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Incidence Rate of Delirium After Cardiac Surgery and Feasibility of a Delirium Prediction Rule

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Dedication

This project is dedicated to my family and friends that have supported me through many years of study. Without you all I would not be in the place I am in today. To my parents, there are no better people that could have allowed me to realize my potential in achievement. To my husband, words cannot give enough thanks for the love and support you have provided me through the last few years. I am forever grateful for each of you.

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Abstract

Delirium is an acute, temporary cognitive disorder that is characterized by a change in mental status, altered level of judgement, and changes in perception and behavior. Elderly patients who undergo open cardiac surgery are particularly at risk for developing delirium postoperatively. Although it is a temporary disorder, there are many consequences associated with delirium after cardiac surgery, including a longer length of stay in the hospital, long term functional decline, a greater use of health care resources and an increase in mortality risk. The purpose of this project was to identify the one-year incidence of postoperative delirium after cardiac surgery at the University of Kentucky Medical Center (UKMC). **Methods:** Retrospective review of medical records of all patients who underwent open cardiac surgery at UKMC to ascertain the incidence of postoperative delirium, and a feasibility study of the use of a 4-point delirium prediction rule in a preoperative clinic setting. **Results:** Delirium at the UKMC was formally diagnosed at a rate of 0.16% in the fiscal year 2015-2016. This project demonstrates that it is feasible to administer a Delirium Prediction *Rule* preoperatively with minimal difficulty and little time commitment in an outpatient setting for a cardiac surgery preoperative clinic visit. **Conclusions**: The use of a Delirium Prediction *Rule* to stratify risk in the preoperative clinic setting could facilitate targeted prevention and treatment strategies with the goal of reducing negative outcomes associated with the disorder.

Introduction

The healthcare system in the United States is rapidly changing. With the adoption of the Patient Protection and Affordable Care Act (ACA), there has been an emphasis on increasing quality healthcare delivery. According to the Health Resources and Services Agency (n.d.) "Quality improvement (QI) consists of systematic and continuous actions that lead to measurable improvement in health care services and the health status of targeted patient groups" (p. 1). One specific patient group that is often targeted to increase quality outcomes is those with cardiovascular heart disease. Many of the 11.5% of people in the United States with cardiovascular heart disease will undergo life-saving procedures (Centers for Disease Control and Prevention, 2017). Almost 250,000 people in the US underwent coronary artery bypass graft (CABG) surgery or valve procedures in 2013 (Centers for Disease Control and Prevention, 2016). To ensure quality outcomes it is imperative to examine and prevent or reduce current negative outcomes associated with cardiac surgery, including CABG and heart valve replacement surgeries.

One disorder that is associated with negative outcomes after cardiac surgery is delirium. Koster, Hensens, and van der Palen (2009) suggest that patients are at a higher risk for delirium after cardiac surgery when compared with other study populations. While there is no lack of available research regarding the consequences of delirium after cardiac surgery, the disorder remains a problem for patients and the healthcare system. There is a gap in current literature related to prevention and treatment of the disorder. Patients who undergo cardiac surgery may benefit from targeted interventions to prevent and treat delirium in order to reduce negative outcomes.

Background

Delirium is an acute, temporary mental disorder that causes a disturbed level of consciousness, impaired level of judgment, alteration in perception, and changes in behavior (Mangusan, Hooper, Denslow, & Travis, 2015). Delirium has 3 subtypes: hyperactive, hypoactive and mixed type (American Geriatrics Society, 2015). Hyperactive delirium includes symptoms such as agitation and aggression, hypoactive delirium may include decreased activity or being withdrawn and mixed type is a mix of symptoms (American Geriatrics Society, 2015). One specific population that is at risk for developing delirium is those that undergo cardiac surgery. It has been established that patients who undergo cardiac surgery with cardiopulmonary bypass (CPB) are at higher risk for delirium, when compared with those that do not require CPB however, evidence is lacking as to the reason for the association (Andrejaitiene & Sirvinskas, 2012).

Although it is a temporary disorder, there are prolonged consequences associated with the development of delirium, particularly after cardiac surgery. A patient that experiences delirium while hospitalized requires additional health care resources, has an increased risk of mortality, and has a risk of cognitive and functional decline (Manguson et al.; 2015; Gottesman et al., 2010; Koster et al., 2009; Koster et al., 2011; and Kryzych et al., 2014).

Length of hospital stay, incidence of readmission, and discharge to a nursing home or the use of home health services are all increased for patients with postoperative delirium (Manguson et al.; 2015, Gottesman et al., 2010; Koster et al., 2009; and Koster et al., 2011). Length of stay in the hospital for patients without delirium after cardiac surgery ranges from 5.5 days (Manguson et al., 2015) to 7.3 days (Gottesman et al., 2010). In contrast, those with delirium had a longer length of stay ranging from 8.3 days (Manguson et al., 2015) to 15.3 days

(Gottesman et al., 2010). The percentage of patients readmitted to the hospital is almost 20% higher than those without delirium (Koster et al., 2011). A patient who develops delirium after cardiac surgery is 4.31 times more likely to be discharged to a nursing facility, and 2.64 times more likely to require home health services (Manguson et al., 2015).

Cognitive function and a patient's ability to care for oneself are significantly impacted by delirium. One-third of patients who develop delirium have disorientation and 25% report auditory or visual hallucinations (Koster et al., 2009). Patients diagnosed with delirium have a decreased ability to perform activities of daily living(ADL) when compared with those that were not diagnosed with delirium for up to 1 year after surgery (Rudolph et al., 2010).

Mobility is also affected by the development of delirium after cardiac surgery. A greater number of patients with delirium are less mobile for a longer duration compared to patients that do not develop the disorder (Koster et al., 2011). Manguson et al. (2015) report patients with postoperative delirium after cardiac surgery were 4 times more likely to fall when compared with patients who did not have delirium. In addition to increased falls, patients with delirium are over 3 times more likely to utilize physical therapy services compared to patients without delirium (Manguson et al., 2015).

Similar to the effects on mobility, postoperative delirium after cardiac surgery also negatively effects mortality risk. There is an increase in mortality risk in patients with delirium after cardiac surgery compared to patients without delirium (Gottesman et al., 2010, Koster et al., 2009, Koster et al., 2011, Kryzych et al., 2014). Patients without delirium after cardiac surgery have a mortality risk as low as 2% (Koster et al, 2011), whereas patients with delirium had a mortality risk as high as 23.31% (Krzych et al., 2014). Mortality risk for patients with delirium after cardiac surgery is further increased if the hospital course is complicated by

cerebral ischemia to 44.62% (Krzych et al., 2014). There are many intraoperative factors that could contribute to the development of delirium and the increased morality risk. Some of those factors that are associated with patients diagnosed with delirium include the following: longer duration of mechanical ventilation, lower mean arterial pressures, lower serum hemoglobin levels, lower body temperatures and a higher frequency of blood transfusions (Rudiger, et al., 2016).

Therefore, the purpose of this project was to identify the incidence of delirium after cardiac surgery in patients who had CPB at the University of Kentucky Medical Center and determine the feasibility of a Delirium Prediction *Rule,* as a screening instrument to be administered in a preoperative clinic setting.

Methods

This project was conducted at the University of Kentucky Hospital (UKMC) and the Kentucky Clinic in Lexington, Kentucky. The University of Kentucky Hospital is a level I trauma center that is comprised of 489 inpatient beds with 100 of them housed in the different Intensive Care Units. This project was approved by the University of Kentucky Institutional Review Board and supported by Dr. Michael Sekela, a cardiothoracic (CT) surgeon who facilitated access to his patients for phase 2 of this project.

The first phase of this project was to determine the scope of the problem at the University of Kentucky Hospital, and was conducted as a retrospective review of medical records. All patients greater than age 64 who underwent open heart valve replacement/repair surgery or CABG requiring CPB between July1, 2015 and June 31, 2016 by all CT surgeons at the facility were included. Records were reviewed for a delirium diagnosis using the following ICD-10 codes: F05, R41, F23, F11.921, and F13.921 (table 1). The following data points were

collected from each patient medical record: age, gender, ethnicity, hospital length of stay, preoperative albumin level, history of CVA prior to surgery, and discharge disposition. Exclusion criteria consisted of all patients who had percutaneous heart valve repair or CABG not requiring the use of the cardiopulmonary bypass machine.

All data were collected with the assistance of the University of Kentucky Center for Clinical and Translational Science (CCTS). Data analysis was performed by use of SPSS version 22. Descriptive statistics were used to describe the sample.

The second phase of the project was a pilot study, testing the feasibility of using a delirium prediction screening instrument developed and validated by Rudolph et al. (2009). This phase of the project proposed to enroll 40 English speaking patients 40 years of age or greater that had scheduled heart valve replacement surgery or CABG. Patients were recruited at their preoperative clinic appointment with the surgeon. Exclusion criteria included: patients requiring emergency surgery and those that scored less than 24 on the Mini Mental State Exam (MMSE). The prediction instrument provides a score on 4 different variables related to preoperative mental status and mood using the Mini Mental State Exam (MMSE) and Geriatric Depression Scale (GDS), nutritional state prior to surgery using preoperative serum albumin level and past medical history of stroke. The variables and their associated value are shown in Table 2.

The MMSE and GDS were administered at the patients' preoperative clinic appointment. The MMSE tests for cognitive impairment within 6 domains: orientation, registration, attention, calculation, recall and language (Chernecky & Berger, 2013). A score of 30 on the MMSE indicates no cognitive impairment while a score of 24 or less is significant for some impairment (Chernecky & Berger, 2013). The GDS is a 15 item screening instrument for depression in the geriatric population. A higher score on the GDS is more indicative of a depressive mood (Greenberg, 2007). Preoperative serum albumin level and history of cerebral vascular

accident/transient ischemic attack (CVA/TIA) were collected from the medical record. Data was abstracted from de-identified medical records with the assistance of CCTS staff.

Results

Phase I- Retrospective Chart Review

Six hundred twenty-five patients had open cardiac surgery with CPB during the 2015-2016 fiscal year at the UKMC. One patient was diagnosed with delirium using the specified ICD-10 codes. No demographic data is reported on the single patient diagnosed with delirium to protect patient confidentiality. Characteristics of all 625 patients who had cardiac surgery are included in table 3. Patients who had cardiac surgery at UKMC were more likely to be male, non/Hispanic or Latino and had a mean age of 62.5 years. Most of the patients included in this review had a lower than normal preoperative serum albumin level, with the mean being 3.05 mg/dl. Only 19.2 % of patients had a past medical history of CVA prior to surgery. Although there was an attempt to obtain objective delirium scores with the Confusion Assessment Method for the Intensive Care Unit (CAM-ICU) which is utilized by the bedside nurses, there was an inability to obtain that information due to poor documentation of the assessment instrument by the nursing staff hospital wide. The incidence of delirium diagnosed after cardiac surgery at the UKMC was 0.16%.

Phase II- Testing the Feasibility of the Prediction *Rule*

There were 40 patients that attended the CT surgery clinic for preoperative evaluation during the study period. Many of the patients required additional testing for further evaluation prior to surgery, including cardiac catheterization with coronary angiogram and echocardiogram. Ten patients were scheduled for surgery during their appointment. Of those 10 patients, 2 declined to participate in the project, 2 did not meet inclusion criteria for the age

requirement, and 2 scored below the cut off score on the MMSE and were deemed unable to provide informed consent for participation in the study. Out of the 4 patients that met eligibility requirements and provided informed consent to participate, 2 were Caucasian women, and 2 were Caucasian men. The enrollment process took on average 10 minutes to complete. One patient received a *rule* score of 0, two patients received a score of 1, and one patient received a score of 2 (See table 4). After completion of their cardiac surgery, none of the enrolled patients were diagnosed with delirium using the specified ICD-10 codes.

Discussion

There are many consequences associated with delirium after cardiac surgery. Identification of risk factors and early diagnosis of the disorder could help prevent those consequences (Krzych et al., 2013). Establishing the risk for the development of delirium is an important step in prevention (Arora, Djaiani, & Rudolph, 2017). The health care team can then focus on those at highest risk to prevent negative outcomes. For example, the patient that received a score of 2 with the Delirium Prediction *Rule* could be identified as high risk preoperatively, and therefore could receive evidence based interventions that could prevent negative consequences associated with the disorder. Targeted interventions that may prevent the development of delirium are: decreasing the use of sedation medications, controlling pain appropriately, early mobilization and sleep promotion. (DiSabatino, 2017; American Geriatrics Society, 2015).

Low Incidence of Delirium

In this project, delirium incidence rate was 0.16% in 625 eligible cases of cardiac surgery with CPB, which is consistent with previously reported data using diagnosis codes for analysis. A review of patients medical records may identify words like “confusion” or “mental

status change" that suggest the presence of the disorder, yet a diagnosis was not documented by providers (Hope et al., 2014). When patients are diagnosed with delirium by an independent healthcare provider, delirium is only mentioned in nursing notes and physician progress notes 20-35% of the time (Hope et al., 2014; Zalon, Sandhaus, Kovaleski & Roe-Prior, 2017). Words suggestive of a potential diagnosis of delirium in medical records include: confusion, mental status change and disorientation, and when those words are documented by nurses, only 5.9% of the time was there additional documentation of provider notification (Zalon et al., 2017).

The retrospective chart analysis performed at the UKMC identified the incidence of delirium at the University of Kentucky to be significantly lower than rates previously reported by others of 13.3% to 55% (Smulter, Lingehall, Gustafson, Olofsson & Engstrom, 2013; and Norkiene, Ringaitiene, Kuzminskaite & Sipylaite, 2013). These results are similar to a study done in Massachusetts that investigated the rate of delirium in hospitalized adults using ICD-9 codes, finding a delirium diagnosis 2.1% of the time (McCoy, Snapper, Stern, & Perlis, 2016). Although a rate of 2.1% is higher than that of UKMC, it remains significantly lower than previously discussed (McCoy, Snapper, Stern, & Perlis, 2016). This finding suggests a significant disconnect between what is reported in current literature and diagnosis in analysis of medical records. One possible explanation for conflicting results could be that many research studies employ investigators who are specially trained to detect signs of delirium. This would suggest a need for educational programs regarding signs and symptoms of delirium and proper diagnosis of the disorder by clinical healthcare providers.

The most common barrier to delirium screening by both nurses and advanced practice providers is the absence of understanding of the disorder (Sinvani, Kozikowski, Pekmezaris, Akerman, & Wolf-Klein, 2016). Although current Clinical Practice Guidelines recommend

routing monitoring of delirium using either the CAM-ICU or ICDSC, it is not consistently done (Barr et al., 2013) In a survey that included nurses, nurse practitioners and physicians, only 50% of participants (n= 164) reported that a formal tool should be used to detect delirium (Sinvani et al., 2016). This is particularly troubling considering more patients are diagnosed with delirium using an objective instrument like the CAM-ICU or ICDSC tool rather than with subjective clinical judgement (Devlin et al., 2007; Guenther et al., 2012).

Lastly, delirium may be diagnosed; however that diagnosis may not be documented in the medical record. McCoy et al. suggest it is possible delirium is being diagnosed; however codes are not submitted due to payment bundles and the lack of or very low reimbursement for the secondary diagnosis (2016). It is also possible the lack of diagnosis may be due to the inability of medical staff to document the disorder due to a knowledge deficit or the lack of electronic prompts for documentation in the computerized physician entry system (Wilkerson, Iwata, Wilkerson, & Heflin, 2014).

Feasibility of Delirium Prediction *Rule*

When investigating the validity of the Delirium Prediction *Rule,* Rudolph et al. found the incidence of delirium after cardiac surgery for point levels 0, 1, 2, ≥ 3 to be 18%, 43%, 60% and 87% respectively (2009). The utilization of a prediction rule during the preoperative testing timeframe can be easily administered by healthcare providers to help identify the potential level of risk for developing delirium in the postoperative timeframe. The prediction rule provides healthcare providers with an opportunity to ensure preventative measures are initiated (Rudolph et al., 2009).

The administration of the Delirium Prediction *Rule* is feasible in a preoperative clinic setting as suggested by this project. Testing is not difficult, nor time consuming and can easily

be performed with minimal disruption to the clinic and surgeon's schedule during the preoperative clinic appointment. The collection of preoperative laboratory samples is routine practice prior to cardiac surgery including albumin level, as is a documentation of past medical history, including history of CVA or TIA. The Mini Mental State Exam (MMSE) and Geriatric Depression Scale Short Form are relatively simple exams to administer and generally take 5-10 minutes to complete. These tests add approximately 10 minutes total onto clinic visit time. Using the Delirium Prediction *Rule* is one way to screen patients at high risk for the development of delirium after cardiac surgery. High risk patients can then be targeted for prevention and treatment strategies.

Clinical Implications and Recommendations for Future Research

Using the Delirium Prediction *Rule,* patients can be preoperatively scored to identify risk prior to high risk surgical procedures such as cardiac surgery with CPB. Patients who receive a *Rule* score of ≥ 1 should be considered moderate or high risk for the development of delirium after surgery and can then be closely monitored for signs and symptoms of the disorder. Healthcare providers can then follow clinical practice guidelines for the prevention and treatment of delirium. The first intervention for prevention of postoperative delirium proposed by the American Geriatric Society is education of healthcare professionals (2015). Education should be focused on diagnosis, prevention and treatment of delirium. Additional interventions for prevention include: cognitive reorientation, promotion of sleep hygiene, early mobilization, and appropriate pain management strategies (DiSabatino, 2017; American Geriatrics Society, 2015).

Patients who are diagnosed with delirium can be treated earlier in an effort to decrease negative outcomes. Treatment strategies include continued attempts at reorientation,

mobilization and promotion of sleep/wake cycle (American Geriatrics Society, 2015). Pharmacologic interventions after a patient is diagnosed with delirium consist of avoidance of using narcotic if possible for pain control, as well as benzodiazepines unless otherwise indicated (American Geriatrics Society, 2015). Only in the setting of extreme agitation that may jeopardize the patient's health should antipsychotics, including haloperidol, be administered (American Geriatrics Society, 2015).

Although there is an abundance of research available on the subject of delirium, there remains a lack of screening and documentation of the disorder. The identification of barriers to recognition and documentation of delirium diagnosis by healthcare providers is necessary. If barriers to diagnosis are addressed, this may increase the rate of formal diagnosis of delirium after cardiac surgery, which may lead to improvement of patient outcomes. Prevention and treatments options can be implemented for high risk patients when identified with screening instruments such as the prediction rule used in this project. Negative outcomes have been associated with delirium in patients that undergo cardiac surgery, thus appropriate identification and interventions to reduce negative patient outcomes are of clinical importance and should be prioritized in facilities with significant numbers of populations at risk.

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Table 1. Delirium Codes and Definitions

ICD-10 code	Definition
F05	Delirium due to known condition
R41	Disorientation, unspecified
F23	Brief psychotic disorder
F11.921	Opioid use, unspecified with intoxication delirium
F13.921	Sedative, hypnotic or anxiolytic use, unspecified with intoxication delirium

Table 2. Delirium Prediction Rule and Scoring

Variable	Prediction Rule Score
History of stroke or transient ischemic attack	1 point
Abnormal albumin level (normal value is 3.6-4.4g/dl)	1 point
Geriatric Depression Scale >4	1 point
Mini Mental State Exam score 24-27	1 point
Mini Mental State Exam score <24	2 points

Table 3. Patient Characteristics

Characteristic	**Total (n= 625)**
Age (years), M (SD)	62.48 (10.95)
Gender (male) %	68.5
Discharge Disposition %	
Home	89.9
Long Term Care Facility	0.5
Death ≤ 48 hours	2.6
Death > 48 hours	4.8
Hospice Facility	1.1
Physical Rehabilitation Facility	0.8
Marital Status %	
Single	17.7
Married	48
Divorced	10.7
Widowed	8.6
Separated	0.7
Unknown	14.4
Ethnicity %	
Non-Hispanic/Latino	95.4
Hispanic/Latino	3.7
Unreported	1
Length of Hospital stay (days), M (SD)	16.31 (17.64)
Preoperative Albumin Level (mg/dl), M (SD)	3.05 (0.6)
Positive History of CVA %	19.2

Table 4. Final Delirium Prediction *Rule* Scores

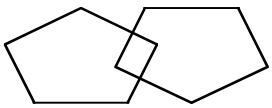
Patient	MMSE Score	GDS	Albumin	History of CVA/TIA	Total Prediction Rule Score
1	30	3	3.4mg/dl	No	1
2	29	10	3.4mg/dl	No	2
3	30	1	2.5mg/dl	No	1
4	28	3	4.1mg/dl	No	0

Appendix A

Mini-Mental State Examination (MMSE)

Patient's Name:_____ Date: _____

Instructions: Score one point for each correct response within each question or activity.

Maximum Score	Patient's Score	Questions
5		"What is the year? Season? Date? Day? Month?"
5		"Where are we now? State? County? Town/city? Hospital? Floor?"
3		The examiner names three unrelated objects clearly and slowly, then the instructor asks the patient to name all three of them. The patient's response is used for scoring. The examiner repeats them until patient learns all of them, if possible.
5		"I would like you to count backward from 100 by sevens." (93, 86, 79, 72, 65, …) Alternative: "Spell WORLD backwards." (D-L-R-O-W)
3		"Earlier I told you the names of three things. Can you tell me what those were?"
2		Show the patient two simple objects, such as a wristwatch and a pencil, and ask the patient to name them.
1		"Repeat the phrase: 'No ifs, ands, or buts.'"
3		"Take the paper in your right hand, fold it in half, and put it on the floor." (The examiner gives the patient a piece of blank paper.)
1		"Please read this and do what it says." (Written instruction is "Close your eyes.")
1		"Make up and write a sentence about anything." (This sentence must contain a noun and a verb.)
1		"Please copy this picture." (The examiner gives the patient a blank piece of paper and asks him/her to draw the symbol below. All 10 angles must be present and two must intersect.) 
30		TOTAL

Appendix B

Geriatric Depression Scale (Short Form) Self-Rated Version

Patient's Name:_____ Date: _____

***Instructions*: Choose the best answer for how you felt over the past week.**

No.	Question	Answer	Score
1.	Are you basically satisfied with your life?	YES / NO	
2.	Have you dropped many of your activities and interests?	YES / NO	
3.	Do you feel that your life is empty?	YES / NO	
4.	Do you often get bored?	YES / NO	
5.	Are you in good spirits most of the time?	YES / NO	
6.	Are you afraid that something bad is going to happen to you?	YES / NO	
7.	Do you feel happy most of the time?	YES / NO	
8.	Do you often feel helpless?	YES / NO	
9.	Do you prefer to stay at home, rather than going out and doing new things?	YES / NO	
10.	Do you feel you have more problems with memory than most people?	YES / NO	
11.	Do you think it is wonderful to be alive?	YES / NO	
12.	Do you feel pretty worthless the way you are now?	YES / NO	
13.	Do you feel full of energy?	YES / NO	
14.	Do you feel that your situation is hopeless?	YES / NO	
15.	Do you think that most people are better off than you are?	YES / NO	
		TOTAL	