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Role of Nursing Interventions in Preventing Delirium in the Cardiac Surgery Intensive Care Unit: A Prospective Cohort Study

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Abstract

Background: Delirium is a common to and life-threatening complication in the Cardiac Surgery Intensive Care Unit (CSICU), which is linked to a prolonged period of mechanical ventilation, a long duration of hospitalization, and cognitive impairment. Although it is becoming more apparent that structured nursing interventions may decrease the prevalence of delirium, their implementation and efficacy in the CSICU setting have not been examined thoroughly.

Methods: The prospective and controlled cohort study was carried out in one tertiary cardiac surgery centre during the period of January and September 2024. One hundred and twenty adult patients (n=120) who had already undergone post-cardiac surgery were included and divided into standard care control (n=60) and multicomponent nursing intervention (n=60) groups. The intervention package included periodic CAM-ICU delirium assessment every 8 hours, reorientation procedures, sleep hygiene, early movement, sensory optimization, family involvement, pain/sedation management, cognitive stimulation, hydration and nutrition, and daily medication review. The main event was the incidence of delirium according to CAMICU. Secondary outcomes were the duration of delirium, ICU stay, mechanical ventilation stay, antipsychotics, physical restraint, and 30-day readmission.

Results: The occurrence of delirium was greatly reduced in the intervention group as opposed to controls (23.3% *vs.* 46.7%; $p<0.01$). Delirium duration was also markedly reduced (1.3±0.9 *vs.* 2.8±1.6 days; $p<0.001$). ICU length of stay (4.7±2.1 *vs.* 6.4±2.9 days; $p=0.001$), mechanical ventilation duration (15.6±9.3 *vs.* 22.4±14.8 hours; $p=0.003$), antipsychotic use (15.0% *vs.* 33.3%; $p=0.02$), and physical restraint (10.0% *vs.* 25.0%; $p=0.03$) were all significantly reduced in the intervention cohort. Independent risk factors for delirium included age ≥70 years (OR 3.7), prior cognitive impairment (OR 4.4), cardiopulmonary bypass duration ≥90 minutes (OR 3.2), and benzodiazepine use in the ICU (OR 3.4).

Conclusion: A multicomponent, structured nursing intervention bundle has a significant impact on reducing the occurrence and length of stay of delirium in CSICU patients. The use of systematic nursing-based assessment and prevention procedures must be included as a routine practice in cardiac surgery intensive care units.

Keywords: Delirium; Cardiac Surgery; Intensive Care Unit; Nursing Interventions; CAM-ICU; ABCDE Bundle; Postoperative Care; Critical Care Nursing

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Introduction

Delirium, which is characterized by the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) as an acute disturbance of attention, awareness, and cognition and is developed within a short period and varies over time, is one of the most common and clinically important complications the Cardiac Surgery Intensive Care Unit (CSICU) is faced with [1, 2]. Postoperative delirium is reported in 11-52 percent of patients who undergo cardiac surgery, depending on the complexity of the procedure, the age of the patient, and comorbid conditions [3, 4]. Delirium in mechanically ventilated ICU patients has been found to predict mortality, extended mechanical ventilation, and months to years of cognitive impairment as an independent variable [1, 5, 6]. A delirium pathophysiology within the CSICU setting is multifactorial and includes neuroinflammatory cascades due to Cardiopulmonary Bypass (CPB), haemodynamic instability, cerebral microemboli, metabolic derangements, and massive pharmacological exposures such as opioids, benzodiazepines,

and volatile anaesthetic drugs. Aging, cognitive impairments, and limited functional capabilities (specifically underlying conditions) can predispose one to the development of delirium, which is then induced by intraoperative and postoperative factors [7]. The delirium burden is not only symptomatic: delirious patients are more prone to unexpected device removals, physical trauma, and infections, and have significantly higher healthcare expenses than their non-delirious counterparts [8]. Although evidence-based guidelines on preventing delirium are available, even the latest publication of Pain, Agitation/Sedation, Delirium, Immobility, and Sleep disruption (PADIS, 2018) guidelines, published by the Society of Critical Care Medicine (SCCM) on Pain, Agitation, and Delirium (2013), has not been consistently applied in clinical practice [9, 10]. The bundle of Awakening Trials, Breathing Trials, Coordination, Delirium Monitoring and Management, and Early Mobility, known as the ABCDE bundle, has been demonstrated to decrease the occurrence of delirium and enhance patient outcomes, although bedside nurses have multiple complex barriers, such as patient acuity, staffing level, and institutional assistance in protocol implementation [11]. Nurses are strategically placed in the role of delirium prevention as they are the first to evaluate cognitive change, as well as to organize non-pharmacological support and promote patient centred care in the ICU. It has been shown that nursing-led interventions can decrease the incidence of delirium by up to 3050 percent when systematically put in place [12, 13]. The conceptual framework of multicomponent non-pharmacological prevention bundles, which was initially developed around older medical patients, was the Hospital Elder Life Program HELP), which showed a 34 to 37 percent reduction in delirium. Later implementations of this framework in the setting of surgical and critical care have demonstrated similar effectiveness, but there is a dearth of evidence on specific groups of cardiac surgery [14]. There are special issues in the CSICU that make delirium prevention more difficult. Patients come out of long anaesthesia intubation, invasive haemodynamic monitoring, chest drains, and urinary catheters, all of which are causes of physiological and psychological stressors. The acute setting, which is highly alert and lit, and imposes passivity on the mechanical ventilation, significantly interferes with circadian rhythms and sleep geometry. Sleep deprivation, in its own right, has been recognized as another modifiable risk factor of delirium onset, highlighting the essence of the paramount importance of specific sleep hygiene interventions. The role of family engagement is a dimension of delirium prevention in critical care that is underused and has a strong impact. Knowledge about loved ones, repetitive reorientation administered by family members, and provision of such personal objects as photographs or hearing aids have been indicated to reduce the disorientation that characterizes hyperactive and mixed subtypes of delirium. Sensory optimization, such as the issuance and support of hearing aids and spectacles, is a misleadingly straightforward yet effective nursing intervention in CSICU populations in which the patients may be highly frail with a preexisting hearing or visual deficit [7]. Although the literature on the use of delirium in the overall ICU population has increased, research that specifically analyzes the impact of structured nursing intervention bundles on the results of adult patients in the CSICU is limited. The literature that is currently available is mainly based on heterogeneous surgical or mixed medical/surgical ICU cohorts, making it difficult to generalise the results to the specific physiological environment of post-cardiac surgery care. This research was thus intended to fill this knowledge gap by assessing the effect of an extensive, nurse-based multicomponent delirium prevention bundle on adult post-cardiac surgery patients admitted to a tertiary CSICU. We hypothesized that the systematic application of this bundle would have a major reduction in the incidence, duration, and adverse outcomes of delirium in comparison to normal care.

Literature Review

Epidemiology and burden of delirium in cardiac surgery

Post-Cardiac surgery Delirium (PCD) is a clinically specific phenomenon that is also becoming more understood, and which is dissimilar to delirium in general surgical or medical ICU groups in several key respects. Incidence rates of up to 11% with isolated Coronary Artery Bypass Graft (CABG) surgery to more than 50% in high-risk valve and combined surgery have been reported in landmark epidemiological studies [3]. In the IPDACS study, Kazmierski *et al.,* found a PCD incidence rate of 16.7 percent in a prospective study of patients undergoing cardiac surgery, with delirium onset being most common on postoperative day one. According to Giltay *et al.,* psychotic characteristics such as visual and auditory hallucinations were prevalent amongst this population and made it difficult to identify and control. PCD has severe clinical impacts. Ely *et al.,* have shown that delirium acquired in the ICU, measured by an established, validated, and reliable ICU version of the Confusion Assessment Method (CAM-ICU), was independently predictive of a 3.2-fold higher 6-month mortality and a much higher rate of long-term cognitive impairment [1]. The groundbreaking BRAIN-ICU study by Pandharipande et al. found that the longer the incidence of delirium in the ICU, the worse the cognitive outcome of the patient 3 and 12 months after discharge, and delirium dose responses linearly with neurocognitive sequelae [5]. In cardiac surgery, in particular, Saczynski *et al.,* illustrated that the progression of cognitive recovery in the immediate postoperative delirium patients was six times slower than in patients without delirium [6].

Pathophysiology and risk stratification

The CSICU pathophysiological processes underlying delirium are multifactorial. CPB triggers a systemic inflammatory response syndrome, including complement activation, cytokine release, and breakdown of blood-brain barriers, which provide neuroinflammatory conditions that favour delirium. Transcranial Doppler studies have found cerebral microemboli being developed during aortic manipulation and CPB in most cardiac surgery patients, with the number of cerebral microemboli being associated with postoperative neurological dysfunction. The vulnerable post-surgical brain is further impaired as intraoperative hypoperfusion, prolonged aortic cross-clamping, and haemodynamic instability further damage cerebral autoregulation. Pharmacologically, benzodiazepines, which were traditionally employed as the primary form of ICU sedation, were always found to be independent risk factors of delirium [15]. The iconic MENDS and SLEAP trials found that dexmedetomidine-oriented protocols of sedation had a much lower occurrence of delirium than benzodiazepine-oriented protocols. Rudolph et al. created and tested the Cardiac Surgery-Specific Delirium Risk Score, which used age, cognitive impairment, depression, prior stroke, peripheral vascular disease, atrial fibrillation, and pre-operative glucose >7.77 mmol/L as the independent predictors of post-cardiac surgery delirium.

Evidence for non-pharmacological nursing interventions

The body of evidence on the topic of non-pharmacological nursing interventions in delirium prevention has increased significantly within the last twenty years. The Hospital Elder Life Program

(HELP) is a program that was created by Inouye et al. and that has been formally validated, a randomized controlled trial, in a study involving 852 patients, has shown that delirium incidence is reduced by 34% with systematic application of cognitive stimulation, sleep preservation, early mobilization, adaptive vision and hearing, oral hydration and dehydration prevention. Although this historic trial took place in a general medical inpatient environment, its principles have been applied to the ICU environment with similar findings [2]. Hshieh *et al.,* carried out a meta-analysis of 14 randomised controlled trials in which multicomponent non-pharmacological interventions were applied and found that the pooled incidence rate of delirium was 0.47 (95% CI 0.38058), which equates to a 53% relative risk ratio [12]. Rivosecchi *et al.,* conducted a systematic review of non-pharmacological prevention methods of delirium in surgical patients and found that the interventions that have the strongest evidence base are those that involve early mobilization, sleep protocols, reorientation, and family engagement [14]. Importantly, they have observed that when individual interventions were used alone, they showed relatively small effects, whereas a bundle of interventions, *i.e.,* the simultaneous impact on multiple delirium risk pathways, yielded considerably greater effects. The ABCDE bundle (since later called the ABCDEF bundle (with Family engagement and engagement added)) has become the most popular evidence-based model of ICU delirium prevention. According to Bounds *et al.,* the proportion of CAM-ICU-positive days dropped to 40.0% (74.4%), which was statistically significant [11]. According to Patel *et al.,* a multicomponent bundle consisting of light and noise reduction, reorientation, sleep hygiene, and early mobilisation decreased the incidence of delirium by 50 to 29 percent in a UK ICU [16]. The seminal TEAM trial by Schweickert et al. has proven early physical and occupational therapy as a foundation intervention to cut back ICU-acquired weakness and delirium at the same time [17].

Cardiac surgery-specific interventions and evidence gaps

Although the arguments supporting the role of nursing in delirium prevention in general ICU patients are overwhelming, the evidence on the CSICU setting is limited. A randomised controlled trial of a delirium management intervention with structured nurse-family communication and family engagement in the care of patients undergoing post-cardiac surgery was reported as a study by Mailhot et al. that showed less delirium time and better family outcomes. A systematic review of cardiac surgery risk factors of delirium by Koster et al. found that advanced age, pre-operative cognitive impairment, and long CPB were the most powerful predictors, but lacked high-quality intervention research in this group [4]. Moon and Lee used a personalized protocol of ICU delirium prevention in a Korean cardiac surgical ICU and showed that a nurse-led bundle reduced the incidence of delirium significantly.

An identified critical evidence gap in these studies is that of protocol adherence and fidelity. According to Troglilić *et al.,* in a systematic review of implementation strategies to assess and manage ICU delirium, even though formal delirium monitoring programmes enhanced recognition, their outcome effect was strongly related to nurse-to-patient ratio, organizational culture, and continued educational support. Balas *et al.,* had also reported that nursing involvement and empowerment were the most important predictors of ABCDE bundle adherence, and the most commonly breached elements of workflow were adherence to sedation and mobility aspects. These results highlight the need to go beyond creating detailed intervention guidelines by also assessing the fidelity of their accurate performance in the real world systematically.

Materials and Methods

Study design and setting

The study is a prospective, controlled cohort study that will be carried out in the Cardiac Surgery Intensive Care Unit of a tertiary referral centre between January 2024 and September 2024. The CSICU is a 16-bed unit that is manned by registered nurses with a nurse-to-patient ratio of 1:2 and has a specific intensive care unit for cardiac surgery that is managed by a specialized team of cardiac surgery intensive care. It only accepts adult patients who have undergone open cardiac surgery such as Coronary Artery Bypass Grafting (CABG), valve replacement or repair, and both. The Institutional Review Board gave its approval of the study (Reference: IRB-2024-CSICU-0114), and all the patients or their legally appointed representatives signed written informed consent before enrolment. The research has been carried out based on the provisions of the Declaration of Helsinki and has been reported in several provisions of STROBE (Strengthening the Reporting of Observational Studies in Epidemiology).

Participants

The study population was the adult patients (aged 18 years and above) who were admitted to CSICU after an elective or emergency cardiac surgery. The exclusion criteria included: the presence of severe dementia (Clinical Dementia Rating 2 or higher); delirium diagnoses before surgery; current psychosis or severe psychiatric disorders; receptive aphasia and which preclude CAM-ICU evaluation; predicted ICU stay less than 24 hours; patients referred by other institutions within 48 hours of surgery; refusal to provide informed consent; non-English and non-Arabic speaking without an interpreter present. One hundred and forty-eight patients were screened according to the eligibility criteria, where 28 of them were ineligible (14 met exclusion criteria, 9 declined consent, and 5 were late transfers), and 120 subjects were enrolled. Group assignment was performed in accordance with a temporal cohort design: patients who were hospitalized in January-April 2024 (n=60) were assigned to the control group that would get standard care, and patients who were admitted in May-September 2024 (n=60) were assigned to the structured nursing intervention bundle group.

Intervention protocol

The multicomponent nursing intervention bundle is the result of the multidisciplinary consultation between ICU nurses, cardiac surgeons, anaesthesiologists, physiotherapists, dietitians, and clinical pharmacists, as well as a thorough review of the literature. The ten domains of evidence-based practice included in the bundle were operationalised into ten domains of nursing actions, timings, and documentation requirements, as indicated in Table 3. Before the intervention period, all nursing personnel were provided with a 4-hour education programme organized in the form of a structured seminar with the discussion of the pathophysiology of delirium, CAM-ICU administration, the rationale behind the bundle components, and the documentation. The evaluation of competency was done through direct observation and written examination. Each shift was assigned a specialist delirium prevention nurse champion to help with the solution and compliance within the intervention period. The CAM-ICU (Confusion Assessment Method to the Intensive Care Unit) was the initial tool of screening delirium due to its previously validated sensitivity (93100) and specificity (98100) in both ventilated and non-ventilated patients in the ICU [18]. The clinical information system

of the unit electronically registered CAM-ICU evaluations every time the nurse reported to work in an 8-hour shift. Favourable results with CAM-ICU led to an automatic notification to the physician in charge and a standardised nursing response plan that involved assessment of reversible factors, medication re-evaluation, and intensification of environmental and supportive care.

Control group

The control group was under regular CSICU nursing care according to the existing unit guidelines. Routine vital sign check and prescribed pain management, regular sedation protocol with the Richmond Agitation-Sedation Scale (RASS) target of -1 to -2, daily physiotherapy assessment, and routine nutrition protocol were considered standard care. Delirium surveillance in the control period did not have a systematic methodology; it was through behavioural changes and physician evaluation that clinically detected delirium without any formal, validated instrument-based screening schedules. Visitation of the family was conducted according to the standard restricted visiting hours (10:0012:00 and 16:0018:00 everyday).

Outcome measures

The main outcome was the occurrence of delirium, which can be described as at least one CAM-ICU positive assessment in the course of an ICU stay. Secondary outcomes were: length of delirium (days with one or more CAM-ICU positive shifts per day); length of stay (at CSICU) (days); length of mechanical ventilation (hours); antipsychotic drug use (yes/no); physical restraint use (yes/no); in-hospital mortality; unplanned removal of the endotracheal tube; and re-hospitalization. Also, the intervention bundle compliance was assessed by each component using a structured daily audit form answered by the delirium prevention nurse champion.

Statistical analysis

The a priori calculation of sample size was done based on the expected incidence of delirium, which is 45% in the control group and a minimum clinically significant reduction of 20 percentage in the intervention group (α=0.05, power=80%, two-sided test), resulting in a minimum required sample size of 112 (56 in each group) and 120 participants were enrolled to accommodate the possibility of loss. Continuous normally distributed variables are presented as mean ± standard deviation and compared with the independent samples t - tests. Continuous variables that do not follow the normal distribution are presented in the form of median (interquartile range) and compared with the help of the Mann-Whitney U test. The categorical variables are represented as frequencies and percentages and compared through the Pearson chi-squared test or the exact test of Fisher, where the number of cells expected to occur was less than five. Multivariate logistic regression was further performed to establish the independent risk factors of delirium, with variables included where the univariate p-value was less than 0.10. A statistical significance of less than p<0.05 was considered significant. All the analyses were carried out with the help of IBM SPSS Statistics, Version 28.0 (IBM Corp., Armonk, NY).

Results

Patient characteristics

The number of patients recruited throughout the study (control, n=60; intervention, n=60) was 120, shows demographic and clinical characteristics. Both groups were similar in terms of baseline, where there were no statistically significant differences in terms of age, sex, body mass index, comorbidities, type of surgical procedures, cardiopulmonary bypass time, or preoperative APACHE II scores (all p>0.05). The average age of the whole cohort was 64.1 years with a standard deviation of 11.0, and 65 percent were male. Surgical operations were mainly isolated CABG (55.0%), then valve (31.7%), and combined (13.3%). Mean APACHE II admission was 18.9 ± 5.0, indicating a moderately high-acuity population.

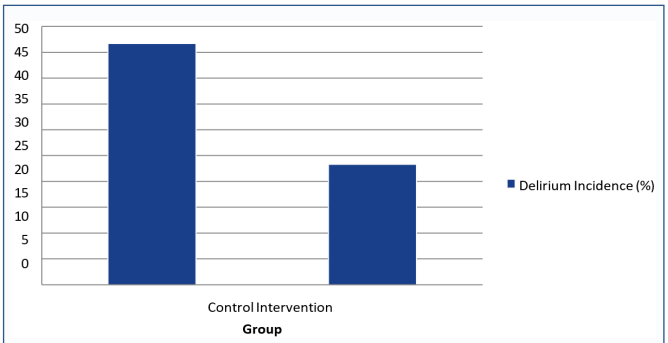

Figure 1: Delirium incidence – Control *vs.* Intervention.

Primary outcome

Delirium Incidence The main consequence of delirium occurrence was far better in the intervention group than in the controls. There was a statistically significant decrease in delirium in 14/60 intervention group (23.3%) *versus* 28/60 control group (46.7%) (χ^2=7.06, p=0.008; relative risk reduction 50.1%). In the group of all cohort participants (n=120), the overall rate of delirium was 35.0% (42/120). Most often, delirium began on postoperative day 1 (38.1) and day 2 (33.3), with a total of 28.6% of delirious patients beginning after the 3rd day. The subtype most common was hypoactive delirium, which was experienced by 52.4% of delirious patients, with 33.3% and 14.3% taking up mixed and hyperactive delirium, respectively (Figure 1).

Secondary outcomes

The intervention group showed a great improvement in all the hemodynamically meaningful secondary outcomes. The duration of mean delirium (1.3±0.9 days) compared to controls (2.8±1.6 days; p<0.001) was significantly lower in the intervention group than in controls. The intervention group had a significantly shorter Length Of Stay (LOS) in the ICU (4.7±2.1 days *vs.* 6.4±2.9 days; p=0.001), which equated to a 1.7 CSICU bed-days per patient mean. The mechanical ventilation period was also considerably lessened. Mechanical ventilation period was also reduced (15.6±9.3 hours *vs.* 22.4±14.8 hours; p=0.003). 9/60 intervention patients (15.0%), but 20/60 controls (33.3%; p=0.02) needed antipsychotic agent administration. The use of physical restraint was also much less in the intervention group (10.0% *vs.* 25.0%; p=0.03). The length of stay in the hospital was also much less in the intervention cohort (9.8±3.2 days *vs.*12.6±4.8 days; p=0.001). The mortality in-hospital was not different (3.3% *vs.* 6.7%; p=0.40), and 30-day readmission rates (6.7% *vs.* 13.3%; p=0.22).

Nursing intervention bundle protocol

Table 1 gives the detailed multicomponent nursing intervention bundle. The development of the bundle was informed by the systematic review of the existing evidence and the agreement of the multidisciplinary team. All the domains were operationalised into specific, time-bound nursing actions to achieve the greatest reproducibility and adherence. Some of the reorientation interventions were verbal reorientation, which involved every patient

Table 1: Multicomponent nursing intervention bundle: domains, actions, and scheduling. Intervention domain specific actions frequency/schedule.

Reorientation	Verbalre-direction of person, place, time; display clocks, calendars; white board communication.	Every 2 hours, continuous environmental cues
Sleep Hygiene	Reduction of light at night, reduction of noise, grouping of nursing activities, earplugs, and reduction of night time interventions.	Daily 22:00-06:00 protocol
Early Mobilization	Passive ROM, progressive sitting, standing and ambulating with the help of a nurse and physiotherapist.	Twice daily from POD1 when haemodynamically stable
Sensory Optimization	Make sure that glasses/hearing aids are available; minimize excessive restraints; encourage eye contact in communication.	At every patient contact
Pain & Sedation Management	Measured pain on CPOT; aim at Richmond Agitation-Sedation Scale (RASS)-1=0; benzodiazepines should be avoided.	Every 4 hours; adjust per protocol.
Cognitive Stimulation	Communicate with the patient, make the family interact, and engage in reading/music therapy.	Morning and afternoon sessions
Family Engagement	Educate families about delirium; Promote a family voice and presence; gather cognitive baseline in family.	Daily family meeting; unrestricted visiting
Hydration & Nutrition	Follow-up fluid balance; in early enteral nutrition; replace electrolyte imbalances (Na, K, Mg).	Per ICU protocol, daily labs
Medication Review	Medication reconciliation (removal of high-risk medications, anticholinergics, benzodiazepines, and polypharmacy review) on a daily basis.	Daily multi-disciplinary rounds

Table 2: Univariate and multivariate analysis of risk factors for delirium in the cardiac surgery ICU.

Risk Factor	Delirious (n=42)	Non-delirious (n=78)	OR (95% CI)	*p* - value
Age ≥70 years	22 (52.4%)	18 (23.1%)	3.7 (1.6–8.4)	<0.01*
APACHEII score ≥20	26 (61.9%)	24 (30.8%)	3.6 (1.6–8.0)	0.002*
CPB duration ≥90 min	28 (66.7%)	30 (38.5%)	3.2 (1.4–7.2)	0.005*
Pre-operative cognitive impairment	14 (33.3%)	8 (10.3%)	4.4 (1.6–11.9)	0.004*
Benzodiazepine use in ICU	18 (42.9%)	14 (17.9%)	3.4 (1.4–8.2)	0.006*
Mechanical ventilation >24 hrs	20 (47.6%)	16 (20.5%)	3.5 (1.5–8.3)	0.004*
Diabetes mellitus	18 (42.9%)	28 (35.9%)	1.3 (0.6–2.9)	0.46
Prior history of delirium	12 (28.6%)	6 (7.7%)	4.7 (1.6–13.9)	0.005*
Sleep disturbance (pre-ICU)	16 (38.1%)	12 (15.4%)	3.4 (1.3–8.7)	0.01*

Table 3: Adherence to the multicomponent nursing intervention bundle components during the intervention period.

Intervention Component	Number of Patients Receiving (%)	Adherence Rate (%)	Barrier Identified
CAM-ICU Assessment (every shift)	60/60 (100%)	94.2%	Documentation gaps
Re-orientation Protocol	58/60 (96.7%)	91.0%	Understaffing evenings
Sleep Hygiene Bundle	56/60 (93.3%)	87.4%	Unavoidable night procedures
Early Mobilization	52/60 (86.7%)	82.1%	Haemodynamic instability
Sensory Aid Optimization	59/60 (98.3%)	96.0%	Glasses misplaced (1pt)
Pain/Sedation Protocol	60/60 (100%)	92.5%	Breakthrough pain events
Cognitive Stimulation	55/60 (91.7%)	85.3%	Patient fatigue/refusal
Family Engagement	57/60 (95.0%)	89.0%	Visiting hour conflicts
Medication Review	60/60 (100%)	97.3%	Delayed pharmacy response
Nutrition/Hydration Protocol	60/60 (100%)	95.8%	Intolerance (2 patients)

contact, provision of environmental cues (visible clocks, calendars, whiteboard communication boards), and interaction with named nursing staff. A disciplined nocturnal regimen, 22:00 to 06:00, with light reduction, quieting noise, task concentration, and earplugs and eye mask routine handing out to all patients of the intervention group, was applied as sleep hygiene. Family involvement was enlarged, not only to the conventional limited visiting, but to unrestricted daytime visiting, daily planned structured family meetings with a special nurse, and formal family education about delirium recognition and response.

Risk factors

Delirium Univariate and multivariate logistic regression analyses of potential risk factors for delirium are presented in Table 2. On multivariate analysis, age ≥70 years (OR 3.7, 95% CI 1.6-8.4; $p<0.01$), pre-operative cognitive impairment (OR 4.4, 95% CI 1.6-11.9; $p=0.004$), CPB duration ≥90 minutes (OR 3.2, 95% CI 1.4-7.2; $p=0.005$), benzodiazepine use in the ICU (OR 3.4, 95% CI 1.4-8.2; $p=0.006$), prior history of delirium (OR 4.7, 95% CI 1.6-13.9; $p=0.005$), mechanical ventilation >24 hours (OR 3.5, 95% CI 1.5-8.3; $p=0.004$), APACHE II score ≥20 (OR 3.6, 95% CI 1.6-8.0; $p=0.002$), and pre-operative sleep disturbance (OR 3.4, 95% CI 1.38.7; $p=0.01$) were identified as significant independent predictors. Diabetes mellitus was not independently associated with delirium after multivariate adjustment.

Nursing intervention adherence

The adherence to the bundle was also assessed systematically by daily nursing audit forms during the intervention. Table 3 provides the results. The total compliance of all bundle components was

91.1%. The highest adherence rates were found in the CAM-ICU assessment component (94.2%) and medication review component (97.3%), and lowest adherence rates in the early mobilisation (82.1%), mostly due to the requirement of haemodynamic instability to delay the mobilisation process in 8 patients. Adherence to sleep hygiene protocols was 87.4% and the major hindrance is found to be inevitable nighttime clinical operations like emergency laboratory investigation and radiology procedures.

Discussions

The results of this prospective cohort study indicate that, a structured multicomponent intervention bundle that was led by the nurse and included multicomponent measures was significantly effective in reducing the incidence of delirium (by 50.1%), the length of delirium, length of stay in the ICU, the length of mechanical ventilation, the use of antipsychotics, and the use of physical restraints in adult patients who were admitted to the CSICU after cardiac surgery. These findings are not only clinically interesting but also in agreement with the evidence base, in general, on the effectiveness of non-pharmacological intervention in delirium in critical care units, but also directly apply this evidence to the cardiac surgery population [12, 14]. The incidence of delirium found in the control condition (46.7) is very similar to the published epidemiological data on CSICU populations and therefore validates the external validity of our control group [3, 4]. The 23.3% occurrence in the intervention group is consistent with the findings of the best-performing components of multicomponent delirium prevention trials in general ICU environments, indicating that the nursing bundle was showing almost maximum preventive efficacy in a cardiac surgery population [12]. The percentage change in risk of 23.4 is equal to a Number Needed to Treat (NNT) of 4.3, which means that in every four to five patients receiving the intervention bundle, one case of delirium was avoided. This NNT is favourable to most of the pharmacological treatments of delirium prevention, which show significantly greater NNTs. The decrease in the ICU length of stay (1.7 days per patient) is of great consequence to the use of healthcare resources in a highly expensive critical care setting. Because the costs of the CSICU bed usually lie within the range of USD 2,500 to 4,500 per day, the average cost reduction due to the implementation of the intervention bundle can be up to USD 3,8007,500 per patient, which is a strong economic consideration to implement the intervention bundle regularly regardless of the clinical outcomes. Shorter mechanical ventilation time (6.8 hours per patient) also lowers the risk of ventilator-associated pneumonia, iatrogenic airway damage, and respiratory muscle deconditioning, and has a multiplicative beneficial impact on the recovery pathway. Particular attention should be given to the significant decrease in the number of physical restraints (10.0% *vs.* 25.0%; p=0.03) in the intervention group. Although used with the intent of self-harm and device removal prevention, physical restraints are unrelated to delirium aggravation, dementia progression, psychological trauma, and, ironically, agitation [7]. The ability of the nursing bundle to decrease the use of restraints is probably the aggregate impact of designed reorientation, increased family presence, and selective attention to pain and sedation, all of which lead to the agitation and confusion that often result in the use of restraints. This observation confirms that proactive prevention by nursing leadership will save the responsive limiting action. 10 The risk factors found independent in our multivariate analysis are also in line with the cardiac surgery delirium literature. The age of 70 years and more (OR 3.7) and the cognitive impairment of the pre-operative period (OR 4.4) indicate the depth of the ageing brain to the multi-hit stressors of cardiac surgery, CPB, and the CSICU environment. The condition of CPB duration 90 minutes or longer (OR 3.2) supports the impact of neuroinflammatory and embolic processes as cardiac surgery-specific, and intraoperative methods of reducing CPB time and improving cerebral perfusion may be beneficial as a complement to post-operative nursing prevention. This finding is consistent with the repeated results of numerous studies, which have shown that the practice of sedation by benzodiazepines continues to be a risk factor that can be reduced or avoided by application of non-benzodiazepines instead of benzodiazepines (ICU) (OR 3.4). The adherence rate of 91.1% about bundle elements is favourable in comparison with adherence rates published in studies of ICU bundle implementation, which usually vary between 60% and 85%. A number of factors must have led to high adherence to this study. The title of per-shift delirium prevention nurse champion gave a focused point of support protocol and a cultural indicator that delirium prevention was a nursing concern. The educational programme provided in a well-organized manner before implementation dealt with knowledge gaps and attitudinal challenges that often hinder protocol adoption. The integration of electronic documentation facilitated the fact that CAM-ICU assessments were fully incorporated into the regular nursing processes and were not an independent task on their own. These principles of implementation science include nurse champions, education, and workflow integration, which are congruent with the set of principles of bundle adherence facilitation in systematic reviews. The adherence of the early mobilisation component was relatively lower (82.1), thus indicating a continuing problem with the implementation of mobility protocol among high-acuity cardiac surgery patients. The practical impediments to early mobilisation are haemodynamic instability, continued vasopressor use, the presence of multiple indwelling devices, and nursing workload in the acute postoperative period, despite having the significance and value of early mobilisation. The observation is similar to those of Schweickert *et al.,* and Needham *et al.,* who also found that early mobilisation, although undoubtedly effective, was the most commonly withheld aspect of a bundle as perceived as unsafe [17]. Subsequent research ought to compare standardised physiological thresholds of enabling safe early mobilisation initiation in the CSICU particular setting, enabling more regular protocol use. 7 39 It is not surprising that there is no significant difference in in-hospital mortality (3.3% *vs.* 6.7%; p=0.40) and 30-day readmission rates (6.7% *vs.* 13.3; p=0.22) in the two groups since the rates of these events are relatively low. A statistically significant study needed to identify mortality and readmission differentials would need much larger sample sizes, and such outcomes were hence considered secondary exploratory endpoints in the present study. However, both results are affected in terms of directionality, and a well-powered multicentre trial would be a reasonable next step to determine the benefit of a sustained nursing intervention bundle in mortality.

Comparison with existing literature

Our results concur and build upon a series of critical previous studies. Our findings were closely similar to the results of Moon and Lee (2015) in a randomised controlled trial conducted in a Korean cardiac surgery ICU, who demonstrated a decrease in incidence of delirium in 44.4% to 20.0% with a nurse-led tailored prevention protocol. The finding of family engagement was supported by Mailhot *et al.,* (2017), who reported the substantial reduction in the duration of delirium and family distress in the post-cardiac surgery patients with the help of the structured nurse-family communication

intervention. This is in line with the meta-analytic analysis by Hshieh *et al.,* that reported a pooled delirium incidence ratio of 0.47 with multicomponent interventions [12, 19, 20], indicating that our bundle had a near-average level of effectiveness as an intervention in this category. Our results contrast with the reports by other studies that indicated no significant effect of individual single-component interventions, indicating the theoretical conditioning that delirium is a multifactorial syndrome and that it needs targeting of multiple predisposing and precipitating factors, and no single-pathway pharmacological or non-pharmacological interventions. This is the kind of pathophysiological complexity that is reflected in the bundle architecture of our intervention of circadian.

Conclusion

This prospective cohort study is a strong piece of evidence that a multicomponent delirium prevention bundle involving nurses in a structured form will help to reduce the incidence of delirium, delirium duration, the length of stay in the ICU, mechanical ventilation duration, the use of antipsychotics, and physical restraint in cardiac surgery ICU patients. The clinical and financial argument to adopt systematic nursing bundles in the CSICU has strong adherence, which is achievable with a number needed to treat of 4.3, and a strong clinical and economic argument. The age of 70 years and above, pre-operative cognitive impairment, CPB time, benzodiazepine, and history of delirium are independent variables that allow the targeted stratification and intensification of preventive measures in the most vulnerable patients. The results highlight the primary and invaluable nature of bedside nurses in delirium prevention and early detection in the ICU of cardiac surgery. The CAM-ICU assessment tool, developed by nurses, and the combination of the systematic application of environmental, physical, pharmacological, and psychosocial interventions are the most resilient tools of delirium prevention research in such a vulnerable group. The training, resource allocation, and empowerment of nursing teams in CSICUs should be a priority of healthcare institutions to adopt and maintain evidence-based delirium prevention bundles as a standard of care. The main research areas to consider in the future are multicentric randomised controlled studies that have a long-term cognitive follow-up, the implementation fidelity and sustainability of preventive delirium care bundles in cardiac surgery, and economic modelling of the cost effectiveness of nursing delirium prevention bundles. Also, risk-stratified preventive strategies would be implemented by the creation of predictive risk scoring systems with the modifiable factors discovered during this study to support individualised resource allocation and patient outcomes in the CSICU. Page 27 of 28 - Integrity.

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