Risk factors for postoperative delirium and subsyndromal delirium in older surgical patients in the general ward: a prospective observational study

Maya Kanno (mkan@yokohama-cu.ac.jp)
Yokohama Shiritsu Daigaku
Mana Doi
Yokohama Shiritsu Daigaku
Kazumi Kubota
Yokohama Shiritsu Daigaku
Yuka Kanoya
Yokohama Shiritsu Daigaku

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Abstract

Background

Postoperative delirium (POD) among older patients is a common, serious disease and is associated with a high incidence of negative outcomes. For early detection of POD and subsyndromal delirium (SSD), this study was conducted to identify risk factors of POD and SSD in older patients in a general ward who were scheduled for surgery.

Methods

This was a prospective observational study. Study participants were older than 65 years, underwent urology surgery, and were hospitalized in the general ward between April and September 2019. Both POD and SSD were assessed by using the Confusion Assessment Method on the preoperative day, the day of surgery, and postoperative days 1–3. Personal characteristics, clinical data, cognitive function, physical functions, laboratory test results, medication use, type of surgery and anesthesia, and use of restraints were collected from medical records. Univariate and multivariate analyses were conducted to identify the risk factors for POD and SSD.

Results

A total of 101 participants (mean age 74.9 years) were enrolled; 19 (18.8%) developed POD and SSD. The use of bed sensors (odds ratio 10.2, $p = .001$) and preoperative level of C-reactive protein (CRP; odds ratio 1.5, $p = .054$) were identified as risk factors for POD and SSD.

Conclusions

POD and SSD among older patients in general wards were related to bed sensor use and the preoperative CRP level. Therefore, this study suggests that in order prevent POD and SSD for older patients in general wards, it is necessary to avoid bed sensor use as restraints and to assess the preoperative CRP level.

Background

Delirium is a common, serious disease among older patients. Older age and surgery are risk factors for delirium [1, 2]. The incidence of postoperative delirium (POD) in the elderly population ranges from 11–51% [2], and POD in older patients is associated with many negative outcomes, including the high risk of complications, cognitive decline, prolonged hospital stay, rehospitalization, institutionalization, and mortality [2–4]. Therefore, early detection of POD among older patients and appropriate care is important to prevent the worsening of POD and the associated complications.

We also focused on subsyndromal delirium (SSD), which is an important predictor of POD. SSD is characterized by the presence of certain symptoms of delirium without the full symptoms, and it is likely to develop into POD [5, 6]. Furthermore, SSD in older patients is associated with many negative outcomes as well as POD, including a decline in activities of daily living (ADL), prolonged hospital stay, and high mortality [5–8]. Therefore, the identification of older patients at risk for SSD is important.

Careful observation and evaluation of the patients is necessary to prevent delirium because the symptoms of POD usually fluctuate throughout the day. Nurses are often the first to notice the symptoms of delirium because of their close involvement in the provision of patient care. However, in the general ward, nurses may face difficulties in keeping an intensive watch on all patients, especially the postoperative patients, because of a lower nurse-to-patient ratio in contrast to that in the high care units such as the intensive care unit (ICU), which provides one-to-one care. Thus, general ward nurses need to preoperatively identify patients who have high risk of POD and SSD and modify their approach to these patients. Regarding postoperative SSD, several risk factors in the ICU have been identified; these risk factors include duration of extracorporeal circulation, cardiopulmonary bypass, larger transfusion volume, etc. [9–11]. For POD, the risk factors are cognitive state [13, 14], ADL [13], and anxiety [15]. The umbrella term “functioning” that refers to all body functions, activities, and participation is an aspect of the aforementioned risk factors [12]). In contrast, only three risk factors for SSD have been identified in the general ward in previous studies: higher pain level, a recent history of falls within the past 6 months, and a longer preoperative fasting time [16, 17]. We predicted that there are more risk factors of SSD particular to the general ward, e.g. functioning because patients in the general ward have experiences more closely resembling their usual lifestyle than the patients in the ICU, and independence of lifestyle requires higher functioning. Thus, the risk factors of SSD in older patients admitted to the general ward need to be widely investigated. In addition, we need to understand both risk factors of POD and SSD because POD and SSD are continuous concept [7]. Therefore, the aim of this study was to identify both risk factors of POD and SSD in older patients who underwent surgery and were admitted postoperatively in the general ward.

Methods

Study design and participants

This was a prospective observational study. This single-center study recruited older patients (>65 years) who underwent surgery, under general or spinal anesthesia, for urological diseases and were postoperatively treated in the general ward of a tertiary care hospital in a metropolitan area of Japan between April and September 2019. Eligible patients were enrolled if they provided consent for study participation. The exclusion criteria were: (1) ICU admission, (2) low consciousness level before the surgery (Japan Coma Scale 100–300), (3) inability to speak Japanese, (4) impaired judgment because of developmental disorders or cognitive decline, and (5) preoperative onset of delirium. Participants with missing data for the dependent variables were excluded from the analysis.

In the primary analysis of this study, we specified the key independent variables from the Comprehensive Geriatric Assessment-short version (CGA7), which comprises seven items. To calculate the sample size, the smaller incidence rates in the outcome holders and non-outcome holders require at least 6 to 10 patients per independent variable for logistic regression analysis [18]. Shim et al. [6] reported POD and SSD incident rates to be 58.1% among older patients undergoing surgery. Thus, we calculated that a minimum of 100 participants were required for the primary analysis

Study procedures

The ward nurses assessed all patients for POD and SSD for five days—the day before surgery, the day of surgery, and three consecutive days post-surgery—using the Japanese version of the Confusion Assessment Method (CAM), which was developed from the diagnostic criteria specified in the Diagnostic and Statistical Manual of Mental Disorders- [19], which enabled easy screening for delirium. We defined the assessment periods in this study based on prior studies [20]. On the day before surgery, the CAM was applied once during the day shift (from hospitalization until 17:00). Postoperatively, patient evaluation with the CAM was undertaken three times in a day, once during each shift (9:00 to 17:00, 17:00 to 1:00, and 1:00 to 9:00). The ward nurses received training that imparted basic knowledge on the identification of postoperative delirium and learned how to use CAM to ensure consistency in the assessments by a researcher. The training was designed to minimize the burden on the ward nurses with reference to the Short CAM Training Manual [21], as well as a previous study [22], and included: (1) the presentation, (2) a SHORT CAM POST-TEST in accordance with the instructions in the Short CAM Training Manual, and (3) an assessment for delirium in three situations, provided by a case presentation video and discussion.

Measurement of study variables

Outcomes: the incidence of POD and SSD

We specified the incidence of both POD and SSD as outcomes because episodes of SSD are closely related to POD [5, 6]. Patients were evaluated for both POD and SSD by using the CAM, which comprises four criteria: (1) acute onset and fluctuating course, (2) inattention, (3) disorganized thinking, and (4) altered level of consciousness. The CAM algorithm for the diagnosis of delirium requires the presence of both the first and the second criteria, and of either the third or the fourth criterions [23]. In this study, POD was defined by the diagnosis of delirium based on the CAM algorithm. The SSD was defined as a presence of one or more CAM criteria and the absence of a diagnosis of delirium based on the CAM algorithm [6, 11, 13, 24]. The CAM can be completed in less than 5 minutes [25], and the Japanese version of the CAM has high sensitivity (83.3%) and high specificity (97.6%) when validated for use by nurses compared with psychiatrists [26]. We obtained permission for the use of the Japanese version of CAM from the copyright holder (Hospital Elder Life Program) and the developer (Akira Watanabe).

Demographic characteristics and surgical clinical variables

The demographic characteristics and surgical clinical variables were defined as independent variables, and CGA7 was set as the key independent variable. We obtained age, sex, the Barthel Index, Charlson Comorbidity Index (CCI), history of dementia and cerebrovascular disease, medication use, emergency admission, visual and hearing disabilities, the Independence degree of daily living for the demented elderly, the stage of long-term care need, and the score from the CGA7 at the baseline. The use of physical restraints (belt and mitten), and bed sensors (clip and bed sensors) were examined for the day of surgery and all three days after surgery. We gathered the lesion site, operative method, anesthesia type, operative duration, intraoperative blood loss, preoperative and postoperative results of laboratory blood tests [white blood cell (WBC), red blood cell (RBC), hemoglobin (Hb), hematocrit (Ht), platelet (Plt), total protein (TP), albumin (Alb), blood urea nitrogen (BUN), creatinine (Cr), sodium (Na), potassium (K), chlorine (Cl), calcium (Ca), and C-reactive protein (CRP)], the use of narcotic analgesics, and the number of days that the patient's regular medication was interrupted postoperatively as surgical clinical variables that were recorded on all five days.

The CCI is a severity classification scoring tool for comorbidities (0 to 37); increasing score indicates worse illness [27]. The Barthel Index is an objective scale to evaluate the ADL with scores ranging from 0 to 100; increasing score indicates greater independence [28]. Both of these tools have good reliability and validity.

Independence degree of daily living for the demented elderly and the stage of long-term care need are the assessments of the appropriate care requirements of older adults and that have been developed by the Ministry of Health, Labour and Welfare of Japan. Independence degree of daily living for the demented elderly has five levels: □, □, □, □, and M, with M indicating maximum dependence. The stage of long-term care need has seven levels: support needed (1 and 2) and care needed (1 to 5); care needed 5 indicates maximum dependence.

The CGA7 is a screening tool that extracted seven key items from a total of 40 items in four validated scales: Barthel Index, revised version of Hasegawa's Dementia Scale, Vitality Index, and Geriatric Depression Scale [29]. The CGA7 assesses functioning for older adults on aspects in the geriatric physical, psychological, and social domains. The CGA7 comprises the following questions: CGA1 (motivation): "Can the subject greet the examiner by himself/herself?", CGA2 (cognitive function): "Can the subject repeat 'cherry blossoms, cats, trains'?," CGA3 (instrumental ADL): "Can the subject go to the hospital by himself/herself?," CGA4 (cognitive function): "Can the subject recall three words in CGA2 and repeat that?," CGA5 (ADL): "Can the subject take a bath by himself/herself?," CGA6 (ADL): Can the subject use the toilet by himself/herself?," and CGA7 (emotion/mood): "Do the subject feel he/she is powerless?"). The CGA7 is assessed with "can"/"yes" or "cannot"/"no" for each question; negative outcomes on the CGA7 indicate older adults have low functioning. The specific assessment of the reliability and validity of the CGA7 test was deemed unnecessary because all four scales from which the tool was compiled have good reliability and validity.

Statistical analyses

We conducted logistic regression analysis (Forward Selection: Likelihood Ratio) with POD and SSD as the dependent variables. The primary analysis was carried out with the key independent variables in the CGA7. The secondary analysis incorporated the CGA7 and the related variables of the POD and SSD. Before the logistic regression analysis, data were analyzed by using the Student's *t*-test, Mann–Whitney *U* test, chi-square test, and Fisher's exact test to identify the factors related to POD and SSD. Variables with a *p*-value <0.2 on the univariate analysis were included in the secondary analysis. All data were analyzed in SPSS statistics version 26 and the significance level was set at $p<0.05$.

Results

Study population

A total of 121 participants were recruited; of these, 20 were excluded and 101 participants were included in the final analysis (Fig. 1). The demographic characteristics and surgical clinical variables of participants are shown in Tables 1 and 2. The mean age of patients in this study population was 74.9 ± 6.2 years and more than half were male (66.3%). The mean CCI score was 2.3 ± 1.1. Most participants underwent transurethral resection (60.4%), under general anesthesia (92.1%), had no dementia (98.0%), had high independence degree of daily living for the demented elderly (97.0%), and had no long-term care need (93.1%). The mean Barthel Index score was 97.7 ± 9.9. A few participants had a negative on the CGA7 (8.9%).

Table 1
Demographic characteristics

	Total, n = 101	CAM delirium status		
Variables		No delirium, n = 82	POD and SSD, n = 19	*p*-value
Age (years)[a], mean (SD)	74.9 (6.2)	74.8 (6.9)	75.7 (6.9)	0.623
Men[b], n (%)	67 (66.3)	51 (62.2)	16 (84.2)	0.439
Barthel Index[a], mean (SD)	97.7 (9.9)	98.1 (9.1)	94.4 (16.0)	0.329
CCI[a], mean (SD)	2.3 (1.1)	2.2 (1.1)	2.8 (1.4)	0.023*
Dementia[b], n (%)	2 (2.0)	0 (0)	2 (10.5)	0.034*
Cerebrovascular disease[b], n (%)	6 (5.9)	4 (4.9)	2 (10.5)	0.315
Emergency admission[b], n (%)	2 (2.0)	0 (0)	2 (10.5)	0.034*
Number of medications[a], mean (SD)	4.1 (4.0)	3.7 (4.5)	5.8 (30.5)	0.016**
Anticholinergic drug use[b], n (%)	5 (5.0)	3 (3.7)	2 (10.5)	0.236
Diazepam conversion (regular drugs)[a], mean (SD)	0.8 (2.2)	0.7 (2.0)	1.2 (3.2)	0.520
Non-visual disorder[b], n (%)	16 (15.8)	12 (14.6)	4 (21.1)	0.495
Non-hearing disorder, n (%)	71 (70.3)	59 (72.0)	12 (63.2)	0.655
Degree of Independence degree of daily living for the demented elderly[b], n (%)				
Independent	98 (97.0)	82 (100.0)	16 (84.2)	

Note. SD, standard deviation; CCI, Charlson Comorbidity Index; CGA7, Comprehensive Geriatric Assessment-short version.

Continuous variables were analyzed by the Student's *t*-test or [a]Mann–Whitney *U* test.

Categorical variables were analyzed by the chi-square test or [b]Fisher's exact test.

P-values significant at the 20% and 5% levels are shown as *, $p < 0.2$ and **, $p < 0.05$.

	Total, n = 101	CAM delirium status		
□	1 (1.0)	0 (0)	1 (5.3)	
□	2 (2.0)	0 (0)	2 (10.5)	0.006**
Stage of long-term care need[b], n (%)				
Independent	94 (93.1)	76 (92.7)	18 (94.7)	
Needed support 1	3 (3.0)	2 (2.4)	1 (5.3)	
Needed support 2	1 (1.0)	1 (1.2)	0 (0)	
Requiring care 5	1 (1.0)	1 (1.2)	0 (0)	0.779
Negative outcome in CGA7, n (%)	9 (8.9)	6 (7.3)	3 (15.8)	0.36
(1) Can the subject greet the examiner by himself/herself?	1 (1.0)	1 (1.2)	0 (0)	1.00
(2) Can the subject repeat 'cherry blossoms, cats, trains'?	1 (1.0)	1 (1.2)	0 (0)	1.00
(3) Can the subject go to the hospital by himself/herself?	5 (5.0)	3 (3.7)	2 (10.5)	0.24
(4) Can the subject recall three words in CGA2 and talk that?	1 (1.0)	1 (1.2)	0 (0)	1.00
(5) Can the subject take a bath by himself/herself?	5 (5.0)	3 (3.7)	2 (10.5)	0.24
(6) Can the subject use the toilet by himself/herself?	1 (1.0)	0 (0)	1 (5.3)	0.19
(7) Do the subject feel he/she is powerless?	3 (3.0)	2 (2.4)	1 (5.3)	0.47
Use of physical restraint[b]	2 (2.0)	0 (0)	2 (10.5)	0.034**
Bed sensor use[b]	12 (11.9)	5 (6.1)	7 (36.8)	0.001**

Note. SD, standard deviation; CCI, Charlson Comorbidity Index; CGA7, Comprehensive Geriatric Assessment-short version.

Continuous variables were analyzed by the Student's *t*-test or [a]Mann–Whitney *U* test.

Categorical variables were analyzed by the chi-square test or [b]Fisher's exact test.

P-values significant at the 20% and 5% levels are shown as *, $p < 0.2$ and **, $p < 0.05$.

Table 2
Surgical clinical variables

	Total, n = 101	CAM delirium status		
Variables		No delirium, n = 82	POD and SSD, n = 19	*p*-value
Lesion site[b], n (%)				
Kidney tumor	10 (9.9)	8 (9.8)	2 (10.5)	
Ureteral cancer	2 (2.0)	2 (2.4)	0 (0)	
Bladder cancer	50 (49.5)	42 (51.2)	8(42.1)	
Prostatic cancer	16 (15.8)	12 (14.6)	4(21.1)	
Benign prostatic hypertrophy	13 (12.9)	9 (11.0)	4(21.1)	
Testicular tumor	2 (2.0)	1 (1.2)	1(5.3)	
Penile cancer	3 (3.0)	3 (3.7)	0(0)	
Others	5 (5.0)	5 (6.1)	0(0)	0.621
Operative methods[b], n (%)				
Laparoscopic surgery	29 (28.7)	24 (29.3)	5 (26.3)	
Transurethral resection	61 (60.4)	50 (61.0)	11 (57.9)	
Others	11 (10.9)	8 (9.8)	3 (15.8)	0.668
Anesthesia[b], n (%)				
General anesthesia	93 (92.1)	74 (90.2)	19 (100.0)	
Spinal anesthesia	8 (7.9)	8 (9.8)	0 (0)	0.346
Results of preoperative blood tests, mean (SD)				
WBC (10^3/μL)[a]	6.3 (1.8)	6.1 (1.6)	7.1 (2.5)	0.141*
RBC (10^6/μL)	4.3 (0.5)	4.3 (0.5)	4.3 (0.5)	0.684

Note. SD, standard deviation.

Continuous variables were analyzed by the Student's *t*-test or [a]Mann–Whitney *U* test.

Categorical variables were analyzed by the chi-square test or [b]Fisher's exact test.

P-values significant at the 20% and 5% levels are shown as *, $p < 0.2$ and **, $p < 0.05$.

	Total, n = 101	CAM delirium status		
Hb (g/dL)[a]	12.3 (1.8)	13.4 (1.8)	13.0 (2.1)	0.546
Ht (%)	40.1 (5.2)	40.2 (6.0)	39.2 (5.8)	0.501
Plt (10^3/μL)[a]	237.5 (83.2)	234.7 (76.9)	252.6 (106.8)	0.798
TP (g/dL), n = 100[a]	7.2 (0.6)	7.2 (0.7)	7.1 (0.5)	0.615
Alb (g/dL), n = 100[a]	4.1 (0.4)	4.1 (0.4)	4.1 (0.6)	0.751
BUN (mg/dL)[a]	18.8 (6.8)	18.1 (5.6)	21.6 (10.1)	0.314
Cr (mg/dL)[a]	1.0 (0.6)	1.0 (0.6)	1.2 (0.6)	0.279
Na (mmol/L)[a]	141.5 (2.4)	141.8 (2.2)	140.3 (2.8)	0.056*
K (mmol/L)[a]	4.3 (0.4)	4.3 (0.4)	4.4 (0.4)	0.426
Cl (mmol/L)	104.6 (2.5)	104.8 (2.5)	103.6 (2.6)	0.058*
Ca (mmol/L)	9.4 (0.4)	9.4 (0.4)	9.5 (0.5)	0.305
CRP (mg/L)[a]	0.5 (1.9)	0.3 (0.5)	1.8 (4.0)	0.030**
Operative duration (min)[a], mean (SD)	119.7 (112.4)	116.0 (113.7)	141.1 (113.7)	0.088*
Intraoperative blood loss (mL)[a], mean (SD)	87.9 (87.0)	95.0 (234.0)	55.3 (146.1)	0.847
Use of narcotic analgesics, n (%)	28 (27.7)	22 (26.8)	6 (31.6)	0.777
Postoperative physical status, n (%)				
Inflammation[b]	2 (2.0)	1 (1.2)	1 (5.3)	0.342
Anemia	27 (26.7)	20 (24.4)	7 (36.8)	0.269
Undernutrition	28 (27.7)	21 (25.6)	7 (36.8)	0.395

Note. SD, standard deviation.

Continuous variables were analyzed by the Student's *t*-test or [a]Mann–Whitney *U* test.

Categorical variables were analyzed by the chi-square test or [b]Fisher's exact test.

P-values significant at the 20% and 5% levels are shown as *, $p < 0.2$ and **, $p < 0.05$.

	Total, n = 101	CAM delirium status		
Electrolyte abnormality[b]	11 (10.9)	11 (13.4)	0 (0)	0.119*
Decline in renal function[b]	18 (17.8)	13 (15.9)	5 (26.3)	0.322
Duration of suspension of regular medication[a], mean (SD)	1 (0.9)	1.1 (0.9)	0.9 (4.7)	0.541
Postoperative use of sleeping pills[b], n (%)	8 (7.9)	6 (7.3)	2 (10.5)	0.643
Note. SD, standard deviation.				
Continuous variables were analyzed by the Student's *t*-test or [a]Mann–Whitney *U* test.				
Categorical variables were analyzed by the chi-square test or [b]Fisher's exact test.				
P-values significant at the 20% and 5% levels are shown as *, $p < 0.2$ and **, $p < 0.05$.				

[Insert Fig. 1 here]

Figure 1. Patient enrollment flowchart

[Insert Table 1 **here]**

[Insert Table 2 **here]**

Association between indicators and POD and SSD by univariate analysis

A total of 19 participants were postoperatively observed for POD and SSD by CAM (POD, n = 3; SSD, n = 16). Both POD and SSD were significantly associated with low independence degree of daily living for the demented elderly ($p = 0.006$), many medications ($p = 0.016$), preoperative high CRP ($p = 0.030$), restraint use ($p = 0.034$), and bed sensor use ($p = 0.001$) on univariate analysis (Tables 1 and 2).

Risk factors of POD and SSD by logistic regression analysis

First, we conducted a primary analysis by the logistic regression analysis, which included the key independent variables. The model did not work out due to the separation variables, which is an issue in the logistic regression analysis [30].

Second, we included the CGA7 as a key independent variable along with eight independent variables for the logistic regression analysis (e.g., CCI, medication use, preoperative WBC, preoperative Na, preoperative Cl, preoperative CRP, operative duration, and bed sensor use), which showed correlations on univariate analysis (p-value < 0.2). Logistic regression analysis showed that POD and SSD were associated with bed sensor use [odds ratio (OR) 10.2; $p = 0.001$, 95% confidence interval (CI) 2.68–38.65] and preoperative high CRP (OR 1.5; $p = 0.054$, 95% CI 0.99–2.19; Table 3).

Table 3
Risk factors of POD and SSD on logistic regression analysis

Variables	β	SE	*p*-value	OR	95% CI
Bed sensor use (No, 0; Yes, 1)	2.321	0.681	0.001	10.18	2.682–38.652
Preoperative CRP (mg/dL)	0.388	0.202	0.054	1.47	0.993–2.188
Note. β, regression coefficient; SE, standard error; 95% CI, 95% confidence interval					

Discussion

In this study, the incidence of POD and SSD was 18.8%, compared to the 58.1–67.9% that was reported previously [6, 16, 17]. Moreover, the incidence was low in comparison to ranges from 11–51% as the common incidence of POD in older patients [2]. Three reasons may account for this difference. The first reason would be the characteristics of the department for patient treatment. Participants of prior studies underwent joint replacement surgery [16, 17]. Patients with joint disorders tend to have joint pain and limited mobility, that may limit the preoperative ADL, which is a risk factor for SSD [13, 31]. However, participants in this study had a greater independence of ADL. Moreover, we predict that transurethral resection, which is a minimally invasive surgery, constituted 60.4% of the surgeries in this study and may have affected the low incidence of POD and SSD. Thus, high ADL and minimally invasive surgery caused a lower incidence of POD and SSD. The second reason would be the selection bias of the surgical patients. Primary doctors might select healthy older patients to conduct a safe surgery. In addition, participants had few negatives on the CGA7, which is an indicator of the independence of functioning, and most participants of this study might be independent. Prior studies have found that the CGA is associated with POD for older patients [32, 33]. Thus, while we predicted that high functioning for older patients may have reduced the incidence of POD and SSD, we did not find an associated correlation. The third reason would be the influence of good nursing care. Pain management, maintenance of nutrition and hydration, promotion of mobilization and sleep are effective for preventing delirium [34]. Thus, we predicted that good nursing care, comprising the abovementioned factors, had been performed and might have prevented the development of POD and SSD.

Furthermore, the logistic regression analysis suggested that bed sensor use was associated with an increased risk of POD and SSD. We attributed two reasons for this. The first reason is the intentional bed sensor use by nurses. Bed sensors are usually used to prevent falls. We predicted that nurses expected signs of POD and SSD and intentionally used the bed sensor to check mobility in older patients. The second reason is the restraint of using a bed sensor. Using a bed sensor makes older patients unable to move freely because of its high monitoring function. The World Health Organization found that physical restraint, defined as something that restricts a person's ability to move freely [35] was a risk factor of POD [36]. Therefore, using bed sensors might increase the risk for POD and SSD. It is necessary to avoid using bed sensors as restraint to prevent the incidence of POD and SSD.

Next, the secondary analysis suggested that a preoperative high CRP level is associated with an increased risk of POD and SSD, which has also been suggested previously [37, 38]. Ward nurses can check the CRP of patients in the general ward because CRP is routinely tested before surgery. Thus, preoperative CRP is a possible biomarker of risk for POD and SSD in older patients in the general ward.

This study has several limitations. First, there was a low incidence of POD and SSD in contrast to the expectation because most of the participants were independent and healthy. This independence limited factors that have a strong risk relationship and may have been a cause of missing other potential factors. Second, the influence of nursing care could not be evaluated. Good nursing care might suppress the relationship between other factors and the study outcomes. Third, we did not assess postoperative cognitive functions such as dementia. There was a possibility to identify participants with dementia as POD and SSD because of their similarity. However, despite these limitations, this study provides a knowledge base for the evaluation of POD and SSD in older patients in the general ward in future studies. Further large-scale studies are needed to confirm the findings of these factors.

In conclusion, POD and SSD among older patients in the general ward are related to bed sensor use and the preoperative CRP level. Therefore, this study suggests that to prevent POD and SSD among older patients in the general wards, it is necessary to avoid bed sensor use as restraint and assess the preoperative CRP level.

Abbreviations

ADL, activities of daily living; POD, postoperative delirium; SSD, subsyndromal delirium; CAM, Confusion Assessment Method; OR, odds ratio, CI, confidence interval; WBC, white blood cell; RBC, red blood cell; Hb, hemoglobin; Ht, hematocrit; Plt, platelet; TP, total protein; Alb, albumin; BUN, blood urea nitrogen; Cr, creatinine; Na, sodium; K, potassium; Cl, chlorine; Ca, calcium; CRP, C-reactive protein

Declarations

- **Ethics approval and consent to participate:** This study was approved by the Institutional Review Board of the Medical Department of the Yokohama City University on April 1, 2019 (approval no. B190200026). All participants provided formal written informed consent prior to study participation.
- **Consent for publication:** Not applicable
- **Availability of data and materials:** The datasets generated and/or analyzed during the current study are not publicly available to protect patient privacy.
- **Competing interests:** The authors declare that they have no competing interests.
- Funding: Not applicable
- **Authors' contributions:** All authors read and approved the final manuscript and meet the journal's criteria of authorship. MK, MD, KK and YK: Design. MK: data collection. MK, MD, KK and YK: analysis. MK, MD, KK and YK: manuscript preparation.

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Figures

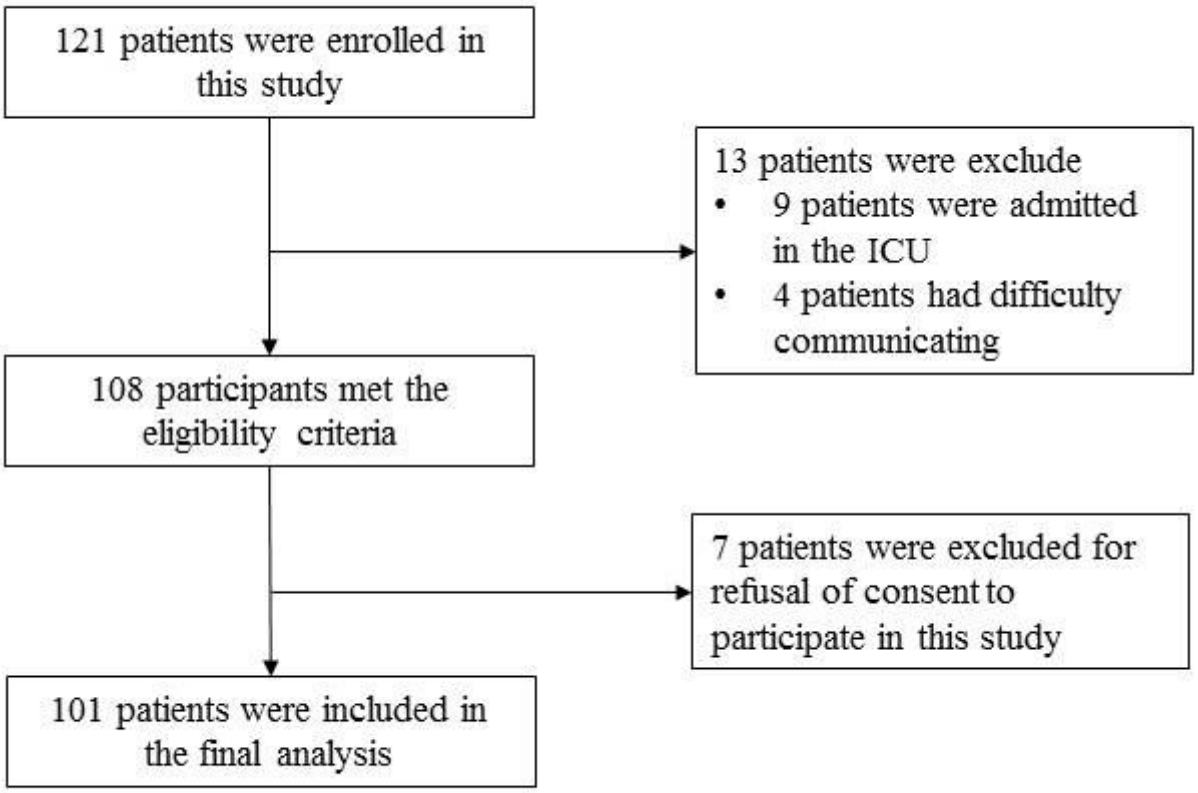

Figure 1

Patient enrollment flowchart