Incidence and Risk Factors for Delirium in Older Patients Following Intensive Care Unit Admission: A Prospective Observational Study

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ABSTRACT

Background: Both high prevalence and incidence rates of delirium occur frequently among patients aged 65 years or older in intensive care units (ICUs) and are accompanied by adverse outcomes. Because of lack of nursing staff resources and imperfect humanistic care, delirium is easily overlooked by both physicians and nurses in the ICU in Mainland China.

Purpose: This study aimed to explore the incidence rate of delirium and to determine the risk factors among critically ill older patients.

Methods: A prospective observational study was conducted on patients aged 65 years and older who were admitted consecutively to two ICUs of a university-affiliated hospital in China. The Confusion Assessment Method for the Intensive Care Unit and the Richmond Agitation–Sedation Scale were used to assess delirium status twice daily. Patient demographic, laboratory, medical, therapeutic, and prognostic data were collected.

Results: One hundred fifteen patients were included as participants, with a median age of 70 years (range 65–93 years). Seventy-six (66.1%) patients presented with delirium. Half of the sample had a hypoactive subtype. Patients who developed delirium had a longer mean length of ICU stay, greater chance of physical restraints use, greater use of fentanyl, and poorer sleep quality. A logistic regression analysis revealed that poor sleep quality (OR = 10.74, 95% CI [1.59, 72.47]) and physical restraints (OR = 13.04, 95% CI [1.57, 107.94]) were significantly associated with delirium.

Conclusions/Implications for Practice: Delirium is a common aggravation in older patients following ICU admission. The factors found in this study to be independently associated with delirium include poor sleep quality and physical restraints. Both critical care physicians and nurses should pay greater attention to the quality of the ICU stay experienced by their older patients.

KEY WORDS:
aged, delirium, critical care, nursing, risk factors.

Introduction

Delirium, a frequent and complicated syndrome of brain dysfunction in the intensive care unit (ICU), is marked by impaired cognition and consciousness with attention and global cognitive impairments that developed over hours to days (van Eijk et al., 2010). This syndrome continues to be underdiagnosed and is particularly prevalent among hospitalized older patients (Hshieh et al., 2015). The incidence of delirium among older adults has been shown to reach as high as 58%–75.6%, depending on patient population and screening instrument (Lin et al., 2015).

Delirium contributes to adverse outcomes such as increased mortality and morbidity, longer length of ICU stays, prolonged mechanical ventilation, and costlier hospitalizations (Pandhanapande et al., 2017). Prevention and treatment protocols of delirium such as routine assessment for delirium and use of sedation scales and interdisciplinary approaches (e.g., involving experienced pharmacists) have been shown to improve sequelae, alleviate long-term cognitive impairment, and decrease mortality (Neufeld et al., 2011).

Older patients who are aged 65 years or older (hereafter referred to as patients) account for almost half of all ICU admissions and about two thirds of ICU days (Inouye et al., 2014). In critically ill patients, delirium has been found to be quite common, and rates of unrecognized delirium were estimated to be around 60% in 2015 (de la Cruz et al., 2015). The three subtypes of delirium, defined based on motor activity profile, are hypoactive, hyperactive, and mixed. It has been verified that these different subtypes differ by pathophysiology, incidence rates, duration of delirium episode, treatment, and clinical outcomes (Morandi et al., 2017). A hypoactive subtype is
misdiagnosed as depression or dementia, in which patients exhibit lethargy, little spontaneous movement, and slow response to questions. Patients with this subtype have a significantly poorer prognosis (Barisone et al., 2007), and delirium goes unrecognized due to difficulties in diagnosing this subtype (Peritogiannis et al., 2015). Hyperactive patients with delirium, often accompanied by hallucinations and delusions, are physically aggressive, agitated, and restless. Patients with mixed delirium show a combination of hypoactive and hyperactive subtype symptoms (Oh et al., 2017). These latter two subtypes are associated with higher detection rates and better outcomes than the hypoactive subtype (Meagher et al., 2012).

The prevention and treatment of delirium has been extensively covered in the literature. However, this study focused on older people in ICUs. Critically ill geriatric patients are at a greater risk of developing delirium (Inouye et al., 2014). Therefore, this study aimed to explore the incidence rate of delirium in older patients following ICU admission and to identify the risk factors in order to facilitate the diagnosis, prevention, and treatment of delirium.

**Methods**

**Study Design**

The ethics committee of Xiangya Hospital, Central South University (Hunan, China) approved this study (201612641), and written informed consent was obtained from patients or their first-degree relative. The protection of the interests of patients was maximized, and no harm was caused to any of the patients. The enrollment criteria included any patient aged 65 years or older admitted to the general or cardiothoracic ICUs on medical or surgical grounds between March 2017 and February 2018. The two ICUs had 33 and 15 beds, respectively, and specialist physicians and nurses were on duty 24 hours daily.

In this prospective cohort study, the study physicians enrolled patients each night and recorded information upon enrollment. A validated daily record list was used to collect laboratory test results, use of medications, and other correlative information from each patient. The physicians or nurses used the confirmed Chinese version of the Confusion Assessment Method for the Intensive Care Unit (CAM-ICU) twice daily (at 8–10 a.m. and 6–10 p.m.) after admission to the ICU until discharge from the ICU or death to assess whether the patient developed delirium. The validity and feasibility of the CAM-ICU Chinese version were confirmed in a sample of medical and surgical ICU patients who understand simplified Chinese in a previous study (Wang et al., 2013). The timings were chosen based on delirium being more likely to occur in the morning and early evening during the first 7 days of admission (Guenther et al., 2012). Only patients with a Richmond Agitation–Sedation Scale (RASS) score greater than –4 could be identified, because those with scores of –4 or less hardly respond to verbal stimulus. The researchers did not interfere with the routine ICU management of participants, and the two ICUs had similar intensive care practices.

**Participants**

The predetermined study exclusion criteria were as follows: (a) patients unable to speak or understand Mandarin; (b) those diagnosed with delirium before ICU admission or in a coma resulting from hypoxic–ischemic encephalopathy, cerebrovascular accident, traumatic brain injury, brain death, intracranial infection, or cardiac arrest; (c) those with a RASS score of −5 to −4 caused by individual sedative needs; (d) those with mental retardation or neuromuscular disorder; (e) those who refused to participate; and (f) those admitted to the ICU for less than 24 hours.

**Variables**

**Demographics**

Baseline demographic data were obtained at time of enrollment. These data included age, gender, marital status, education level, diagnoses at ICU admission, surgical or medical patient status, general or cardiothoracic surgical ICU status, surgery information (type of surgery, modus operandi, duration of surgery, intraoperative shock, blood transfusion, and vasoactive drug), anesthetic information (anesthetic management, type of anesthetic, time of extracorporeal circulation, time of aortic occlusion, and time of postoperative recovery), and past medical history. Acute Physiology and Chronic Health Evaluation II (APACHE II; ranging from 0 to 71, with higher score representing more severe disorder) and Sequential Organ Failure Assessment (SOFA; ranging from 0 to 24) scores were registered for every patient in the cohort after the first 24 hours of admission as an estimate of baseline severity of illness. All information related to the diagnosis was directly obtained from each patient’s medical chart.

**Daily record list**

A daily record list was used to identify the potential risk factors for delirium on the basis of previous studies (Ouimet et al., 2007) and the suggestions of chief physicians. The senior physician, who had clinical and experimental expertise in delirium, trained three study researchers to collect the checklist content. Information regarding infections (infection at ICU admission [yes/no], infection portion [intraperitoneal/pulmonary/urinary/bloodstream/other], septic shock [yes/no], and type of bacteria [Escherichia coli/Staphylococcus aureus/Enterococcus faecium/others]), fever (normal/fever), laboratory values using the most abnormal value during the first 48 hours of ICU admission (including white blood cell, hemoglobin, neutrophil percentage, platelet, hematocrit, fibrinogen levels, sodium, potassium, blood ammonia, albumin, total bilirubin, direct bilirubin, lowest level of alanine aminotransferase and aspartate aminotransferase, blood urea nitrogen, serum creatinine, blood glucose, pH, blood lactate level, partial pressure of oxygen, carbon dioxide partial pressure, base excess, serum hydrocarbonte, oxygenation index [\(\frac{P_\text{O}_2}{F_\text{O}_2}\)], normal range: 400–500 mm Hg, if < 300 mm Hg indicated respiratory dysfunction], prothrombin time, activated partial thromboplastin
time, international normalized ratio, and procalcitonin), acidosis and alkalosis (yes/no for both), urinary volume less than 400 ml (yes/no), and Critical Care Pain Observation Tool (CPOT; using validated Chinese version; Li et al., 2014) was collected. CPOT had been tested in ICU patients with delirium and been found to improve pain management and achieve better clinical outcomes when applied regularly (Kanji et al., 2016). Sleep quality was assessed by the bedside nurses by observing the patient’s reduction in sleep time and symptoms due to lack of sleep such as their mental state and daytime sleepiness and by using a 5-point questionnaire (Van Rompaey et al., 2012). This questionnaire included the following questions: (a) Did you sleep well? (scored 1 point if yes); (b) Did you sleep better than expected? (scored 1 if yes); (c) Did you sleep better than at home? (scored 1 if yes); (d) Were you awake for a long time before falling asleep? (scored 1 if no); and (e) Do you feel sufficiently rested? (scored 1 point if yes). The scores were summed and categorized as poor sleep (0–1), moderate sleep (2–4), or good sleep (≥ 4).

Treatments and complications
Information about anti-infection treatment (type of antibiotic and antifungal drugs), time of mechanical ventilator, use of medication (total numbers of medications, type of sedative, type of analgesic, type of vasoactive drug and dose of each drug each day, nonsteroidal anti-inflammatory drugs, corticosteroids, antipsychotic medications, insulin, hypotensive drugs, and warfarin), catheters (central venous catheter, pericardial drainage, mediastinum drainage, gastric tube, abdominal drainage, and wound drainage), and physical restraints with soft wrist strips and boxing gloves was recorded to assess risk factors. Prognosis indicators (unplanned extubation, death during ICU stay, and length of ICU stay) were also recorded.

Delirium identified
In this study, delirium was measured routinely based on CAM-ICU, which is a well-validated and highly sensitive instrument. The criteria of CAM-ICU include the following four assessment criteria: (1) acute change or fluctuation in mental status, (2) inattention, (3) altered level of consciousness, and (4) disorganized thinking. The CAM-ICU assessment was positive (indicating presence of delirium) if criteria (1) and (2) plus either (3) or (4) were present. Delirium was confirmed if the patient’s RASS score was −3 to +4 and had a positive CAM-ICU assessment. The subtypes of delirium were diagnosed using the RASS score. If the patients’ RASS score was −3 to −1, their delirium subtype was classified as hypoactive, whereas RASS scores of +1 to +4 were classified as the hyperactive subtype and RASS scores that fluctuated from +4 to −3 were classified as the mixed subtype. The nurses in this study conducted research assessments after receiving extensive training and scorer reliability testing. They did not care for the patients included in this study to ensure that their observations were independent of observations made by the clinician.

Statistical Methods
All data analyses were performed using SPSS Version 24.0 (IBM, Inc., Armonk, NY, USA). Continuous data were presented as mean and standard deviation (SD) if normally distributed and as median and interquartile range (IQR) otherwise. However, categorical data were presented as numbers and percentages. The scorer reliability was tested using the Kendall’s coefficient of concordance W, which was calculated from a sample of 25 patients (not included in the final enrollment) and compared with each patient’s physicians and nurses in charge. Differences between patients with and without delirium were analyzed using the Student’s t test for normally distributed, continuous variables; using the Pearson’s chi-square or Fisher’s exact test for dichotomous or nominal variables; and using the Mann–Whitney U test for ordinal or nonnormal distributed continuous variables. A p value of <.05 was considered statistically significant. Variables with p < .05 in the univariate analysis were selected to identify risk factors related to delirium. Binary logistic regression was then applied to model the risk of delirium using significant univariate predictors. Odds ratio (OR) and the 95% confidence interval (95% CI) were used to evaluate the independent contribution of significant factors.

Results
Baseline Characteristics of Patients
One hundred fifty-one ICU patients were selected at hospital admission. Thirty-three (21.9%) were excluded, and 118 (78.1%) met the inclusion criteria and were enrolled as participants. Three of the participants were later excluded due to constant need of persistent sedation (RASS score = 4 or −5). Therefore, 115 participants were included in the final analyses (Figure 1). The participants had a median age of 70 years (ranging from 65 to 93 years) and were predominantly men (n = 71, 61.7%) and postoperative patients (n = 90, 78.3%). One hundred fifteen patients were observed for 467 ICU days. The scorer reliabilities of the study physicians and nurses were .92 and .89, respectively. No significant differences were found between the two study groups in terms of demographic variables with the exceptions of organ dysfunction, as measured using the SOFA score (median 5 [IQR = 8] vs. median 3 [IQR = 5], p = .009), and severity of illness, as measured by the APACHE II score (median 14 [IQR = 9] vs. median 11 [IQR = 5], p = .003). The characteristics of the study population are shown in Table 1 (surgery information, anesthetic information, and source of ICU are not shown).

Incidence and Patterns of Delirium
Delirium developed in 76 of the 115 participants during the 467 observational (ICU) days, leading to an incidence rate of 66.1% (95% CI [57.4, 74.8]). Forty-six (60.5%) patients developed delirium within 24 hours of ICU admission. The distribution by subtype of delirium was 50% hypoactive subtype (n = 38), 38.2% mixed type (n = 29), and 11.8% hyperactive subtype (n = 9). No significant differences were observed in
the outcomes (death or ICU discharge) among the participants with delirium [13 (17.1%) vs. 63 (82.9%), \(p = .483\)], and no significant differences were observed in the outcomes between patients who developed delirium within 24 hours and those who developed delirium more than 24 hours after admission (46 [60.5%] vs. 30 [39.5%], \(p = .694\)).

**Daily Record List**

A higher risk of developing delirium was observed in patients who had infections (51.3% vs. 25.6%, \(p = .008\)) or septic shock (22.4% vs. 7.7%, \(p = .049\)) at the time of ICU admission, but no differences were identified in terms of infection site or type of bacteria. In terms of laboratory values, lactate on the second day (median 1.4 mmol/L [IQR = 1.8 mmol/L] vs. median 1.2 mmol/L [IQR = 1.0 mmol/L], \(p = .031\)) was higher in the group with delirium, although still within the normal value range, as detected using spectrophotometry. The oxygenation index for the second day was significantly lower in the group with delirium (269 ± 114 mm Hg vs. 312 ± 90 mm Hg, \(p = .033\)). In terms of sleep quality, poor sleep quality was more likely to be associated with delirium (97.4% vs. 69.2%, \(p < .001\)). Patients with delirium had a higher CPOT score than patients without delirium (median 2.0 [IQR = 3.0] vs. median 1.0 [IQR = 2.0], \(p < .001\); Table 2). No significant between-group differences were found for fever, acidosis, alkalosis, urinary volume less than 400 ml, activities of daily living, or other laboratory indicators (data not shown in Table 2).

**Therapeutic Data and Clinical Outcomes**

In terms of medications, significant differences were found between the two study groups for sedatives used (75.0% vs. 56.4%, \(p = .042\)), especially fentanyl (26.3% vs. 18.2%, \(p = .032\)), glycopeptide antibiotics (15.8% vs. 0.0%, \(p = .021\)), and physical restraint (46.1% vs. 2.6%, \(p < .001\)). Moreover, patients with delirium were more likely to experience unplanned extubation (13.2% vs. 0.0%, \(p = .043\)), prolonged time of mechanical ventilator (median 9.0 hours [IQR = 22 hours] vs. median 5.5 hours [IQR = 7.5 hours], \(p = .026\)), and longer stays in the ICU (median 3.0 days [IQR = 3.0 days] vs. median 2.0 days [IQR = 1.0 days], \(p = .017\); Table 2). Most of the participants used mechanical ventilators (\(n = 97, 84.3\%\)). Total number of medications, other types of medications, and any type of catheter use were not different between the participants with and without delirium (data not shown in Table 2).

**Risk Factors for Delirium**

Based on univariate analyses, 12 significant variables were included in the binary logistic regression model: infection at ICU admission, septic shock, SOFA score, APACHE II score, time of mechanical ventilator, poor sleep quality, physical restraint, sedation treatment, use of fentanyl, CPOT score, use

**Figure 1.** Study flowchart. ICU = intensive care unit; RASS = Richmond Agitation–Sedation Scale.
of glycopeptide antibiotics, and the oxygenation index on the second day. Lactate on the second day was not included because both groups were in the normal range. Only poor sleep quality and physical restraints were associated with the onset of delirium. The appearance of poor sleep quality increased the chance of developing delirium by 10.74 times (95% CI [1.59, 72.47]), whereas the use of physical restraints increased this chance by 13.04 times (95% CI [1.57, 107.94]; Table 3).

### Discussion

Although delirium is a frequent complication in older ICU patients, no difference in age was found between the participants with and without delirium. This finding was similar to other studies (Lin et al., 2015), indicating that the factor of age was undetectable in studies on older patients because the age of patients was 65 years or older. APACHE and SOFA scores represent illness severity and organ dysfunction, respectively. In this study, the participants with delirium had higher APACHE II and SOFA scores than those without delirium. Patients with severe illness and organ dysfunction may face a higher risk of developing delirium (Wolters et al., 2014).

Despite finding no difference in the incidence of delirium between medical and surgical patients in this study, it should be still pointed out that postoperative delirium is one of the most unexpected and confusing complications encountered in older patients following surgery (Reddy et al., 2017) and that its subtypes often are hypoactive and mixed (Albrecht et al., 2015). Thus, clinicians and nurses should improve their abilities to assess these two subtypes of delirium with greater precision.

In terms of mechanical ventilation, prolonged time on mechanical ventilators may explain the higher oxygenation index on the second day for the group with delirium. A low oxygenation index value (i.e., < 300) indicates that a patient may need to be placed on a mechanical ventilator. Older patients who use mechanical ventilators are at a higher risk of developing delirium than patients in other age groups (Lin et al., 2015), and delirium is known to prolong the time of mechanical ventilators (Shehabi et al., 2010). Furthermore, patients on ventilators are often relatively neglected in the

### Table 1. Baseline Characteristics of Participants

| Characteristic                        | Delirium (n = 76) | No Delirium (n = 39) | p   |
|---------------------------------------|-------------------|----------------------|-----|
| Age in years, Mdn (IQR)               | 70 (12.0)         | 71 (8.0)             | .727|
| Men                                   | 43 (56.6)         | 28 (71.8)            | .112|
| Education level                       |                   |                      |     |
| Illiterate                            | 9 (11.8)          | 3 (7.7)              | .575|
| Primary school                        | 53 (69.7)         | 26 (66.7)            |     |
| Middle school or above                | 14 (18.4)         | 10 (25.6)            |     |
| Tobacco use                           | 22 (28.9)         | 17 (43.6)            | .116|
| Alcohol use                           | 8 (10.5)          | 4 (10.3)             | 1.000|
| Past medical history at ICU admission |                   |                      |     |
| Hypertension                          | 39 (51.3)         | 18 (46.2)            | .600|
| Heart disease                         | 33 (43.4)         | 13 (33.3)            | .296|
| Cerebrovascular disease               | 8 (10.5)          | 2 (5.1)              | .533|
| Diabetes                              | 10 (13.2)         | 4 (10.3)             | .920|
| Pulmonary dysfunction                 | 14 (18.4)         | 7 (17.9)             | .951|
| Diagnosis at ICU admission            |                   |                      | .227|
| Disease of respiratory system         | 12 (15.8)         | 5 (12.8)             |     |
| Disease of circulatory system         | 21 (27.6)         | 14 (35.9)            |     |
| Disease of digestive system           | 23 (30.3)         | 12 (30.8)            |     |
| Disease of urinary system             | 4 (5.3)           | 5 (12.8)             |     |
| Others                                | 16 (21.1)         | 3 (7.7)              |     |
| Surgical patients                     | 56 (73.7)         | 34 (87.2)            | .097|
| Within 24 hours of ICU admission      |                   |                      |     |
| APACHE II score, Mdn (IQR)            | 14 (9)            | 15 (9)               | .003*|
| SOFA score, Mdn (IQR)                 | 5 (8)             | 3 (5)                | .009*|

Note. IQR = interquartile range; ICU = intensive care unit; APACHE II = Acute Physiology and Chronic Health Evaluation II; SOFA = Sequential Organ Failure Assessment.

*Multiple choice. bCompared with medical patients.

*p < .05.
ICU, and required interventions are often delayed because of difficulties that these patients have in expressing their complex situations (Guttormson et al., 2015). Physicians should assess changes in patient status and modify treatment accordingly.

The results of this study indicate that patients with delirium use sedatives, particularly fentanyl, more often than other patients and have higher CPOT scores. This study did not record sedative and analgesic dose due to individual patient variations. However, sedation level (RASS score) and analgesia level (CPOT score) were recorded. Deep sedation and analgesia are applied to reduce anxiety, stress, and pain during the process of adaptation of being on a ventilator. However, these interventions have side effects such as prolonged mechanical ventilation time, prolonged length of ICU stay, and difficulties in assessing the patient’s mental status. In patients with delirium, it is important to point out which sedatives affect delirium because the management of these patients under anesthesia for perioperation or postoperative pain depends on the use of sedatives, especially fentanyl (Yang et al., 2017). Although the use of fentanyl is not an independent risk factor for delirium, the current protocols for perioperative opioid use and postoperative pain management may influence the incidence of delirium (Rozycki et al., 2017).

Patients with delirium are significantly more likely to have infections at ICU admission (Salluh et al., 2017). They are also significantly more likely to have septic shock. However, ICU, and required interventions are often delayed because of difficulties that these patients have in expressing their complex situations (Guttormson et al., 2015). Physicians should assess changes in patient status and modify treatment accordingly.

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significant differences in glycopeptide antibiotics should only allowed in limited cases. In the group without delirium in this study, only 10 patients had infections at ICU admission, and none were given glycopeptide antibiotics. Therefore, there was a significant difference in use of glycopeptide antibiotics.

Among the variables analyzed in this study, poor sleep quality was frequently found in the group with delirium and was associated with delirium. The most important contributor to poor sleep quality was the ICU environment (Bannon et al., 2018). For example, room lighting at night reduces melatonin levels; excessive noise may wake patients, especially older patients with difficult sleep issues; and constant patient care or treatment may disturb normal sleep patterns (Engwall et al., 2015). Other factors such as patient discomfort, pain, and ventilation conditions may also contribute to sleep deprivation (Xie et al., 2009). In this study, sleep quality was recorded daily until the onset of delirium. Thus, poor sleep quality was regarded as a potentially modifiable risk factor for the development of delirium in older patients following ICU admission. This study provided not only good nursing care but also facilities such as earplugs, sound masking, and acoustic absorption to prevent delirium by improving sleep quality (Xie et al., 2009). However, it is worth mentioning that, although sleep assessments in this study were reliable, using polysomnography is the gold standard of sleep measurement and should be implemented in further studies (Hu et al., 2015).

Physical restraints may be necessary under many conditions to obviate adverse outcomes such as unplanned extubation, which is frequent in patients with delirium. In this study, ICUs often used soft wrist strips and boxing glove restraints. Constraint, as a nursing routine, remains a widespread practice in ICUs in many countries (Suliman et al., 2017). Similarly, the finding in this study of physical restraints being a risk factor for delirium supports the results of prior studies (Inouye et al., 2014). Physical restraint highlights either a shortcoming in nurse staffing levels or substandard care. Several studies (McPherson et al., 2013) suggest that minimizing the physical restraining of patients through the use of early physical therapy reduces the risk and duration of developing delirium among critically ill patients. Thus, implementing appropriate interventions for restraint-free patient care is necessary.

Limitations

This study was affected by several limitations. First, the sample size was small. Second, the duration of delirium was not recorded, and hence, the fluctuations in delirium could not be assessed. These factors may have influenced the results. Sedation treatment (especially the use of fentanyl) and the CPOT score may have been identified as independent factors related to the development of delirium if a larger sample size was used in this study. In addition, factors affecting the development of delirium may have been missed because the duration and fluctuations in delirium were not recorded. However, the main strength of this study is that the risk factors for delirium were identified for all aspects in the medical and surgical older patients in the ICU. Further studies should be conducted on delirium in the older patients following ICU admission in other types of hospitals and ICUs.

Conclusions

The incidence rate of delirium among older critically ill patients is high. The importance of using routine monitoring and effective instruments to detect and prevent delirium should be emphasized in the ICU. Many risk factors exist for delirium, such as length of ICU stay, infection at ICU admission, septic shock, and the use of fentanyl and glycopeptide antibiotics. However, the independent risk factors found to be associated with delirium in this study were poor sleep quality and the use of physical restraints. Therefore, greater attention should be paid to infection control, analgesic drug use, and, especially, sleep quality and nursing behavior management in the future.

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Author Contributions

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Data analysis and interpretation: XL, LZ
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