

Table 6: Causes in delay to surgery of over 36 hours

Cause	N (%)
Lack of resources*	640 (59)
Medically Unfit	200 (18)
Awaiting investigations	157 (15)
Deranged Coagulation	57 (5)
Other	28 (3)

*"lack of resources" is a broad coding category that can include: a delay due to a caseload with a higher NCEPOD classification (21), theatre staff availability and unexpected theatre delays such as prolonged operating time

Discussion

The introduction of BPT was not associated with a reduction in mortality or length of hospital stay in our hip fracture population. However, at a patient level, failure to achieve BPT was associated with significantly poorer survival. Consistent with NHFD data, delay to surgery is the most common reason not to meet the BPT criteria, despite a significant reduction in the average time from admission to theatre.

The data concerning the impact of BPT are inconsistent. Some studies have reported a temporal association between implementation of BPT and improved outcomes;(11, 12) other studies have not demonstrated a change, though this may have been due to inadequate power.(13) In Wales, which provides data to the National Hip Fracture Database but does not have a BPT mechanism, there have been modest temporal reductions in mortality over a similar time period. As this is an observational study we are not able to distinguish association and causation. Despite Nottingham having one of the largest hip fracture units in England, combined with a long-standing high-quality clinical database, the analysis is probably underpowered to demonstrate a clinically achievable difference at an organisational level. Of note, mortality in the post-BPT cohort was non-significantly greater than in the pre-BPT cohort. Conversely, the data do support an association at individual level between meeting BPT criteria and outcome.

Patients in the post-BPT cohort were more frail as demonstrated by a significantly higher NHFS, and individual criteria associated with worse outcome such as male sex, anaemia and malignancy were

all more common in the post-BPT cohort.(22) This may have negated any benefit as a cohort from the introduction of BPT due to the population having a poorer physiological state, and hence worse outcomes despite improvements in peri-operative care. Should this failure of BPT to improve outcomes is real and not a type 2 error, then the clinical practice of individual units at the time of its introduction should be considered. The BPT encourages best practice that was already recommended by several national bodies. Expedited surgery and MDT based rehabilitation were also strongly promoted to prior to its introduction. Hence many of the BPT criteria may have already been implemented within the department and hence introducing BPT would have only improved monitoring of these processes rather than significantly changing the pre-existing model of care.

Failure to achieve BPT at an individual level was associated with poorer outcomes. This suggests that either meeting some or all of the BPT criteria matters or that patients who fail to meet them have pre-existing conditions that are associated with poorer outcomes – or a combination of the two. Those who failed to meet the BPT criteria had a worse NHFS and possessed factors known to adversely affect survival such as being male, anaemia and malignancy. However, the difference in NHFS is relatively small and unlikely to account for all the observed difference in mortality. The two BPT criteria associated with poorer outcomes were delay to surgery and post-op assessment of cognition.

A significantly higher proportion of males did not achieve BPT (35% of men did not achieve BPT vs 24% of women; p<0.005). Male sex has previously been shown to be an independent predictor of 30-day mortality. (14) In the post-BPT cohort males were more likely to have over two co-morbidities (158/306 of males had >2 co-morbidities vs 344/871 of females; p<0.005) and were more likely to have surgery delayed (66/306 males' time to surgery was >36hrs vs 140/871 females; p=0.03). The failure of males to meet BPT criteria may be due to their underlying co-morbid state delaying surgery whilst their condition is optimised. However, this association has not been reported previously and may be a chance finding. Replication (or not) of this finding in other units is needed before firm conclusions can be drawn.

A delay to surgery was also the most common reason behind not meeting the BPT, those who did not achieve BPT took twice as long to receive surgery (41hrs vs 21hrs, p = 0.004). This is despite a significant reduction in the time to surgery after the introduction of BPT (median time to theatre 44hours pre-BPT vs 23hours post-BPT, P<0.005). Expedited surgery is known to be associated with improved survival.(23-25) However, this may be a reflection of the underlying medical co-morbidity requiring optimisation prior to surgery rather than a direct benefit of early surgery itself.

Previous studies have demonstrated no increase in mortality when surgery is delayed up to four days when the delay is not due to medical co-morbidities.(26) A delay to surgery of over 36 hours was not associated with an increased NHFS (mean NHFS 4.63, time to theatre <36 hours vs mean NHFS 4.72, time to theatre over 36 hours; p=0.08) and the commonest cause for a delay to theatre was a lack of resources rather than the patient being medically unfit (table 5). This, along with an increased NHFS in the post-BPT cohort, may explain why the reduction in time to theatre was not associated with a reduction in mortality.

The association between poor outcome and failure to record an abbreviated mental test (AMT) score postoperatively was an unexpected finding. We regard this result as hypothesis generating and it may be a spurious finding. As with delay to surgery there may be patient factors resulting a failure

to document the AMT, or there be an impact on care resulting from this omission, such as missed diagnoses. Patients without a documented AMT may have been clearly confused; both pre-existing cognitive impairment and delirium are known risk factor for poorer outcome.(27-29)

Anecdotally, an AMT is omitted when the patient is critically unwell or on an end of life pathway, which might explain the association between 30-day mortality and AMT monitoring. However, the median time to death in those patients who died and missed an AMT was 308 days (IQR 4-708), which perhaps makes this less likely.

The length of stay in hospital did not significantly vary between cohorts, it is known to be multi-factorial hence the lack of improvement is likely to reflect the availability of medical, nursing and social services to provide support after discharge in a population with low physiological reserve, as well as the post-operative recovery.

The quality and accuracy of the data used in this study is of a high standard; a dedicated audit team prospectively maintain the electronic database which is cross checked for inaccuracy and has previously been shown to have an error rate of <3%.(25) However, despite this, there are limitations to this study. The time over which the data was collected introduces potential confounders, as changes in other aspects of care are likely to have occurred. During this time period our major trauma network was activated which may have both positive and negative effects on aspects of hip fracture care. However other centres have reported no changes in hip fracture care from becoming a major trauma centre.(30) The introduction of the BPT is likely to have resulted in a gradual change in practice along with a period of adjustment to the new protocol where the reported results may not reflect actual practice. We attempted to account for this by omitting the year after its introduction from the data.

Conclusion

The introduction of the BPT has not led to a demonstrable improvement in outcomes across our hip fracture population. However, during this time period the patients with hip fractures have become significantly more frail with more co-morbidities.(3) There does appear to be a benefit to individual patients associated with achieving BPT. The survival benefit from achieving BPT is potentially due to selection bias, as patients with less co-morbidities are less likely to have acute medical problems that would delay surgery or affect their recovery. It may also be that the process of care makes a difference to outcome.

Legends

Figure 1: Kaplan-Meier survival analysis comparing long-term survival before and after the introduction of BPT

Figure 1: Kaplan-Meier analysis of long-term survival comparing those who achieved BPT criteria against those who did not

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Competing Interests Statement

The authors have read and understood the BMJ policy on declaration of interests and declare that we have no competing interests

Ethics Statement

The study was registered and accepted with the local audit department and deemed exempt from ethics review in accordance with trust guidelines.

Authors Contribution

1. Ben Oakley: data and statistical analysis, data interpretation, manuscript preparation
2. Jessica Nightingale: data collation and analysis
3. Christopher Moran: study design, data interpretation, manuscript review
4. Iain Moppett: study design, statistical analysis, data interpretation, manuscript review

Data Sharing Statement

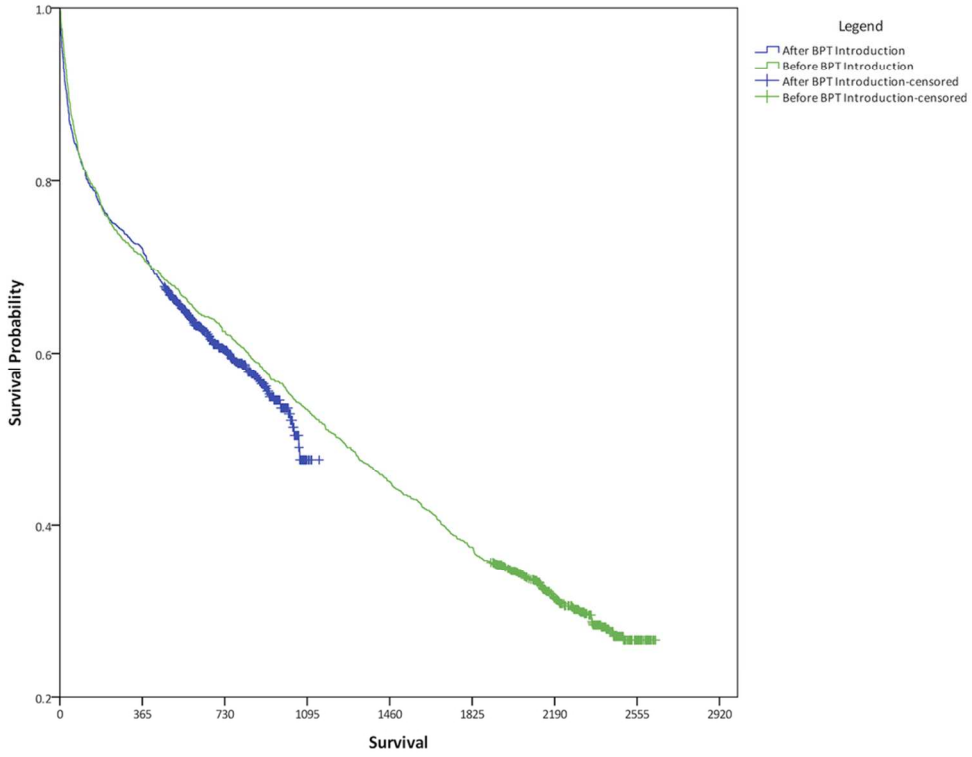
Data, suitably anonymized and summarized where appropriate, are available upon request to the authors.

References

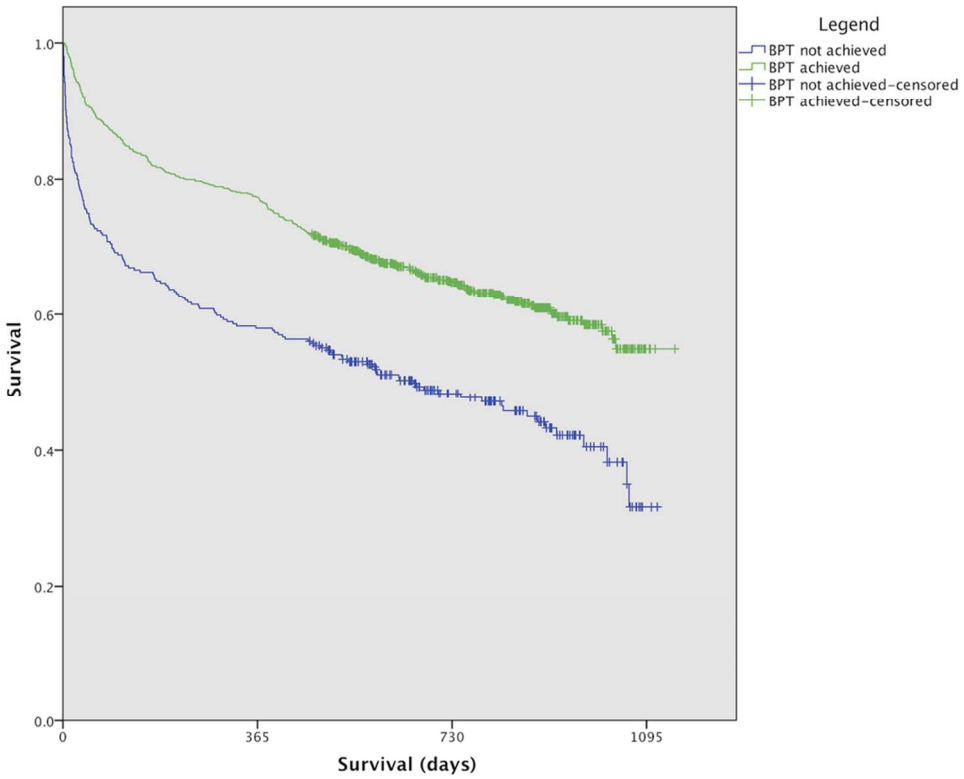
1. Holt G, Smith R, Duncan K, Hutchison JD, Reid D. Changes in population demographics and the future incidence of hip fracture. Injury 2009;40:722-6.
2. Cooper C, Campion G, Melton LJ, 3rd. Hip fractures in the elderly: a world-wide projection. Osteoporos Int 1992;2:285-9.
3. Baker PN, Salar O, Ollivere BJ, Forward DP, Weerasuriya N, Moppett IK, et al. Evolution of the hip fracture population: time to consider the future? A retrospective observational analysis. BMJ open 2014;4:e004405.
4. Royal College of Physicians. National Hip Fracture Database annual report 2016 London: RCP, 2016.
5. Griffin XL, Parsons N, Achten J, Fernandez M, Costa ML. Recovery of health-related quality of life in a United Kingdom hip fracture population. The Warwick Hip Trauma Evaluation--a prospective cohort study. Bone Joint J 2015;97-b:372-82.
6. Lawrence TM, White CT, Wenn R, Moran CG. The current hospital costs of treating hip fractures. Injury 2005;36:88-91.

7. Department of Health. Payment by results guidance for 2010–11. Leeds: Payment by Results team, Department of Health; 2010
8. British Orthopaedic Association and the British Geriatric Society. The Care of Patients with Fragility Fracture. Blue book publication by the British Orthopaedic Association, 2007.
9. Royal College of Physicians. Best Practice Tariff (BPT) for Fragility Hip Fracture Care User Guide. 2010.
10. Department of Health. Payment by results guidance for 2013–14. Leeds: Payment by Results team, Department of Health; 2013
11. Hawkes D, Baxter J, Bailey C, Holland G, Ruddlesdin J, Wall A, et al. Improving the care of patients with a hip fracture: a quality improvement report. BMJ Qual Saf 2015;24:532-8.
12. Khan SK, Weusten A, Bonczek S, Tate A, Port A. The Best Practice Tariff helps improve management of neck of femur fractures: a completed audit loop. Brit J Hosp Med (Lond) 2013;74:644-7.
13. Khan SK, Shirley MD, Glennie C, Fearon PV, Deehan DJ. Achieving best practice tariff may not reflect improved survival after hip fracture treatment. Clin Interv Aging 2014;9:2097-102.
14. Maxwell MJ, Moran CG, Moppett IK. Development and validation of a preoperative scoring system to predict 30 day mortality in patients undergoing hip fracture surgery. Br J Anaesth 2008;101:511-7.
15. Moppett IK, Parker M, Griffiths R, Bowers T, White SM, Moran CG. Nottingham Hip Fracture Score: longitudinal and multi-assessment. British journal of anaesthesia. 2012;109(4):546-50.
16. Parker MJ, Currie CT, Mountain JA, Thorngren K-G. Standardized audit of hip fracture in Europe (SAHFE). Hip Int 1998; 8: 10-15.
17. Marufu TC, Mannings A, Moppett IK. Risk scoring models for predicting peri-operative morbidity and mortality in people with fragility hip fractures: Qualitative systematic review. Injury 46:2325-34.
18. Karres J, Heesakkers NA, Ultee JM, Vrouenraets BC. Predicting 30-day mortality following hip fracture surgery: Evaluation of six risk prediction models. Injury 46:371-7.
19. White SM, Moppet IK, Griffiths R, Johansen A, Wakeman R, Boulton C, Plant F, Williams A, Pappenheim K, Majeed A, Currie CT, Grocott MPW. Outcomes after anaesthesia for hip fracture surgery. Secondary analysis of prospective observational data from 11 085 patients included in the UK Anaesthesia Sprint Audit of Practice (ASAP 2). Anaesthesia 2016;71:506-14.
20. Marufu TC, White SM, Griffiths R, Moonesinghe R, Moppett IK. Comparison of the Nottingham Hip Fracture Score (NHFS) with the Surgical Outcome Risk Tool (SORT) in predicting 30-day mortality after hip fracture surgery. Anaesthesia 2016;71:515-21.
21. National Confidential Enquiry into Patient Outcome and Death. The NCEPOD Classification of Intervention. 2004.
22. Potter LJ, Doleman B, Moppett IK. A systematic review of pre-operative anaemia and blood transfusion in patients with fractured hips. Anaesthesia 2015;70:483-500.
23. Colais P, Di Martino M, Fusco D, Perucci CA, Davoli M. The effect of early surgery after hip fracture on 1-year mortality. BMC Geriatr 2015;15:141.
24. Simunovic N, Devereaux PJ, Sprague S, Guyatt GH, Schemitsch E, Debeer J, et al. Effect of early surgery after hip fracture on mortality and complications: systematic review and meta-analysis. Can Med Assoc J 2010;182:1609-16.
25. Wiles MD, Moran CG, Sahota O, Moppett IK. Nottingham Hip Fracture Score as a predictor of one year mortality in patients undergoing surgical repair of fractured neck of femur. Br J Anaesth 2011;106:501-4.
26. Moran CG, Wenn RT, Sikand M, Taylor AM. Early mortality after hip fracture: is delay before surgery important? J Bone Joint Surg Am 2005;87:483-9.
27. Heruti RJ, Lusky A, Barell V, Ohry A, Adunsky A. Cognitive status at admission: does it affect the rehabilitation outcome of elderly patients with hip fracture? Arch Phys Med Rehabil 1999;80:432-6.

28. Van Dortmont LM, Douw CM, van Breukelen AM, Laurens DR, Mulder PG, Wereldsma JC, et al. Outcome after hemi-arthroplasty for displaced intracapsular femoral neck fracture related to mental state. Injury 2000;31:327-31.
29. Zakriya K, Sieber FE, Christmas C, Wenz JF, Sr., Franckowiak S. Brief postoperative delirium in hip fracture patients affects functional outcome at three months. Anesthesia and analgesia 2004;98:1798-802.
30. Wong K, Rich J, Yip G, Loizou C, Hull P. Management of hip fractures pre- and post-Major Trauma Centre activation. Injury 2015;46:1975-7.



Kaplan-Meier survival analysis comparing long-term survival before and after the introduction of BPT
Figure 1
89x71mm (300 x 300 DPI)



Kaplan-Meier analysis of long-term survival comparing those who achieved BPT criteria against those who did not
Figure 2
89x71mm (300 x 300 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	2-4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4,5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	4,5
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	Not matched
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4,5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*4,5*
Bias	9	Describe any efforts to address potential sources of bias	4
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5
		(*b*) Describe any methods used to examine subgroups and interactions	5
		(*c*) Explain how missing data were addressed	prospective
		(*d*) If applicable, explain how loss to follow-up was addressed	Not applicable
		(*e*) Describe any sensitivity analyses	Not applicable

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5
		(b) Give reasons for non-participation at each stage	5
		(c) Consider use of a flow diagram	Not used
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6
		(b) Indicate number of participants with missing data for each variable of interest	Not missing
		(c) Summarise follow-up time (eg, average and total amount)	5
Outcome data	15*	Report numbers of outcome events or summary measures over time	6
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	7
		(*b*) Report category boundaries when continuous variables were categorized	6
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	7
Discussion			
Key results	18	Summarise key results with reference to study objectives	8
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	9
Generalisability	21	Discuss the generalisability (external validity) of the study results	9,10
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	11

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.