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Preoperative Risk Factors for Subsyndromal Delirium in Older Adults Who Undergo Joint Replacement Surgery

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BACKGROUND: Older adults with subsyndromal delirium have similar risks for adverse outcomes following joint replacement surgery as those who suffer from delirium.
PURPOSE: This study examined relationships among subsyndromal delirium and select preoperative risk factors in older adults following major orthopaedic surgery.
METHODS: Delirium assessments of a sample of 62 adults 65 years of age or older were completed on postoperative Days 1, 2, and 3 following joint replacement surgery. Data were analyzed for relationships among delirium symptoms and the following preoperative risk factors: increased comorbidity burden, cognitive impairment, fall history, and preoperative fasting time.
RESULTS: Postoperative subsyndromal delirium occurred in 68% of study participants. A recent fall history and a longer preoperative fasting time were associated with delirium symptoms ($p \leq .05$).
CONCLUSIONS: Older adults with a recent history of falls within the past 6 months or a longer duration of preoperative fasting time may be at higher risk for delirium symptoms following joint replacement surgery.

Introduction

Subsyndromal delirium is common in older adults with an occurrence of up to 68% for those who undergo major elective orthopaedic surgery (Liptzin, Laki, Garb, Fingeroth, & Krushell, 2005). Subsyndromal delirium refers to the subclinical delirium symptoms that often go unrecognized by nurses as well as physicians and may never progress to delirium (Vollmer et al., 2010). Subsyndromal delirium occurs when one or more core symptoms of delirium are present without the full range of symptoms that would result in a diagnosis of delirium. Risk factors specific to subsyndromal delirium in surgical patients include advanced age, cognitive impairment, and comorbidities including, but not limited to, vision impairment, dementia, admitted from an institution, increasing severity of medical illness (Cole, Ciampi, Belzile, & Dubuc-Sarrasin, 2013; Fong, Tulebaev, & Inouye, 2009), a recent fall history (Korc-Grodzicki et al., 2015), and a prolonged preoperative fasting time (Radtke et al., 2010).

Supportive and environmental interventions can reduce risk for delirium development in hospitalized older adults. Such interventions include early postoperative mobilization, strategies to enhance sleep, utilization of any adaptive communication devices (especially hearing aids and glasses), and encouraging fluid intake to prevent dehydration (Inouye, 2006). The costs of delirium include increased lengths of stay of three to 12 additional days (Robinson et al., 2009), nursing home placements, and higher mortality rates (Ely et al., 2004; Leslie, Zhang, Boganrdus, Holford, Leo-Summers, & Inouye, 2005; Robinson et al., 2009). Although subsyndromal symptoms are less severe than those seen in delirium, they are predictors for adverse outcomes, increased falls postoperatively, including increased lengths of hospital stays and long-term care admissions, and higher mortality rates (Cole, McCusker, Dendukuri, & Han, 2003; Cole et al., 2011; DeCrane, Culp, & Wakefield, 2012). Some have concluded that the presence of even one core symptom of delirium in an older adult is sufficient enough to result in an increase in the length of hospital stay and/or a decline in functional status (Shim, DePalma, Sands, & Leung, 2015). Identification of patients who are at risk for subsyndromal delirium should be made prior to surgery so that prevention strategies can be initiated. Therefore, the purpose of this study was to determine the relationship among subsyndromal

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delirium and preoperative risk factors of increased age-adjusted comorbidity, cognitive impairment, recent fall history, and prolonged preoperative fasting time in older adults following joint replacement surgery.

Operational Definitions

Recognized core symptoms of delirium include an acute onset and fluctuating course, inattention, and either disorganized thinking or an altered level of consciousness (Inouye et al., 1990). See Table 1 for descriptions of the core symptoms of delirium according to the confusion assessment method (CAM). The following operational definitions utilized for this study were derived from the literature and the conceptual framework provided by Inouye and Charpentier's (1996) multifactorial predictive model of delirium:

- *Delirium.* Delirium is defined as an acute state of transient confusion identified by a positive finding of the first two core delirium symptoms, plus either the third core symptom with or without the fourth core symptom according to the CAM (Inouye, 2003)
- *Subsyndromal delirium*. Subsyndromal delirium is defined as the presence of one or two of the four core symptoms according to the CAM
- *Preoperative risk factors*. The preoperative factors examined for potential risk of subsyndromal delirium include age-adjusted comorbidity score, cognitive impairment score, recent fall history (number of falls within the last 6 months), and duration of preoperative fasting times.

Background

Delirium and Preoperative Risk Factors for Delirium

The costs of delirium include increased lengths of stay (Robinson et al., 2009), nursing home placements, and up to three times the mortality rates of those without delirium (Ely et al., 2004). The full syndrome of delirium is costly and represents a national burden of an estimated $152 billion each year (Leslie & Inouye, 2011; Leslie, Marcantonio, Zhang, Leo-Summers, & Inouye, 2008). However, despite these costs and negative outcomes, prevention efforts for delirium are infrequently implemented (Leslie & Inouye, 2011).

The specific pathophysiology of delirium is poorly understood. Two categories of etiological factors thought to contribute to delirium include direct brain insults and aberrant stress responses. Direct brain insults may occur in the context of energy deprivation (e.g., hypoxia, hypoglycemia, stroke), metabolic abnormalities (e.g., hyponatremia, hypercalcemia), alcohol withdrawal, or adverse effects of drugs (MacLullich, Ferguson, Miller, deRooij & Cunningham, 2008; Robinson et al., 2009). Aberrant stress response systems thought to be involved in the pathophysiology of delirium include inflammation and activity of the limbic–hypothalamic–pituitary–adrenal axis (MacLullich et al., 2008).

Subsyndromal Delirium May Lead to Adverse Outcomes

Subsyndromal delirium develops quickly over a few hours or days and represents an acute change in cognitive function that is not directly related to another cognitive disorder (Blazer & Van Nieuwenhuizen, 2012). Subsyndromal delirium may or may not progress to

Table 1. Core Symptoms of Delirium According to the Confusion Assessment Method Algorithm

Delirium Symptom	Description
Acute onset and fluctuating course	This symptom is often noted by primary nurse or family member and is shown by positive responses to the following questions: • *Is there evidence of an acute change in mental status from the patient's baseline?* • *Did the (abnormal) behavior fluctuate during the day, that is, tend to come and go, or increase and decrease in severity?*
Inattention	This symptom is noted when the patient has difficulty focusing attention and is shown by a positive response to the following question: • *Did the patient have difficulty focusing attention, for example, being easily distractible, or having difficulty keeping track of what was being said?*
Disorganized thinking	This symptom is noted when there is a positive response to the following question: • *Was the patient's thinking disorganized or incoherent, such as rambling or irrelevant conversation, unclear or illogical flow of ideas, or unpredictable switching from subject to subject?*
Altered level of consciousness	This symptom is noted when the following question is answered with a response other than "alert": • *Overall, how would you rate this patient's level of consciousness?* ◦ alert (normal) ◦ vigilant (hyperalert) ◦ lethargic (drowsy, easily aroused) ◦ stupor (difficult to arouse) ◦ coma (unarousable)

Note. From *Annals of Internal Medicine*, S. K. Inouye, C. H. van Dyck, C. A. Alessi, S. Balkin, A. P. Siegal, & R. I. Horwitz. Clarifying confusion: The Confusion Assessment Method, 113, 941-948. Copyright © 1990 American College of Physicians. All Rights Reserved. Reprinted with the permission of American College of Physicians, Inc.

delirium (Cole et al., 2003; Vollmer et al., 2010). Subsyndromal delirium that is not associated with delirium is considered temporary and usually resolves in 1–3 days but can persist up to 133 days (Cole et al., 2013). Although the specific pathophysiology of postoperative delirium symptoms is unknown, delirium symptoms are thought to result from a complex interaction of multiple risk factors (Inouye & Charpentier, 1996). In their predictive multifactorial model of delirium, Inouye and Charpentier (1996) assert that predisposing and precipitating risk factors interact in a cumulative manner to cause the symptoms seen in delirium. Subsyndromal delirium occurs when one or two of the core symptoms of delirium are present without meeting the criteria for full delirium (DeCrane et al., 2012). Similar to delirium, subsyndromal delirium is a marker of poor prognosis (Marquis, Ouimet, Riker, Cossette, & Skrobik, 2007).

Although the concept of subsyndromal delirium is controversial, substantial evidence suggests that it is clinically relevant for delirium prevention. Levkoff et al. (1996) and others assert that delirium symptoms represent a spectrum of neurobehavioral impairments rather than a condition with distinct clinical profiles and outcomes (Levkoff et al., 1996; Ouimet et al., 2007; Shim & Leung, 2012). However, others question the notion that subsyndromal delirium is a graded step in the spectrum of brain dysfunction severity due to differences in risk factors (Skrobik, 2009).

Description of Select Preoperative Risk Factors

Comorbidity Burden

Comorbidities have been associated with higher rates of postoperative delirium in hospitalized patients (Marcantonio, Ta, Duthie, & Resnick, 2002; Robinson et al., 2009). The age-adjusted Charlson Comorbidity Index (CCI; Charlson, Pompei, Ales, & MacKenzie, 1987) is a measure that calculates an individual's estimated relative risk of death on the basis of the burden of disease and age.

Older age has been identified as a risk factor that predisposes one to delirium (Kalisvaart et al., 2006; Morrison et al., 2003; Vaurio, Sands, Wang, Mullen, & Leung, 2006). Although there is wide agreement on age as a risk factor for delirium, the evidence is mixed on the subject of whether age increases risk for subsyndromal delirium. Age is not associated with subsyndromal delirium in hospitalized older adults 65 years of age or older on the medical unit (Cole et al., 2003) but is a risk factor for patients in the intensive care unit with a mean age of 69 years (Ceriana, Fanfulla, Mazzacane, Sanroro, & Nava, 2010). In addition, older age was found to be a risk factor for subsyndromal delirium for patients 80 years of age or older following hip fracture surgery (Marcantonio et al., 2002). In our study, the CCI was used as a measure because the calculated score considers age and the impact of comorbid conditions, which are thought to increase risk for delirium symptoms.

Cognitive Impairment

In addition to older age, preexisting cognitive impairment has consistently been associated with postoperative delirium (Bjoro, 2008; Edlund, Lundstrom, Brannstrom, Bucht, & Gustafson, 2001; Kagansky et al., 2004; Kalisvaart et al., 2006). The small number of studies available also provide early evidence for cognitive impairment as a risk factor for subsyndromal delirium in both hospitalized medical patients (Cole et al., 2011; Levkoff et al., 1996) and surgical patients (Marcantonio et al., 2002).

Impaired Mobility and Fall History

Functional status that impairs mobility is associated with delirium (Fong et al., 2009; Korc-Grodzicki et al., 2015). Decreased functional status is identified as a risk factor for subsyndromal delirium in medical inpatients (Cole et al., 2011). Furthermore, a history of a fall in the past 6 months is an independent predictor of postoperative delirium, even more than an abnormal dementia screening result (Korc-Grodzicki et al., 2015). Given the strength of the predictive value of a recent fall history for delirium, a recent fall history within the past 6 months was selected as one of the preoperative risk factors for our study.

Preoperative Fasting Times

Dehydration that can result from prolonged preoperative fasting times has also been found to contribute to delirium risk (Levkoff et al., 1996; Popeo, 2011). A prolonged preoperative fasting time is considered a modifiable risk factor for the development of postoperative delirium, and the duration of preoperative fasting time is a risk factor for delirium symptoms in the postanesthesia care unit and on the first postoperative day (Radtke et al., 2010). However, Radtke et al. (2010) did not assess for delirium symptoms beyond the day after surgery.

Subsyndromal delirium is very common in older adults following joint replacement surgery (Liptzin et al., 2005). Given that one subsyndromal delirium symptom may be sufficient to cause increased lengths of hospital stay, a decline in functional status, and an increased risk for development of delirium (Shim et al., 2015), understanding the significance of subsyndromal delirium seemed essential in identifying high-risk patients for prevention and early detection to minimize adverse outcomes.

Methods

Study Design

This descriptive, correlational study examined the relationship among subsyndromal delirium and the preoperative risk factors of comorbidity, cognitive impairment, recent fall history, and preoperative fasting time in older adults following major elective joint replacement surgery.

Sample Selection

In a sample, adults 65 years of age or older who were scheduled for joint replacement surgery at a northwestern hospital in the United States were recruited for participation in this study. The study was conducted

between August 2013 and May 2014. Approval for human subject protection was obtained prior to the start of the investigation from the university's institutional review board (IRB). The research site, which did not have its own IRB in place, accepted the university's IRB approval for the study (IRB-201306-387). At a preoperative appointment, potentially eligible participants were screened by preoperative nurses according to inclusion and exclusion criteria. Eligible older adults were (1) 65 years of age or older; (2) scheduled for major orthopaedic surgery with an anticipated length of stay of 48 hours; and (3) able to speak and understand English. Patients who had preexisting delirium were excluded from eligibility for participation in the study. Following written informed consent, each participant's preoperative status was verified.

Tests and Measures

Participants were evaluated for preexisting delirium using the CAM; Inouye et al., 1990), and baseline cognitive status was quantified preoperatively using the Mini-Cog dementia screening tool (Borson, Scanlan, Brush, Vitaliano, & Dokmak, 2000). The Mini-Cog combines a three-word recall with a clock-drawing test and is scored from 0 to 3 on the basis of the number of words recalled, with lower scores indicating increased cognitive impairment. None of the participants in this study had delirium symptoms at the time of the initial preoperative meeting; if delirium symptoms had been detected, the participant would have been excluded from study participation. At the enrollment session, participants completed a demographic questionnaire jointly with the researcher.

Delirium Assessment

Postoperative delirium typically emerges 24–48 hours following surgery and may resolve within 48 hours, although it may persist for months in some older patients (Sieber, 2009). Using the CAM algorithm, assessment for delirium was completed daily starting at 24 hours following surgery on postoperative Day 1 and repeated on postoperative Days 2 and 3. Both full delirium and subsyndromal delirium were recorded by indicating the number of delirium symptoms on the CAM present.

The CAM is a diagnostic algorithm used to detect four core symptoms of delirium with high interobserver reliability (κ = 0.81–1.00) and moderate concurrent validity with the Mini-Mental State Examination (κ = 0.64). Detection of full delirium requires positive findings for the first two core symptoms on the CAM (fluctuating course, inattention) and the third core symptom (disorganized thinking), with or without the fourth core symptoms (altered level of consciousness). Our study categorized delirium symptoms as subsyndromal delirium 1 (SSD-1), when one core symptom of delirium was identified, and subsyndromal delirium 2 (SSD-2) when two of the core symptoms of delirium were detected using the CAM.

Preoperative Risk Factor Assessment

Baseline assessments for preoperative risk factors included the CCI and the Mini-Cog (Borson et al., 2000) to detect preexisting cognitive impairment. Using the CCI, an age-adjusted score of comorbidity burden was used to estimate mortality risk. A CCI score was calculated using a preexisting disease burden for each participant. To measure recent fall history, participants were asked whether they had experienced a fall within the previous 6 months, and if so, how many falls occurred during the time period. Patient data regarding fall history were obtained at the time of enrollment as supplemented by information from the medical record. Data regarding preoperative fasting time were collected retrospectively. The duration of preoperative fasting time was calculated in hours from the last known time of oral intake, whether it was solid food or liquids.

Data Analysis

Power analysis was used to determine the appropriate number of participants for the study. A sample of 53 participants was required to achieve a statistical power of 0.80 with an α of .05 and the conventional effect size of 0.30 (f^2= 0.30; Cohen, Cohen, West, & Aiken, 2003). For the primary outcome of subsyndromal delirium, frequencies of delirium symptoms were recorded as the number of symptoms in daily CAM assessments. Data from daily CAM assessments were supplemented by reports of delirium symptoms by members of the healthcare team or family. Regression analysis was selected to analyze the relationship between delirium symptoms and the preoperative risk factors. Utilizing SPSS software, the stochastic regression imputation method was used to replace missing values in SPSS as described by Schlomer, Bauman, and Card (2010).

Preoperative factors (comorbidity status, cognitive status, recent fall history, and preoperative fasting time) were recorded for each participant. Descriptive statistics and correlations were used to examine sample characteristics and significant relationships between preoperative risk factors with delirium symptoms. The relationship between delirium symptoms and each of the preoperative risk factors will be discussed individually in the following section.

Results

Sample Characteristics

The mean age for the participants was 74 years (M = 74, SD = 6.2) with an age range of 65–90 years. The study sample consisted of 57% (n = 30) women and 43% (n = 23) men. Although strict medical clearance is required for elective joint replacement surgery, all of the participants in this study represented a wide variety of comorbidities (see Table 2). Total unilateral total knee arthroplasty was the most common procedure performed (66%, n = 35). Procedures performed on sample participants are reported in Table 3.

Subsyndromal Delirium Symptoms

Delirium symptoms were common among study participants in the first 72 hours following surgery. On postoperative Day 1, 75% (n = 40) of the participants did not

Table 2. Comorbid Conditions in Adults 65 Years of Age or Older Scheduled for Joint Replacement Surgery ($N = 53$)

Coexisting Conditions	*n* (%)
Anemia	3 (5.7)
Atrial fibrillation/heart palpitations	4 (7.5)
Cerebrovascular disease	2 (3.8)
Congestive heart failure	2 (3.8)
Chronic obstructive pulmonary disease	6 (11.3)
Coronary artery disease	4 (7.5)
Cardiovascular disease (not HTN or CAD)	7 (13.2)
Dementia	9 (17.0)
Depression	4 (7.5)
Diabetes (Type I or II)	12 (22.6)
Hypertension	34 (64.2)
Hypothyroidism	14 (26.4)
Obstructive sleep apnea	11 (20.4)

have delirium symptoms and 25% ($n = 13$) presented with one symptom of delirium (SSD-1). On postoperative Day 2, SSD-1 was detected in 19 participants (36%, $n = 19$) and two delirium symptoms (SSD-2) were detected in 19% ($n = 10$) of participants. Although 40% ($n = 21$) of participants did not have any delirium symptoms on Day 2, full delirium developed in 6% ($n = 3$) of the participants. On postoperative Day 3, 28% ($n = 15$) of participants were free of delirium symptoms, whereas SSD-1 was identified in 40% ($n = 21$) of participants, SSD-2 was present in 13% ($n = 7$) of participants, and full delirium in 19% ($n = 10$) of participants. Participants were not evaluated beyond postoperative Day 3. Therefore, follow-up information regarding participant recovery beyond postoperative Day 3 was not available.

Subsyndromal delirium developed in 68% ($n = 36$) of the participants on postoperative Days 1, 2, or 3 (see Figure 1). Of those participants who developed subsyndromal delirium, 68% ($n = 25$) developed one symptom (SSD-1) and 33% ($n = 12$) developed subsyndromal delirium with two symptoms (SSD-2). Full delirium occurred in 17% ($n = 9$) of participants. Of the 53 participants, 15% ($n = 8$) did not develop any delirium symptoms during the study period.

Table 3. Orthopaedic Procedure Performed and Indication for Surgery in Older Adults[a]

Sample Characteristic	*n* (%)
Scheduled surgical procedures	
Total knee replacement	35 (66)
Total hip replacement	11 (20)
Bilateral knee replacement	3 (6)
Total shoulder replacement	3 (6)
Total knee revision	1 (2)
Primary diagnosis	
Osteoarthritis	52 (98)
Rheumatoid arthritis	1 (2)

[a]$N = 53$.

Preoperative Risk Factors Relationship to Delirium Symptoms

Comorbidities

The CCI was used to classify patients by comorbidity burden. The CCI includes 19 diseases weighted on the basis of the strength of their association with mortality, which is then combined with age to calculate a score between 0 and 31 (with higher scores representing a higher burden of comorbidity). The mean CCI score was 3.7 ($SD = 1.2$) with a variance of 1.5. The CCI score was not related to delirium symptoms in older adult participants ($r = .12$). The CCI score averaged 3.6 in participants who developed delirium symptoms ($M = 3.6$, $SD = 1.3$) and 3.8 in participants with no delirium ($M = 3.77$, $SD = 1.2$).

Cognitive Status

Baseline cognitive function was quantified using the Mini-Cog dementia screening tool that combines a three-word recall with a clock-drawing test. The Mini-Cog was scored from 0 to 3, with lower scores indicating increased cognitive impairment. The mean cognitive score for participants in this study was 2.06 ($M = 2.1$, $SD = 1.0$) with a variance of 1.0, reflecting good memory recall overall. The Mini-Cog screen was positive for dementia in 17% ($n = 21$) of study participants. Only two participants had a formal medical diagnosis of dementia in their medical record. Increased delirium symptoms were not significantly associated with preoperative cognitive impairment for the 72-hour study period, $r = -.13$, $p = .34$. Participants with more lower score on the Mini-Cog did not differ significantly in the number of delirium symptoms detected from those participants without cognitive impairment ($r = -.21$, $p = .14$).

Recent Fall History

A history of recent falls was defined as one or more falls reported by participants or on the medical record within

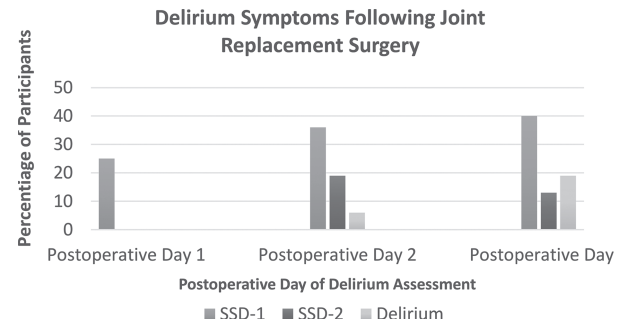

Figure 1. Bar graph showing the percentage of participants with subsyndromal delirium with one delirium symptom (SSD-1), subsyndromal delirium with two delirium symptoms (SSD-2), and full delirium on postoperative Days 1, 2, and 3 following joint replacement surgery.

the past 6 months. Participants with a recent fall history had more delirium symptoms (see Table 4). Recent fall history was significantly correlated with increased delirium symptoms at 48 hours ($r = .37$, $p = .007$) and overall for the 72-hour study period ($r = .33$, $p = .02$).

Preoperative Fasting Time

Participants' fasting times were recorded using a continuous scale of 0 hours to 18 hours of no food or fluids prior to surgery. As shown in Figure 2, fasting times ranged from 5.0 to 17.0 hours without food or fluids with an average of 9.5 hours ($M = 9.5$, $SD = 2.2$) and a variance of 4.2 hours. Those participants who had fasted more hours prior to surgery had significantly more delirium symptoms on the third postoperative day. The most frequent preoperative fasting time was 7.5 hours. It was frequently reported by participants that preoperative instructions directed them to fast after midnight the night prior to surgery. An increased duration of preoperative fasting time was associated with significantly more delirium symptoms on the third postoperative day ($r = .30$, $N = 53$, $p = .03$).

Discussion

In this study, 68% ($n = 36$) of the participants who underwent elective joint replacement surgery developed subsyndromal delirium symptoms on at least 1 of the 3 days following surgery. Most of the individual participants had undergone total knee or hip arthroplasty procedures (87%). Our overall rate of subsyndromal delirium was comparable with previous findings in samples of older hospitalized patients who underwent total joint replacement surgery (Liptzin et al., 2005).

Subsyndromal Delirium is Common in Older Adults Following Joint Replacement Surgery

Reported incidence rates for subsyndromal delirium are variable and range from 12% to 69% (Bourdel-Marchasson et al., 2004; Ceriana et al., 2010; Cole et al., 2003; Liptzin et al., 2005; Marcantonio et al., 2002; Tan et al., 2008). The incidence of subsyndromal delirium in this study is comparable with the incidence rate of 69% reported by Liptzin et al. (2005) following joint replacement surgeries of older adults. Other studies conducted in acute care settings have reported lower incidence rates of subsyndromal delirium among older adults than we found. For example, in a study of both medical and surgical patients, the incidence was 46.2% (Levkoff et al., 1996), 20% in patients with hip fractures (Marcantonio et al., 2002), and 34% in patients following cardiotomy surgery (Tan et al., 2008). Findings from our study suggest that subsyndromal delirium may be more prevalent in older adults who undergo total joint replacement surgery than in some other surgical populations.

Despite the wide range of incidence of delirium symptoms from previous studies, delirium symptoms are most common in older adults during the early postoperative period. Cole (2013) suggested that variation in subsyndromal delirium incidence rates should not be assumed as related to the diagnostic criteria used. Also, some evidence suggests that little difference exists in delirium detection despite the use of different sets of validated diagnostic criteria, such as the CAM or the Diagnostic and Statistical Manual for Mental Disorders III or IV (Cole et al., 2013; Voyer, Richard, Doucet, & Carmichael, 2009).

Like delirium, the detection of subsyndromal delirium occurs through the identification of the number of core symptoms that are present (Cole et al., 2011). In our study, subsyndromal delirium with one symptom of delirium (SSD-1) occurred more frequently than subsyndromal delirium with two or three symptoms (SSD-2). Few researchers have reported SSD-1 and SSD-2 separately; however, Cole et al. (2011) detected SSD-1 in 65.4% and SSD-2 in 26% of long-term care residents who were assessed as negative for delirium prior to the study. Our higher rate of SSD-1 (45.2%) versus SSD-2 (20.8%) occurrence was comparable with those rates reported by Cole et al. (2011). However, significant sample differences between medical patients in long-term care and the surgical patients sampled in our study make comparisons difficult to interpret.

Subsyndromal delirium may progress to delirium or it may resolve without progression. In our study, 18.9% of the participants developed full delirium. Of those participants with full delirium, 60% had either one or two positive findings on one of the postoperative CAM assessments prior to the development of full delirium in comparison with 40% of patients who developed delirium without previous detection of subclinical delirium symptoms. The progression to full delirium from subsyndromal delirium supports the notion that subsyndromal delirium occurs on a spectrum between no delirium and full delirium. Although subsyndromal delirium is not clinically diagnostic, attention is needed

Table 4. Correlations of Preoperative Risk Factors and Delirium Symptoms in Older Adults

	Delirium Score					
	At 24 Hours ($N = 53$)		At 48 Hours ($N = 53$)		At 72 Hours ($N = 53$)	
Risk Factor	Pearson *r*	*p*	Pearson *r*	*p*	Pearson *r*	*p*
Charlson Age Comorbidity Index Score	.04	.76	.18	.20	.01	.90
Cognitive Score	−.21	.13	−.10	.48	−.08	.55
Fall history[a]	−.11	.45	.32	.008**	.26	.06
Preoperative fasting time	.10	.50	.07	.63	.30	.03*

[a]The number of participant falls that had occurred in the 6 months prior to enrollment.
*$p \leq .05$ level. **$p \leq .01$ level.

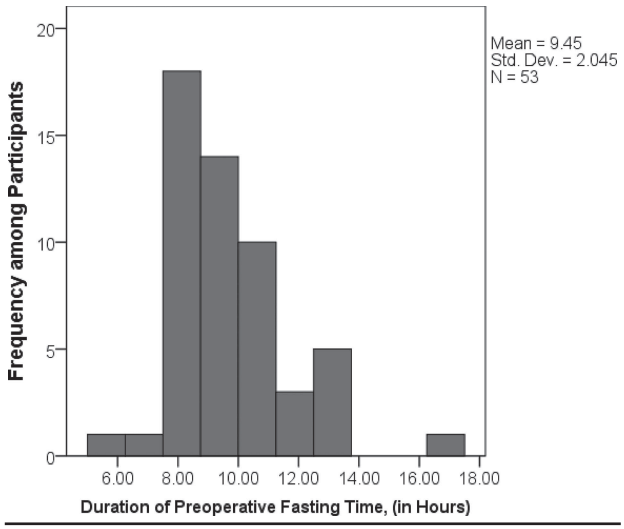

FIGURE 2. Bar graph showing the frequency distribution of preoperative fasting time duration for older adults. Fasting times were calculated starting from the time of the participant's last known oral intake and ending at the surgery start time.

to implement strategies to reverse progression from subsyndromal delirium to delirium in order to reduce the adverse outcomes and costs to patients and the healthcare system.

The most common core symptom of delirium we identified using the CAM algorithm (shortened version) was inattention. Overall, inattention was detected in 66% (n = 35) of participants, the core delirium symptom of disorganized thinking was detected in 42% (n = 22) of participants, the symptom of a fluctuating course in 33% (n = 18), and a change in level of consciousness was detected in 29% (n = 15) of participants.

Preoperative Risk Factors and Subsyndromal Delirium in Older Adults

In this study, preoperative risk factors for subsyndromal delirium for inclusion in data analyses procedures were selected from risk factors repeated in the delirium literature for older surgical patients. Those risk factors included advanced age (Dasgupta & Dumbrell, 2006; DeCrane et al., 2011), a higher number of comorbidities (Cole et al., 2013; Marcantonio et al., 2002), cognitive impairment (DeCrane et al., 2011; Marcantonio et al., 2002), history of a recent fall (Fong et al., 2009; Korc-Grodzicki et al., 2015), and the duration of preoperative fasting times (Radtke et al., 2010). Each of the select preoperative risk factors will be discussed in the following section.

Comorbidities

Mixed results were derived from studies evaluating the role of comorbidities on the development of delirium. For example, some researchers have identified the Charlson Comorbidity Index score as an independent risk factor in hospitalized older adults in medical (Inouye et al., 2007) and surgical patients (Rudolph et al., 2009; Tan et al., 2008), whereas others have failed to demonstrate a significant relationship between delirium and a patient's level of comorbidity burden (Marcantonio et al., 2002; Neufeld et al., 2013; Velilla et al., 2013). Inouye et al. (2007) used the Charlson Comorbidity Index to measure baseline characteristics in hospitalized older adults at discharge to determine delirium risk with a cutoff score of 4. Upon closer examination, it was noted that nearly one-half of participants in this study who developed delirium symptoms (n = 23) had a Charlson Comorbidity Index score of 4 or greater (n = 11). Although correlation and regression analyses did not demonstrate a significant relationship between age-adjusted comorbidity burden and delirium symptoms in the present study, comorbid conditions seemed to pose increased risk in older adults with a more complicated medical history, which would be expected.

Cognitive Status

In our study, cognitive status was considered to be impaired in 25% of participants (n = 13). Of those participants with an abnormal Mini-Cog screen, only 15% had a formal diagnosis of dementia (n = 2). Other studies have shown that onset of postoperative delirium in older adults is related to dementia or cognitive impairment (Cole et al., 2003; Cole et al., 2011; Levkoff et al., 1996; Marcantonio et al., 2002). When broken down by procedure, patients in our study who underwent total hip arthroplasty procedures were older ($M_{\text{hip replacement}}$ = 77 years vs. M_{overall} = 74 years) and had the highest rate of cognitive impairment (36.4%) compared with patients who underwent other total joint replacement procedures (11.9%). Cognitive impairment occurred at similar rates in patients who developed subsyndromal delirium with one symptom (16.7%) and two symptoms (18.2%). It is worth noting that cognitive impairment was detected only in one participant who did not develop delirium symptoms (12.5%). Cognitive impairment has consistently been identified as a risk factor for delirium in other studies. Marcantonio et al. (1994) developed a predictive model for delirium applicable to noncardiac surgical patients in which one of the three strongest predictors is cognitive impairment, and this finding is corroborated by a more recent systematic review (Dasgupta & Dumbrell, 2006). In addition, Cole et al. (2003) found dementia to be a strong predictor of subsyndromal delirium in medical patients. Correlation and regression analysis did not demonstrate a significant relationship between cognitive impairment and subsyndromal delirium in the sample of participants in the present study, presumably due to a small representation of participants with cognitive impairment in the sample.

Recent Fall History

This study found that the number of falls within the past 6 months was significantly related to increased delirium symptoms on the second day and the third day following surgery. After accounting for variances introduced by the other preoperative risk factors (Charlson Comorbidity Index score, Mini-Cog score, and duration of preoperative fasting time), the number of falls within the past 6 months was significantly related to increased delirium symptoms, r = .32, p = .008. Others report that a recent fall is an important risk factor for delirium (Fong et al., 2009). A history of falls is a nonmodifiable

risk factor for delirium (Fong et al., 2009; Korc-Grodzicki et al., 2015) that may be useful to identify high risk for delirium prior to surgery. In a recent investigation with a larger sample (n = 416), Korc-Grodzicki et al. (2015) found a history of falls to be predictive of postoperative delirium in surgical patients 75 years of age and older. Functional status, which may be reflected by a recent history of a fall, has previously been identified as a risk factor for delirium (Levkoff et al., 1996) but was not related to delirium in the present study as measured by the Barthel Index prior to surgery.

Our findings agree with those of previous researchers who concluded that having a recent fall history places the patient at a significant risk for developing postoperative delirium (Fong et al., 2009; Korc-Grodzicki et al., 2015). Our participants who reported falling in the past 6 months had an average CCI score of 6.0. This was significantly higher than the average CCI score of 3.6 for those without a recent fall history. Having a history of a recent fall was significantly correlated with the CCI score (r = .38, p = .003). Identification of a fall history prior to joint replacement surgery in adults older than 65 years may indicate a risk for subsyndromal delirium. Fall history can be easily added to preoperative assessment interview questions to serve as a trigger for the implementation of delirium prevention interventions.

Preoperative Fasting Time

The fasting time of patients' fasts from fluids prior to surgery has been reported as a predictor for early postoperative delirium in older adults in the recovery room and on the first postoperative day (Radtke et al., 2010). Similarly, our finding demonstrated a positive relationship between preoperative fasting time (from food and fluids) and the presence of delirium symptoms on the third postoperative day (r = .30, p = .03) but was not related to increased delirium symptoms at 24 hours (r = .10, p = .50) or at 48 hours (r = .07, p = .63). Radtke et al. (2010) recommended changes in current practice aimed at reducing certain precipitating risk factors for delirium that include reduction of preoperative fasting times. We measured the effects of preoperative fasting time on the development subsyndromal delirium through third postoperative day. Our findings suggest that longer preoperative fasting times may contribute to delirium symptoms that emerge up to the third postoperative day.

Limitations

This study's observational design presents limitations as inferences are drawn from our findings. The sample was largely homogenous with only one Native American and 52 Caucasian participants and may not represent the diverse population of older adults who choose to have elective joint replacement surgery procedures performed. Because delirium assessments were completed by only one of the researchers at a rural site, it was unfeasible to assess for interrater reliability. However, the use of the same researcher for all of the CAM assessments provided consistency throughout the study. Also, this study examined variables that were identified from other studies in the literature, thus limiting the addition of further literature to the body of knowledge on delirium.

Conclusions and Implications for Orthopaedic Nursing Practice

There is a need to incorporate delirium risk assessments into preoperative testing and screening so that prevention measures can be initiated in the preoperative period. With the common occurrence of delirium symptoms, postoperative assessment of older adults should include assessment for delirium symptoms as part of routine practice. It is no longer acceptable to "wait and see" or "watch" the situation when patients develop subsyndromal delirium. Rather, once subsyndromal delirium symptoms are identified, the nurse is advised to initiate an investigation to identify possible culprits that may precipitate delirium symptoms.

A recent fall history may increase the risk for delirium symptoms. Efforts to identify this nonmodifiable risk factor are important to delirium prevention. Nurses who interview patients prior to scheduled orthopaedic surgeries can help identify a recent fall history and initiate delirium prevention strategies. Combined with other known risk factors of increased age, comorbidity, and cognitive impairment, having information regarding fall history as a risk factor may be useful for decisions regarding room placement, staffing, and selection of anesthetic agents and pain medication.

Preoperative fasting times should also be minimized as part of delirium prevention efforts in patients 65 years of age or older scheduled for joint replacement surgery. Fasting times prior to surgery may place older adults at risk for delirium symptoms that may emerge as late as the third postoperative day. Although more research is needed to validate this finding, efforts to minimize longer fasting times in older patients may provide a protective effect from delirium. Individualization of fasting time based on the scheduled surgery start time is recommended by abandoning the requirement that all patients to fast after midnight.

Despite the controversial nature of subsyndromal delirium, its symptoms should not be ignored and may be an important indicator of undetected problems. Orthopaedic nurses are encouraged to routinely assess for delirium symptoms in their patients 65 years of age or older and to respond to the presence of symptoms by initiating an investigation into possible etiological factors. Findings from this study suggest a possible relationship among the hours of fasting prior to surgery and subsyndromal delirium when other preoperative risk factors of increased age, comorbidity, cognitive impairment, and recent fall histories are considered.

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