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Associations of 4AT with mobility, length of stay and mortality in hospital and discharge destination among patients admitted with hip fractures

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ABSTRACT

Background: The 4AT (Alertness, Abbreviated Mental Test-4, Attention and Acute change or fluctuating course), a tool to screen cognitive impairment and delirium, has recently been recommended by the Scottish Intercollegiate Guidelines Network (SIGN). We examined its ability to predict health outcomes among patients admitted with hip fractures to a single hospital.

Methods: The 4AT was performed within 1-day after operation. A 4AT score of 0 means unlikely delirium or severe cognitive impairment (reference group); a score of 1-3 suggests possible chronic cognitive impairment, without excluding possibility of delirium; a score ≥4 suggests delirium with or without chronic cognitive impairment. Logistic regression, adjusted for: age; sex; nutritional status; co-morbidities; polypharmacy and anticholinergic burden, used the 4AT to predict mobility, length of stay (LOS), mortality, and discharge destination, compared to the reference group.

Results: From 537 (392 women, 145 men: 83.7±8.8 yr) consecutive patients, 522 completed the 4AT; 25% had prolonged LOS (>2 wk) and 6.8% died in hospital. Risk of failure to mobilise within 1-day of surgery was increased 2.4-fold with a 4AT score ≥4. Prolonged LOS was increased 2.4- and 3.1-fold respectively with 4AT scores of 1-3 or ≥4. In-patient mortality was increased 3.1-fold with a 4ATscore ≥4; but not with a 4AT score of 1-3. Change of residence on discharge was increased 3.1-fold with a 4AT score ≥4. These associations persisted after excluding patients with dementia.

Conclusions: For older adults with hip fracture the 4AT independently predicts immobility, prolonged LOS, death in hospital, and change in residence on discharge.

250 words

KEYPOINTS

- The prevalence of delirium in older patients with an acute condition is approximately 20-25%, but is often under-detected.
- The 4AT has been recommended by SIGN but there is a paucity of data on outcomes relating to this novel screening tool.
- A 4AT score ≥4 predicts failure to mobilise after hip surgery, prolonged LOS, mortality and change in discharge destination.
- Patients with a 4AT score ≥4 stayed in hospital an additional six days.
- The 4AT is a useful indicator of risk of adverse outcomes among older patients admitted with hip fracture.

INTRODUCTION

Delirium, defined as an acute change of mental status, is characterised by a reduced awareness of the environment and a disturbance in attention [1]. Older individuals admitted to hospital with an acute condition, including those with recent hip fracture, are vulnerable to delirium [2]. Underlying ageing-associated neurological disorders such as cognitive impairment and dementia [3] are risk factors, whilst infections and drugs, especially anticholinergic agents, are also major causes of delirium [4]. Delirium is estimated to occur in 20-25% of acute admissions [4] but it is often under-detected [5] with detrimental consequences. Cognitive impairment, a global term for, and a feature of dementia, delirium and cognitive impairment-no dementia [6], is itself a risk factor of reduced functional ability [7]. An assessment test (the 4AT) has been designed for rapid assessment of cognitive impairment, or delirium with or without cognitive impairment. This screening test comprises four components: “Attention”, “Abbreviated Mental Test-4” (“AMT4”), “Alertness” and “Acute change or fluctuating course”. The entire 4AT assessment takes only about two minutes to complete and does not require formal training [8].

The 4AT has recently been recommended by the Scottish Intercollegiate Guidelines Network [9] for use as a screening tool to identify patients with probable delirium in the National Health Service in Scotland. Moreover, the National Institute for Health and Care Excellence is currently monitoring results from a National Institute for Health Research study before considering recommendation [10]. However, there is a paucity of data on health outcomes in relation to the 4AT tool due to its relative novelty and complex relationship with a number of factors leading to and/or co-existing with delirium throughout the course of an illness. The present study examined the ability of

the 4AT to predict, independent of the presence or absence of delirium: mobility within 1-day after operation for a hip fracture (an indication of rapid recovery); length of stay (LOS) and mortality in hospital; as well as discharge destination for patients admitted with hip fractures.

METHODS

Study design, patients and setting

We conducted a cross-sectional study of a total of 537 consecutive older patients (60.2-101.8 years) admitted with hip fractures between Jan-2018 and June-2019 to the orthogeriatric ward in a single NHS hospital that served a population of over 410,000 people.

Data collection

Through our participation in the National Hip Fracture Database [11], data on hip fracture were collected prospectively by a Trauma Coordinator for every patient admitted with a hip fracture from the time of admission to discharge. The data comprised clinical characteristics and care quality, LOS during admission, and discharge destination. Pre-existing co-morbidities were identified from electronic record databases by the disease codes categorised by the International Classification of Diseases [12]. All data were updated regularly into a database managed by the lead orthogeriatrician. Demographic factors were documented including: residency prior to admission; medications; as well as dates of admission, operation, and death or discharge. Nutritional status (risk of malnutrition, malnourished or well-nourished) was assessed using the Malnutrition Universal Screening Tool (MUST) protocol [13]. Information on type of fracture and on sedation was recorded including general

anaesthesia (GA) only, GA with fascia-iliaca block, spinal block, spinal block with fascia-iliaca block and GA with spinal block.

The median time from hospital arrival to hip operation was 20.1 hours (IQR, 16.8-28.6; range, 3.1 hours-4.6 days). *The 4AT components* were measured within 1-day after hip operation by junior doctors and rated as:

"Alertness" (0: normal; X: mild sleepiness for <10 seconds after waking; 4: abnormal).

"AMT4" tests for recall of age, date of birth, place (name of hospital or building), current year (0: no mistakes; 1: one mistake; 2: two or more mistakes or untestable).

"Attention" tested by instructing the patient to list months in reverse order, starting from December (0: reciting ≥7months backwards correctly; 1: starts but lists <7months or refuses to start; 2: untestable).

"Acute change or fluctuating course" is evidence of significant change or fluctuation in mental status within the last 2 weeks and persisting in the last 24 hours (0: no; 4: yes).

Categorisation of variables

The scores obtained from the 4AT components described above were summated to produce composite scores for 4 the AT (0: unlikely to have delirium or severe cognitive impairment; 1-3: possible cognitive impairment and does not exclude the possibility of delirium; ≥4: possible delirium ±cognitive impairment) [8]. The term 'cognitive impairment' refers to chronic cognitive impairment such as dementia.

Polypharmacy was defined as four or more different types of medications taken daily. The *anticholinergic burden (ACB) scale* was calculated from scores based on the list of medications developed by the Aging Brain Program [14].

Type of sedation was categorised into: 1) GA with any other type of sedation or, 2) spinal nerve block with any other type of sedation except GA. *Mobilisation within 1-day after surgery* was defined as patients with hip fracture who were able to start rehabilitation no later than the day after surgery [15]. *Prolonged LOS* was defined as a LOS>14.4 days in hospital, *i.e.* in the upper quartile of LOS. *Change in discharge destination* was defined as those who came from their own home before hospital admission, but did not return home directly after discharge and transferred to places where increased care was provided, including rehabilitation units, residential home or nursing care. Those who died in hospital were excluded from this particular analysis.

Statistical analysis

Continuous data are expressed as mean values (±SD), except where data were not normally distributed as medians (25,75% interquartiles). Differences of LOS between the 4AT groups were tested by ANOVA, with *post-hoc* analysis using a least significant difference (LSD) test. Differences between categorical outcome variables were tested with chi-squared tests. Logistic regression was conducted to assess the association of 4AT scores with outcome measures including failure to mobilise within 1-day after hip surgery, prolonged LOS, death in hospital, and change in residence on discharge. Results are presented as four models: *model 1*, unadjusted; *model 2*, adjusted for age and sex; *model 3*, additional adjustment to model 2 for nutritional status, co-morbidities (dementia, Parkinson's disease and stroke) and medications (polypharmacy and ACB); *model 4*, repeat of model 3 in patients without a history of dementia. Odds ratios (OR) are given with 95% confidence intervals (CI). Analyses were performed using IBM SPSS Statistics, v23.0 (IBM Corp., Armonk, NY).

RESULTS

A total of 537 patients (392 women, 145 men) were admitted with a mean age of 83.7±8.8 years. In-patient mean LOS was 11.6±8.0 days. The number of deaths was 36 (6.8%). There were 441 (82.1%) patients admitted from their own home, 67 (12.5%) from residential care and 29 (5.4%) from nursing care. Among patients who came from their own home, 229 (51.9%) were discharged back to their original residence, 156 (35.4%) transferred for rehabilitation, 11 (2.5%) to residential or nursing care and 25 (5.8%) died in hospital (the 11 remaining deaths in hospital were of patients from residential/nursing care). For the remaining 20 (4.5%) patients admitted from home 13 (2.9%) were transferred elsewhere and seven (1.6%) were missing cases. A total of 522 patients (97.2%) completed the 4AT (**Supplementary Figure 1**).

Table 1 shows 26% of patients with a history of dementia; 3.9% with Parkinson's disease; 14.8% had suffered a stroke; 7.5%with ischaemic heart disease and 10.3% with diabetes. Alcohol consumption of >14 units of alcohol/week occurred in 7.7%; polypharmacy in 7.2%, whilst 10.8% had an ACB score ≥3. There were 30% of patients at risk of malnutrition or were malnourished on admission. Only four patients (0.7%) had malignancy-related hip fractures and five (0.9%) had pressure ulcers. There were approximately equal proportions of left and right hip fractures: 35.4% had intertrochanteric and 64.6% intracapsular fractures. Almost all patients received specialist falls and physiotherapist assessment. The majority of patients (88.9%) received GA for sedation during their hip operation and the remaining 11.1% had nerve block without GA. There were 117 (22.1%) patients unable to mobilise within 1-day after surgery and 132 (25.0%) patients had prolonged LOS in hospital. Of the 522

patients who completed the 4AT assessment, 156 (29.9%) patients had 4AT scores of 1-3, and 105 (20.1%) had a 4AT score ≥4 (**Table 1**).

ANOVA showed significant differences in LOS between the three 4AT groups (F=21.8, *p*<0.001). The LOS for patients with 4AT=0 (reference group) was 9.5±6.9 days. LOS was progressively and significantly longer as 4AT scores increased from the reference group to 4AT=1-3 (12.5 days, 95%CI=1.5-4.5days, *p*<0.001) and 4AT≥4 (15.4 days, 95%CI=4.0-7.7days, *p*<0.001). The increase of LOS between the 4AT=1-3 and 4AT≥4 groups was also significantly significant (*p*=0.005) (**Figure 1**).

Patients in the 4AT=1-3 and 4AT≥4 categories were significantly (*p*<0.001) older than those in the reference group (**Table 2**). Patients with a 4AT score=0 were 81.0±8.7 years, whilst those with a 4AT score=1-3 were 4.9 years (95%CI=3.3-6.6) older, and those with a 4AT score ≥4 were 5.7 years (95%CI=3.8-7.6) older. The proportions of men and women within each 4AT category were virtually the same, whilst the proportions of patients with underlying dementia, Parkinson's disease, stroke, malnutrition risk/malnourished, polypharmacy and ACB score of ≥3 increased significantly with higher 4AT categories. There were higher proportions of patients with a 4AT score of 1-3 or ≥4 who failed to mobilise within 1-day after surgery, or had prolonged LOS. There was a higher proportion of patients who died in hospital, or were discharged to rehabilitation or residential/nursing care only if the 4AT score was ≥4 (**Table 2**).

Logistic regression analysis without adjustments (model 1, **Table 3**) showed that, compared to the reference group (4AT score of 0), patients with a 4AT score of 1-3 or

≥4 were significantly associated with: failure to mobilise within 1-day after hip surgery; prolonged LOS; death (only with delirium) and change in residence on discharge. After adjustment for age, sex, nutritional status, co-morbidities and medications (model 4, **Table 1**), compared to the reference group, failure to mobilise within 1-day of surgery was increased with a 4AT score ≥4 (event rate=34.3%, OR=2.4; 95%CI=1.3-4.3). Prolonged LOS was also increased among patients with 4AT=1-3 (event rate=31.2%, OR=2.4; 95%CI=1.4-4.1) or with 4AT≥4 (event rate=40.2%, OR=3.5; 95%CI=1.9-6.7). In-patient mortality was increased among patients with a 4AT score ≥4 (event rate=13.7%, OR=3.1; 95%CI=1.2-8.2) but not with a 4AT score of 1-3. Finally, change in residence on discharge was more likely in those with a score 4AT ≥4 (event rate=70.3%, OR=3.1; 95%CI=1.4-6.8 - **Table 3**). Subgroup analysis of 398 patients without a history of dementia showed significant associations between: patients with a 4ATscore of1-3 and prolonged LOS, as well as those with a 4AT score ≥4 and immobility, mortality and change in residence (**Table 3**).

DISCUSSION

The present study, with the novel 4AT tool, has identified a number of unfavourable outcome measures after an operation for a fractured hip. Patients with a 4AT score of 1-3 had a 2.5-fold increased risk of prolonged LOS. Patients with a 4AT score ≥4 had 2.5- to 3.5-fold increases in risks of immobility, prolonged LOS and mortality in hospital after their hip operation, as well as being discharged to places where more care support is provided. These increased risks were independent of age, sex, nutritional status, co-morbidities including dementia and medications including a raised ACB. LOS increased by three and six days, for patients with 4AT scores of 1-3 or ≥4, respectively

The proportion of patients with a 4AT score ≥4 of 20.1% in our study is similar to figures reported by Bellelli *et al* [4]. They reported in-patient prevalences for evidence of delirium were 20.6% in orthopaedics units, 21.2% in general internal medicine units, 24.7% in geriatrics units and 28.5% in neurology units. Prolonged LOS and mortality, as well as residential/nursing care, are high among older patients; especially those admitted with hip fractures [16] with enormous burdens to both patients and healthcare systems [17, 18]. Our study observed that just over one-half of patients returned to their own home directly after discharge while more than a third of patients were transferred to rehabilitation units. Those with evidence of delirium were three times more likely to require rehabilitation or residential/nursing care and 3.5-times more likely to stay in hospital for longer than two weeks, compared with patients who did not have features of cognitive impairment and delirium. Mortality rates for patients admitted to hospital with a hip fracture have improved over the recent decade, dropping from 10.9% in 2007 to 7.1% in 2015 and 6.7% in 2016 [11]. The death rate of 6.8% in our study is comparable to the most recently reported national figure.

Our study also demonstrated that 4AT has predictive validity for a number of adverse outcomes, which should prompt assessment for a definitive delirium diagnosis (including for prior dementia) and a search for underlying causes. Our findings showed clear stepwise increments in LOS and mortality in hospital, as well as discharge to rehabilitation units or residential/nursing care with increasing 4AT scores. These findings support preventative and early interventional measures such as dementia-friendly environments for patients as well as their family members. At our own hospital a concept of “Special Bays for Patients with Dementia” has recently been instigated.

The use of a checklist for anticholinergics, such as the ACB Scale developed by the Aging Brain Program (Indiana University Center for Aging Research) [14] would be helpful to ensure that appropriate omission of these agents is applied.

It is well-recognised that neuropsychiatric disorders are often under-detected. A multicentre study of over 2500 older adults admitted to Italian hospitals with acute conditions found delirium was recorded in only 2.9% of all admitted patients [5]. In order to improve delirium awareness and prevention, our hospital is extending the use of the 4AT over a larger scale through educational lectures, knowledge cards, patient leaflets, incorporation into the acute medical clerking proforma, and the Emergency Casualty Cards and Discharge to Assess Scheme and Accidents [19]. We also promote awareness by participating in “World Delirium Day”, regular training updates for staff, as well as conducting research and audits [20]. Finally, we provide consultant geriatrician-led ward rounds daily, with a focus on pain management, constipation, drugs and urinary retention.

A 4AT measurement within 1-day after hip surgery provides consistency of assessment for all patients. We recognise that the relationship between delirium and these health outcome measures is likely to be complex and multifactorial. The present study observed a number of underlying factors associated with cognitive impairment and delirium prior to 4AT assessment including nutritional status, pre-existing co-morbidities, polypharmacy and ACB. Since these factors also associate with adverse outcomes, they were therefore included in multivariable logistic regression models. However, high 4AT scores remain an independent risk factor for adverse outcomes, even after extensive adjustments for major confounding factors or exclusion of patients

with dementia. Our findings are consistent with previous studies showing delirium was associated with increased LOS between 3 days [21] to more than a week [22], mortality [21, 23, 24] and new nursing home placement [23].

The strengths of this study include data form a large number of participants collected consecutively over a relatively long period of 18 months, as well as records of patients' nutritional status, co-morbidities and medications, and neuropsychiatric function as measured by standardised protocols. The study population was an homogenous group of older adults who were admitted with the same condition, permitting a number of potential confounding factors to be eliminated. Because of the nature of our study design, we could not address the cause-effect relationships between variables. It would be useful to conduct prospective interventional studies to minimise potential risk factors and assess changes in delirium and outcome measures.

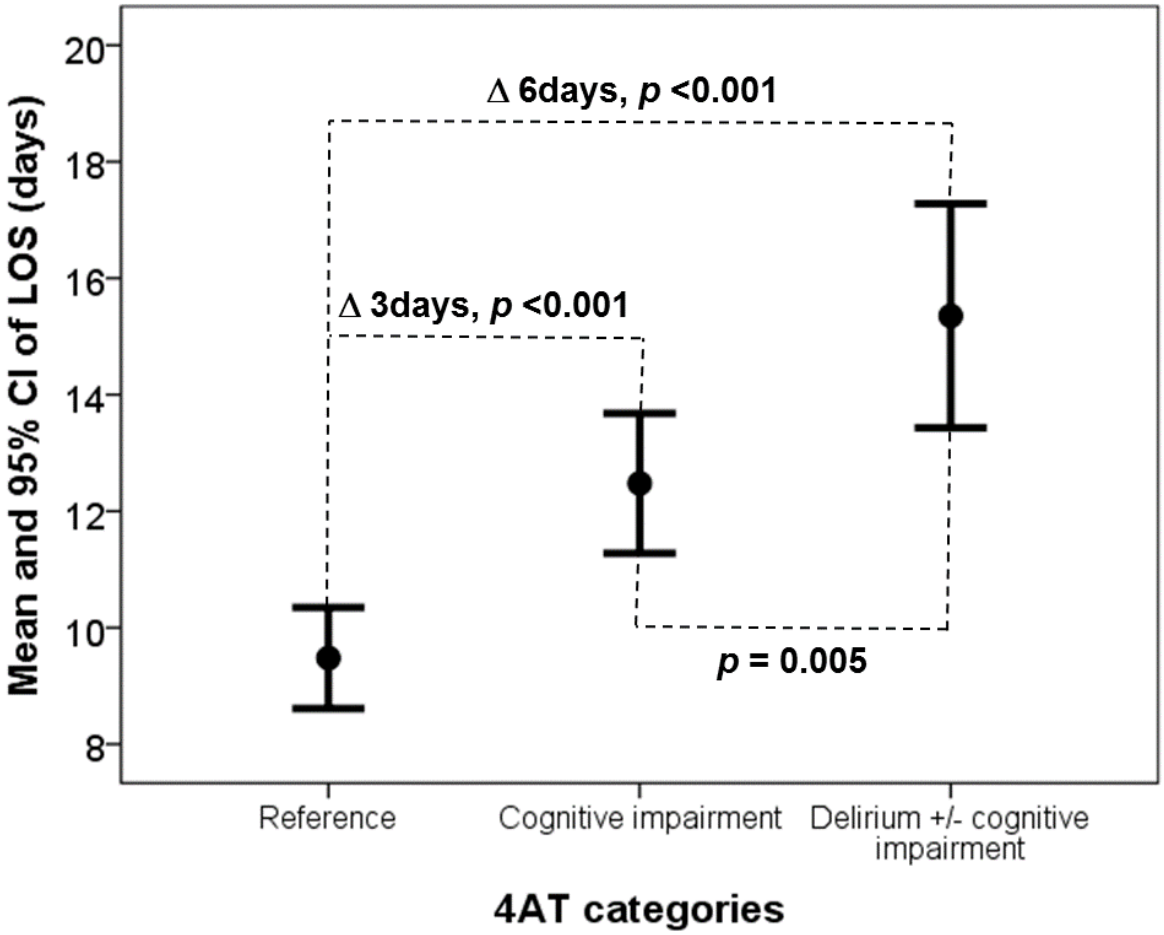
The 4AT has been validated among older populations in many languages and in various clinical settings: furthermore it has been implemented across a number of medical specialties [25-29]. Bellelli et al [25] found the Italian version had a sensitivity of 89.7% and specificity 84.1% for screening delirium, while Hendry et al [26], in a UK study, showed that the 4AT diagnosed delirium with a sensitivity and specificity of 86.7% and 69.5% respectively. O'Sullivan et al, in Eire, reported a positive predictive value of 68% and a negative predictive value of 99% [27]. A study by De et al in Australia[28], with about 40% of patients from a non-English speaking background (NESB), showed a sensitivity of 87-91% regardless of probable dementia or NESB, and an overall specificity of 80% that was somewhat worse (71%) for probable dementia and NESB patients [28]. Finally, Gagné at al [29] evaluated a French version

of 4AT in four Canadian emergency departments with 84% sensitivity and 74% specificity for delirium.

In conclusion, patients with high 4AT scores have increased risk of failure to mobilise after hip surgery, prolonged LOS and death in hospital and discharge to rehabilitation units or residential/nursing care among older patients admitted with hip fractures. Specialist assessment of the patient with delirium is required to identify and treat the cause and may involve: geriatric medicine or frailty services and an integrated rapid-response psychiatric liaison team with dementia services in order to prevent or minimise adverse outcomes.

LEGENDS

Figure 1. LOS in hospital for patients assessed by different categories of the 4AT. Reference group refers to patients with a 4ATscore of 0.



Supplementary figure 1. Flowchart showing patient distribution before and during hospital admission and on discharge. Grey circle indicates predictor and black boxes indicate outcome measures.

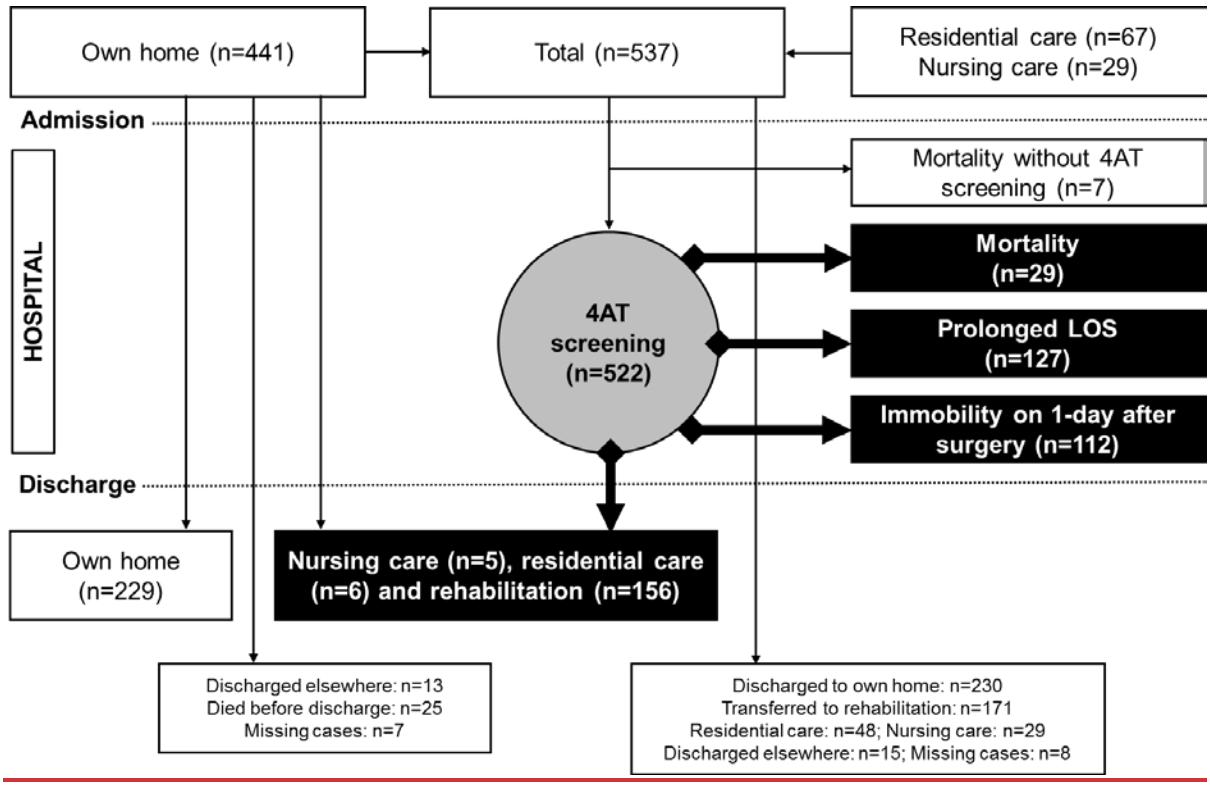


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Table 1. Characteristics of 537 patients admitted with hip fractures.

	Proportion (%)
Sex distribution (women: men)	73.0: 27.0
Residence before admission	
Own home: Residential care: Nursing care	82.1: 12.5: 5.4
Co-morbidities and medications	
Dementia	26.0
Parkinson's disease	3.9
Stroke	14.8
Ischaemic heart disease	7.5
Diabetes	10.3
Alcohol excess (>14 units/week)	7.7
Polypharmacy (≥4 medications/day)	71.2
Anticholinergic burden (0: 1: 2: 3: 4)	63.7: 25.4: 0.7: 10.1
Pressure ulcers	1.0
Fracture sides (left: right)	50.8: 49.2
Pathological fractures (no: malignancy: unknown)	96.5: 0.7: 2.8
Fracture type (IT-grade A1/A2: IT- grade A3: IC-displaced: IC-undisplaced: ST)	35.4: 1.7: 56.2: 4.3: 2.4
Hip surgery within 36 hours after hospital arrival	82.6
Nutritional status (well nourished: malnutrition risk: malnourished)	70.0: 18.8: 11.2
Specialist falls assessment	99.8
Physiotherapist assessment	99.2
Sedation technique (GA: nerve block without GA)	88.9: 11.1
4AT=0: 4AT=1-3: 4AT≥4	50.0: 29.9: 20.1
Mobile: immobile within 1-day after surgery	77.9: 22.1
LOS (<14.4 days: ≥14.4)	75.0: 25.0
Discharge destination	
Own home/sheltered accommodation	45.0
Rehabilitation units	33.6
Residential or nursing home	14.6
Death	6.8

IT = intertrochanteric, IC = intracapsular, ST = subtrochanteric, GA = general anaesthesia.

Table 2. Characteristics, co-morbidities, medications and outcome measures according to different categories of the 4AT measurements.

Mean ±SD	N	(4AT=0)	(4AT=1-3)	(4AT≥4)	ANOVA	
Age (yr)	522	81.0 ±8.7	86.0 ±8.6	86.7 ±7.6	F=25.2	p<0.001
Time to surgery from hospital arrival (hr)	522	25.3 ±14.4	23.8 ±12.7	26.6 ±15.8	F=1.3	p=0.281
					Chi-squared test	
Proportions		%	%	%	χ^2	p
Men	141	50.4	29.1	20.5	0.1	0.9
Women	381	49.9	30.2	19.9		
Co-morbidities and medications						
Dementia	134	2.3	37.8	65.7	174.5	<0.001
Parkinson's disease	20	1.9	4.5	7.6	6.8	0.034
Stroke	78	11.2	16.0	22.9	8.2	0.016
Ischaemic heart disease	40	8.8	4.5	9.5	3.2	0.197
Diabetes	53	8.1	12.8	11.4	2.6	0.269
Alcohol excess	41	10.0	7.1	3.8	4.2	0.122
Malnutrition risk/malnourished	151	16.1	35.9	50.5	48.3	<0.001
Polypharmacy	371	63.1	75.6	84.8	19.3	<0.001
Anticholinergic burden (score ≥1)	190	31.2	44.9	37.1	7.9	0.019
Outcomes						
Failure to mobilise within 1-day after surgery	112	15.3	23.1	34.3	16.3	<0.001
Prolonged LOS (14.4 days)	127	14.7	31.2	40.2	30.4	<0.001
Mortality	29	4.3	2.6	13.7	16.1	<0.001
Discharged to rehabilitation unit or Residential care/Nursing care*	173	36.0	48.4	70.3	17.6	<0.001

*Including only those who were admitted from their own home and excluding those who died in hospital.

Table 3. Logistic regression to assess the relationship between the 4AT and outcomes.

	Failure to mobilise within 1-day after surgery			Prolonged LOS			Death			Discharge to rehabilitation units or residential/NH care*		
All patients (n=537)	OR	95%CI	P	OR	95%CI	P	OR	95%CI	p	OR	95%CI	p
Model 1: Unadjusted												
4AT = 0 (reference)	1	--	--	1	--	--	1	--	--	1	--	--
4AT = 1-3	1.7	1.0-2.7	0.049	3.0	1.8-4.9	<0.001	0.6	0.2-1.9	0.387	1.7	1.1-2.6	0.022
4AT ≥4	2.9	1.7-4.9	<0.001	4.7	2.7-8.2	<0.001	3.6	1.6-8.2	0.003	4.2	2.0-8.9	<0.001
Model 2: Adjusted for age and sex												
4AT = 0	1	--	--	1	--	--	1	--	--	1	--	--
4AT = 1-3	1.7	1.0-2.8	0.046	2.7	1.6-4.6	<0.001	0.6	0.2-2.0	0.391	1.5	0.9-2.3	0.111
4AT ≥4	2.9	1.7-5.1	<0.001	4.2	2.3-7.5	<0.001	3.6	1.5-8.7	0.004	3.5	1.6-7.4	0.002
Model 3: Adjusted for Model 2, co-morbidities† and medications‡												
4AT = 0	1	--	--	1	--	--	1	--	--	1	--	--
4AT = 1-3	1.4	0.8-2.4	0.201	2.4	1.4-4.1	0.005	0.6	0.2-1.9	0.327	1.3	0.8-2.1	0.247
4AT ≥4	2.4	1.3-4.3	0.005	3.5	1.9-6.7	<0.001	3.1	1.2-8.2	0.025	3.1	1.4-6.8	0.006
Excluding patients with dementia (n=398)												
Model 4: Adjusted for age, sex, co-morbidities† and medications‡												
4AT = 0	1	--	--	1	--	--	1	--	--	1	--	--
4AT = 1-3	1.5	0.8-2.7	0.210	2.6	1.4-4.7	0.003	0.4	0.1-2.0	0.260	1.4	0.8-2.4	0.245
4AT ≥4	3.2	1.4-6.9	0.004	2.2	0.9-5.7	0.093	5.0	1.5-16.1	0.011	5.0	1.5-16.2	0.008

*Including only those who were admitted from their own home and excluding those who died in hospital.

†Co-morbidities include dementia (excluded in Model 4), Parkinson's disease, stroke, malnutrition risk/malnourished,

‡Medications include anticholinergic burden and polypharmacy.