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Original Article

A Prospective Observational Study Designed to study the association between Pre-operative Frailty and Post-operative Delirium in Cardiac Surgery Patients

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Abstract

Introduction: Post-operative delirium is a frequent complication after cardiac surgery and is marked by acute disturbances in attention and cognition. It contributes to prolonged hospitalization, functional decline, higher mortality, and increased healthcare costs, affecting roughly one in five patients. Identifying high-risk individuals preoperatively is essential. Frailty – reflecting reduced physiological reserve – is associated with cognitive decline and poorer surgical outcomes, including greater post-operative complications and lower survival. This study will prospectively assess whether pre-operative frailty predicts delirium after cardiac surgery.

Methods: A Prospective observational study was carried out between April 2018 and December 2019 at TNMC and BYL Nair Charitable Hospital, Mumbai, to study the association between pre-operative frailty and post-operative delirium in patients undergoing elective cardiac surgery. Frailty was assessed using the Fried Criteria, Edmonton Frailty Scale (EFS), Short Physical Performance Battery, and 35-Item Frailty Index. Delirium was assessed every 12 hourly for 7 days postoperatively using the confusion assessment method for intensive care unit (CAM-ICU).

Results: We identified frailty in 63.8% patients using the Fried frailty criteria, of which 49.5% developed delirium postoperatively whereas out of the non-frail patients, 13.3% showed post-operative delirium. 61.2% of patients met the criteria for frailty using the short physical performance battery (SPPB), out of which 50.5% developed delirium in post-operative period. Out of the total frail (mild plus moderate frail) patients according to EFS, 47.37% patients showed delirium postoperatively. We observed that those with delirium had a significantly higher EFS score as compared to those without delirium ($P = 0.001$). As per 35 item frailty index scoring, we identified that out of the total patients with a frailty index between 0.2 and 0.3, 12.5% patients showed delirium postoperatively. 19% of patients with frailty index between 0.31 and 0.4 showed delirium whereas 56.95% of patients with frailty index >0.4 showed delirium. The 35-item frailty index was significantly higher in those with delirium ($P < 0.001$)

Conclusion: All the four methods used for identifying and quantifying frailty were effective. The Fried frailty criteria (87.27%) and SPPB (87.95%) had higher negative predictive value and could be used for frailty assessment. 35 item frailty index method helps in quantifying the frailty as patients with higher frailty index were more prone to post-operative delirium. Delirium was more frequently seen in patients who were preoperatively frail, thus emphasizing that frailty can be used as an effective tool for predicting patients prone to post-operative delirium.

Key words: Cardiac surgery, Confusion assessment method, Edmonton frail scale, Frailty, Fried criteria, Post-operative delirium

INTRODUCTION

Delirium is frequently seen postoperatively in cardiac surgery patients, contributing to post-operative mortality and morbidity. Delirium is defined as an acute and overt change in cognition and attention which may include alteration in consciousness and disorganized thinking. The unfavorable outcomes that follow post-operative delirium include prolonged hospitalization, increased rates of delayed institutional discharge, persistent functional and cognitive deficits, and increased 30-day and 5-year mortality.[1-3] This results in a substantial increase in cost to the system.[4] According to the current estimates, the incidence of post-operative delirium is 1 in 5 cardiac surgery patients.[5,6] This necessitates predicting patients susceptible to delirium

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preoperatively, so as to diagnose and treat delirium early, hence reducing post-operative morbidity.

The association between pre-operative frailty and post-operative delirium is not satisfactorily explored. Frailty is defined as a state of decreased physiological reserves due to multisystem decline, which leaves patients in a state of increased vulnerability[1,7] Frailty consorts with multiple undesirable outcomes such as cognitive decline, falls, fractures, and progressive disability in activities of daily living[1,8] Presence of frailty increases the risk for post-operative complications of cardiac surgery such as in-hospital mortality, institutional discharge, and reduced mid-term survival.[9] Our aim was to study the association of pre-operative frailty and post-operative delirium in patients undergoing cardiac surgery by assess frailty using The Fried Criteria, Edmonton frail scale (EFS), Short physical performance battery, 35-Item Frailty Index and assessing post-operative Delirium by confusion assessment method (CAM).

METHODS

After obtaining approval from Departmental review board meeting, ETHICS COMMITTEE for academic research projects at TNMC and BYL Nair Charitable Hospital, Mumbai, and BORS Committee of the College (Maharashtra University of Health Sciences), a total of 152 patients between 20 and 65 years age of both sex, scheduled for elective coronary artery bypass surgery and valvular heart disease surgery under cardiopulmonary bypass with a bypass time of <2 h, were included in the study. After taking written informed consent from the patients, they were assessed preoperatively on the day before surgery for frailty and followed up postoperatively every 12 hourly for 7 days. All patients were induced with injection etomidate 0.3 mg/kg, injection vecuronium 0.1 mg/kg and maintained on sevoflurane as per institutional protocol. Patients undergoing emergency cardiac surgery or with known case of psychiatric illness; patients in whom delirium cannot be assessed reliably such as patients with previous stroke, cerebral palsy, severe dementia, and severe hearing disabilities; and patients who refused to give consent were excluded from the study. All the study participants underwent the following physical tests and questionnaires for assessment of frailty.

Physical Test

5 m gait speed measurement

- Method: Speed was measured as the time required by the patient to walk a short distance of 5 m at a comfortable pace.
- Interpretation:
  1. The Fried criteria: Slowness - After two trials of a 5 m walk, average time >6s
  2. SPPB: After two trials, average time.

  ≤6.5s: 4 points
  6.6–8.3s: 3 points
  8.4–11.6 s: 2 points
  ≥11.7 s: 1 point
  Unable: 0 points.

Handgrip measurement

- Method: Handgrip strength was measured using a hand dynamometer.
- Interpretation: Weakness - After three grip strength measurements with each hand, the maximum value ≤30 kg if male or ≤20 kg if female.

Balance tests

Side by side, semi-tandem, tandem standard balance tests.

- Side by side balance test-
  1. Method: Patient was explained as: "Begin with feet together beside each other. I want you to try to stand with your feet together, side by side, for about 10 s. Please watch while I demonstrate. You may use your arms, bend your knees, or move your body to maintain your balance, but try not to move your feet. Try to hold this position until I tell you to stop." After patient attained the desired position, timing was started.
  2. Interpretation: SPPB ≥10s: 1 point, <10 s: 0 points.
  3. If the patient was able to complete 10 s, we progressed to the semi-tandem balance test.
- Semi-tandem balance test:
  1. Method: Patient was explained as: "Now I want you to stand with the side of the heel of one foot touching the big toe of the other foot for about 10 s. You may put either foot in front, whichever is more comfortable for you. Try to hold this position until I tell you to stop." When the patient stood in the desired position, timing was started. The test was stopped when the patient moved his/her feet, grasped the interviewer for support or when 10 s were elapsed.
  2. Interpretation: SPPB: ≥10 s: 1 point, <10 s: 0 point.
  3. If the patient was able to complete 10 s, we progressed to the tandem stand test.
- Tandem stand test:
  1. Method: Patient should be explained as: "Now I want you to try to stand with the heel of one foot in front of and touching the toes of the other foot for 10 s. You may put either foot in front, whichever is more comfortable for you. Try to hold this position until I tell you to stop." When the patient stood in the desired position, timing was started. The test was stopped when the patient moved their feet, grasped the interviewer for support, or when 10 s were elapsed.
  2. Interpretation: SPPB ≥10 s: 2 points, 3–9.99 s: 1 point, <3 s: 0 point.

- Repeated chair stand test:
  1. Method: Patient was asked to stand up and sit down with arms folded across the chest, as quickly as possible for 5 times without stopping. Timing was started as soon as the patient bent forward at the hips. The number of seconds and the presence of imbalance were recorded. Timing was stopped when the patient sat down having completed the 5th stand, or when the patient started to use their arms, or after 1 min, they have not completed the test. The test was stopped if the patient cannot complete 5 rises, considering the patient's safety.
  2. Interpretation: SPPB ≤11.19s: 4 points, 11.20–13.69 s: 3 points, 13.70–16.69 s: 2 points, 16.70–59.99 s: 1 point, ≥60 s or unable: 0 point.

Question/Questionnaires/Scales Include

1. Self-reported weight loss
2. Modified 2-item center for epidemiologic studies depression scale.

This scale involves the following questions:

- Below is a list of the ways you might have felt or behaved
- Please tell me how often you have felt this way during the past week.

	Week	During the Past		
	Rarely or none of the time (less than 1 day)	Some or a little of the time(1-2days)	Occasionally or a moderate amount of time(3-4 days)	Most or all of the time(5-7days)
1. I was bothered by things that usually don't bother me.				
2. I did not feel like eating; my appetite was poor.				
3. I felt that I could not shake off the blues even with help from my family or friends.				
4. I felt that I was just as good as other people.				
5. I had trouble keeping my mind on what I was doing.				
6. I felt depressed.				
7. I felt that everything I did was an effort.				
8. I felt hopeful about the future.				
9. I thought my life has been a failure.				
10. I felt fearful.				
11. My sleep was restless.				
12. I was happy.				
13. I talked less than usual.				
14. I felt lonely.				
15. People were unfriendly.				
16. I enjoyed life.				
17. I had crying spells.				
18. I felt sad.				
19. I felt that people dislike me.				
20. I could not get "going."				

Scoring: Zero for answers in the first column, 1 for answers in the second column, 2 for answers in the third column, and 3 for answers in the fourth column. The scoring of positive items was reversed. Possible range of scores is zero to 60, with the higher scores indicating the presence of more symptomatology.

3. 5-item depression scale: It consisted of the following questions:

a. Are you basically satisfied with your life? yes/no
b. Do you often get bored? yes/no
c. Do you often feel helpless? yes/no
d. Do you prefer to stay at home rather than going out and doing new things? yes/no
e. Do you feel pretty worthless the way you are now? yes/no.

Interpretation: Two or more answers in bold, as indicated above, were suggestive of depression.

Frailty was Assessed using Following Definitions of Frailty

1. The fried frailty criteria
2. EFS
3. Short Physical Performance Battery
4. 35-item frailty index.

The Fried Criteria

i. Shrinking: Unintentional weight loss of ≥10l bs (4.5 kg)
ii. Weakness: Grip strength
iii. Exhaustion: Self-reported
iv. Slowness: 5 m walking time
v. Low activity: Self-reported.

Edmonton Frailty Scale

FRAILTY DOMAIN	ITEM	SCORE: ____/17		
		0 POINT	1	2 POINTS
			POINT	
COGNITION	Please imagine that this pre-drawn circle is a clock, - I would like you to place the numbers in the correct positions then place the hands to indicate a time of 'ten after eleven'.	No errors	Minor spacing errors	other errors
GENERAL HEALTH STATUS	In the past year, how many times have you been admitted to a hospital ? In general, how would you describe your health ?	0 'excellent' ,' very good', 'good'	1-2 'fair'	≥2 'poor'
FUNCTIONAL INDEPENDENCE	With how many of the following activities do you require help? (meal preparation, shopping, transportation, telephone, housekeeping, laundry, managing money, taking medication)	0-1	2-4	5-8
SOCIAL SUPPORT	When you need help, can you count on someone Who is willing and able to meet your needs?	always	Sometimes	Never
MEDICATIONS USE	Do you use 5 or more different prescription medications on a regular basis? At times,do you forget to take your Prescription medicines?	No No	Yes Yes	
NUTRITION	Have you recently lost weight such that your clothing has become looser?	No	Yes	
MOOD	Do you often feel sad or depressed?			
CONTINENCE	Do you have a problem with losing control of urine when you don't want to?			
FUNCTIONAL PERFORMANCE	I would like you to sit in this chair with your back and arms resting.Then, when I say 'GO', please stand up and walk at a safe and comfortable pace to the mark on the floor(approximately 3m away), return to the chair and sit down'	0-10s	11-20s	One of >20s, patient unwilling, or require assistance
TOTALS	Final score is the sum of column totals			

Short Physical Performance Battery

Patient was deemed frail if the composite score ≤9 points after the following tests:

1) 5 m gait speed measurement:	
i. After two trails, average time	≤6.5 s : 4 points
	6.6-8.3s : 3points
	8.4-11.6 s : 2points
	≥1 1.7 s :1point
	Unable : 0 points
2) Balance tests	
Side by Side stand time	≥10 s : 1point
	<10 s : 0 points
Semi-tandem stand	≥10 s : 1point
	<10 s : 0 point
Tandem stand	≥10 s : 2 points
	3-9.99 s : 1 point
	<3 s : 0 point
3)Repeated chair stand test	
Time to stand up from chair 5times	≤11.19 s : 4 points
	11.20 – 13.69 s : 3 points
	13.70-16.69 s : 2 points
	16.70 – 59.99 s :1 point
	≥60 s or unable : 0 point

35-Item Frail Index

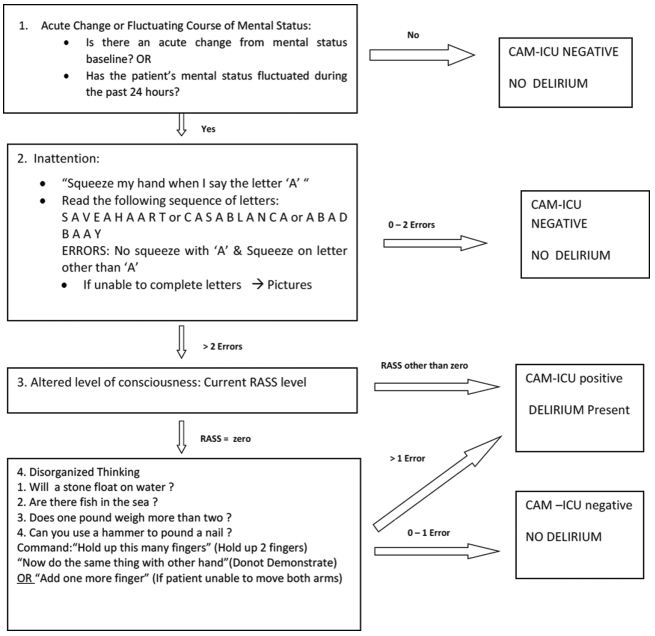
Frailty index score = individual's total number of deficits/35.

Deficits, each counted as present or absent:

1. Comorbidities:
   a. Angina
   b. Arthritis
   c. Asthma
   d. Cerebrovascular disease
   e. Cognitive impairment
   f. COPD
   g. Dyslipidemia
   h. Gastrointestinal disease
   i. Hearing impairment
   j. Hypertension
   k. Myocardial infarction
   l. Pacemaker
   m. Peripheral vascular disease
   n. pre-operative atrial flutter or fibrillation
   o. Prior angioplasty or stent
   p. Pulmonary hypertension
   q. Solid tumor
   r. Visual impairment.
2. Physical and emotional measures:
   a. Decline in food intake
   b. Depression based on the five-item depression scale
   c. Exhaustion based on the two - item center for epidemiological studies depression
   d. Falls in the past year
   e. Inability to complete the repeated chair stand test
   f. Low physical activity (self-reported)
   g. Poor balance
   h. Self-rating of health
   i. Timed Get-Up and Go
   j. Unintentional weight loss in the past 3 months
   k. Unintentional weight loss >4.5 kg
   l. Weak grip.
3. Functional measures:
   a. Banking, Inability to perform
   b. leaning, Inability to perform
   c. Cooking, Inability to perform
   d. Driving, inability to perform
   e. Shopping, inability to perform.

Delirium was assessed postoperatively every 12 hourly for 7 days by CAM-ICU method.

Confusion Assessment Measurement



Statistical Analysis

For sample size calculation, we considered 95% confidence interval and 90% power. Chi-square test, Fisher's exact test, and Mann–Whitney U test were used to analyze the results.

RESULTS

The study included 152 patients undergoing cardiac surgery out of which males were 67.8% and females were 32.2%. The mean age of subjects was 51.31 years. The BMI of the study population varied between 13.32 and 31.20, with the mean being 23.69.

After assessing for frailty using Fried's Frailty Criteria, frailty was seen in 63.8% patients whereas 29.6% were non-frail and 6.6%

were pre-frail. Frailty assessment using EFS showed 21.05% patients to be mild frail, 3.95% patients moderately frail, 32.9% patients to be non-frail, and 42.1% were vulnerable.

The Short Physical Performance Battery showed 61.2% patients to be frail and 38.8% to be non-frail.

Out of the total patients who underwent cardiac surgery, 36.2% showed delirium postoperatively.

Delirium was seen to develop between post-operative day 2 and day 5 with maximum frequency on day 3 followed by day 4 of surgery.

Day of delirium	Frequency	Percent
No delirium	97	63.8
2	5	3.3
3	27	17.8
4	19	12.5
5	4	2.6
Total	152	100.0

Table showing the association between pre-operative frailty and post-operative delirium.

Fried's criteria	Any delirium				*P*-value
	Absent		Present		
	Count	Row *n* (%)	Count	Row *n* (%)	
Weight loss					
Absent	68	68.7	31	31.3	0.088
Present	29	54.7	24	45.3	
Exhaustion					
Absent	53	86.9	8	13.1	<0.001
Present	44	48.4	47	51.6	
Low physical activity					
Absent	53	86.9	8	13.1	<0.001
Present	44	48.4	47	51.6	
Slowness					
Absent	53	86.9	8	13.1	<0.001
Present	44	48.4	47	51.6	
Weakness					
Absent	51	86.4	8	13.6	<0.001
Present	46	49.5	47	50.5	
Result					
Frail	49	50.5	48	49.5	<0.001
Non-frail	39	86.7	6	13.3	
Pre-frail	9	90.0	1	10.0	

Edmonton frail scale	Any delirium				*P*-value
	Absent		Present		
	Count	Row *n* (%)	Count	Row *n* (%)	
Cognition					
0	97	63.8	55	36.2	-
General health status					
0	13	81.3	3	18.8	0.261[a]
1	71	62.8	42	37.2	
2	13	56.5	10	43.5	
Functional independence					
0	4	50.0	4	50.0	0.594[a]
1	75	65.8	39	34.2	
2	18	60.0	12	40.0	
Social support					
0	13	76.5	4	23.5	0.493[a]
1	77	62.6	46	37.4	
2	7	58.3	5	41.7	
Medication use					
0	19	76.0	6	24.0	-
1	77	61.1	49	38.9	
2	1	100.0	0	0.0	
Nutrition					
0	53	63.1	31	36.9	0.837[a]
1	44	64.7	24	35.3	
Mood					
0	25	67.6	12	32.4	0.585[a]
1	72	62.6	43	37.4	
Continence					
0	97	63.8	55	36.2	-
Functional performance					
0	28	96.6	1	3.4	<0.001
1	40	63.5	23	36.5	
2	29	48.3	31	51.7	
Result					
Mild frail	16	50.0	16	50.0	
Moderate frail	4	66.7	2	33.3	
Non-frail	40	80.0	10	20.0	
Vulnerable	37	57.8	27	42.2	

SPPB	Any delirium				*P*-value
	Absent		Present		
	Count	Row *n* (%)	Count	Row *n* (%)	
5 m gait speed					
1	20	46.5	23	53.5	<0.001[a]
2	18	42.9	24	57.1	
3	7	87.5	1	12.5	
4	52	88.1	7	11.9	
Side-by-side stand test					
1	97	63.8	55	36.2	-
Semi tandem stand					
1	97	63.8	55	36.2	-
Tandem stand test					
1	71	56.8	54	43.2	<0.001
2	26	96.3	1	3.7	
Repeated chair stand test					
0	11	39.3	17	60.7	-
1	28	53.8	24	46.2	
2	15	65.2	8	34.8	
3	42	87.5	6	12.5	
4	1	100.0	0	0.0	
Result					
Frail (≤9)	46	49.5	47	50.5	<0.001[a]
Non frail (>9)	51	86.4	8	13.6	

49.5% of frail subjects identified by Fried's frailty index suffered delirium which was significantly greater than the occurrence of delirium in pre-frail (10.0%) and non-frail (13.3%) subjects. Out of the total mild frail patients according to EFS, delirium was seen in 50% patients. Out

of the total moderate frail patients, delirium was seen in 33.3% patients. 20% of total non-frail patients showed delirium whereas 42.2% of total vulnerable patients showed post-operative delirium. It was seen that weight loss was associated with post-operative delirium but there was no significant statistical correlation whereas exhaustion, low physical activity, slowness, and weakness had statistically significant correlations with post-operative delirium.

The study showed that those with delirium had a significantly higher EFS score as compared to those without delirium ($P = 0.001$ by Mann–Whitney U test).

50.5% of frail patients according to the Short Performance Physical battery showed delirium postoperatively whereas only 13.6% of non-frail patients showed post-operative delirium.

SPPB score was significantly lower in those with delirium ($P < 0.001$ by Mann–Whitney U test).

Table showing the association between 35-item frailty index and post-operative delirium.

Frailty index	Number *n*	Delirium present	Delirium absent	Percentage
0.2–0.3	8	1	7	12.5
0.31–0.4	70	13	58	19
>0.4	72	41	30	56.95
Total	150	55	95	

It was seen that out of the total patients with a frailty index between 0.2 and 0.3, 12.5% showed delirium postoperatively.

19% of patients with frailty index between 0.31 and 0.4 showed delirium whereas 56.95% of patients with frailty index >0.4 showed delirium.

The 35-item frailty index was significantly higher in those with delirium ($P < 0.001$ by Mann–Whitney U test.

Variable	Delirium absent		Delirium present		*P*-value
	Median	IQR	Median	IQR	
Age (years)	56.0	20.0	56.0	15.0	0.683
Weight (kg)	63.0	9.0	61.0	13.0	0.776
Height (M)	1.6	0.0	1.6	0.0	0.826
BMI	24.5	3.4	24.2	4.1	0.679
Serum creatinine	1.2	0.5	1.1	0.3	0.097
LVEF	60.0	10.0	58.0	15.0	0.363
EFS-total score	6.0	2.0	7.0	2.0	0.001
SPPB-score	10.0	4.0	6.0	3.0	<0.001
35-item frailty index	0.4	0.2	0.4	0.1	<0.001

BMI: Body mass index, IQR: Interquartile range

Pre-operative frailty assessed using EFS, Short Physical Performance Battery, 35 item Frailty Index showed statistically significant association with post-operative delirium. No statistically significant correlation was seen between patient demography, LVEF, and post-operative delirium

Table showing the association between gender and comorbidities with post-operative delirium.

Variable	Any delirium				*P*-value
	Absent		Present		
	Count	Row *n* (%)	Count	Row *n* (%)	
Gender					
Female	36	73.5	13	26.5	0.088[a]
Male	61	59.2	42	40.8	
Comorbidity-IHD					
Absent	33	71.7	13	28.3	0.181[a]
Present	64	60.4	42	39.6	
Comorbidity-RHD					
Absent	62	59.6	42	40.4	0.113[a]
Present	35	72.9	13	27.1	
Comorbidity-prior angioplasty					
Absent	88	64.7	48	35.3	0.506[a]
Present	9	56.3	7	43.8	
Comorbidity-atrial fibrillation					
Absent	83	63.4	48	36.6	0.770[a]
Present	14	66.7	7	33.3	
Comorbidity-pulmonary hypertension					
Absent	12	54.5	10	45.5	0.328[a]
Present	85	65.4	45	34.6	
Comorbidity-hypertension					
Absent	44	60.3	29	39.7	0.382[a]
Present	53	67.1	26	32.9	
Comorbidity-diabetes mellitus					
Absent	67	64.4	37	35.6	0.819[a]
Present	30	62.5	18	37.5	
Comorbidity-hypothyroidism					
Absent	88	62.0	54	38.0	0.095[b]
Present	9	90.0	1	10.0	
Comorbidity-smoking					
Absent	91	64.5	50	35.5	0.528[b]
Present	6	54.5	5	45.5	
Comorbidity-COPD					
Absent	87	62.6	52	37.4	0.378[b]
Present	10	76.9	3	23.1	
Comorbidity-GI disease					
Absent	82	64.1	46	35.9	0.884[a]
Present	15	62.5	9	37.5	
Comorbidity-CKD					
Absent	94	63.1	55	36.9	-
Present	3	100.0	0	0.0	
Comorbidity-arthritis					
Absent	88	62.9	52	37.1	0.538[b]
Present	9	75.0	3	25.0	

DISCUSSION

Our study included 67.8% males and 32.2% females, out of which 40.8% males and 26.5% females showed delirium postoperatively. The higher male preponderance points to the inference that males were at higher risk of developing post-operative delirium, but there was no statistically significant

correlation between gender and post-operative delirium. ($P = 0.088$). Similar results were found in a review of 80 Primary Data-Collection Studies done by Dyer *et al.*, which showed that there was no statistically significant association between gender and post-operative delirium which is comparable to our study.[11]

We also observed that delirium was seen in patients of all ages, but there was no statistically significant association between age and post-operative delirium. ($P = 0.683$). Wang *et al.*, carried out a study to determine an association between age and post-operative delirium and they concluded that there is a significant association between the same. The difference in the outcome of their study from ours may be because of a larger sample size and average age of subjects in their study being over 65 years of age.[12]

BMI of the study population varied between 13.32 and 31.20 with the mean being 23.69 which did not show any statistically significant association with post-operative delirium ($P = 0.679$). Similar results were found in a systemic review and meta-analysis done by Feinkohl *et al.*, wherein they found a non-significantly higher risk of post-operative cognitive dysfunction among persons with BMI >30 kg/m versus ≤30 kg/m.[13]

It was seen that the prevalence of comorbidities in patients undergoing cardiac surgery did not show any statistically significant correlation with post-operative delirium. We noted serum creatinine level, LVEF had no statistically significant correlation with post-operative delirium ($P = 0.097$, 0.097 respectively) Similar findings were concluded in a study done by Kazmierski *et al.*, which incorporated 260 patients undergoing cardiac surgery, to determine pre-operative predictive factors for post-operative delirium, they studied pre-operative variables such as serum creatinine, age, gender, diabetes, prior angioplasty, alcohol use, diabetes, and hypertension and found no statistically significant association between serum creatinine ($P = 1$), diabetes ($P = 0.267$), hypertension ($P = 0.843$), and prior MI ($P = 0.438$).[14] In our analysis, we were able to identify the elements of frailty which are most associated with the occurrence of post-operative delirium. We found that weight loss was associated with post-operative delirium but there was no significant statistical correlation whereas exhaustion, low physical activity, slow gait speed, and weakness had statistically significant correlations with post-operative delirium. Jung *et al.* in their study found that weight loss and weak handgrip strength (weakness) were commonly associated with delirium whereas low physical activity, exhaustion, and slowness were not significantly associated with post-operative delirium.[15] Another study done by Afilalo *et al.* has suggested a strong association of slow gait speed and delirium and mortality.[10]

49.5% of frail subjects as per Fried Frailty Index suffered deliriumand 50.5% of frail patients according to the Short Performance Physical battery showed delirium postoperatively. Both Fried criteria and SPPB frailty assessment methods identified a similar proportion of frail patients and perform similarly in predicting post-operative delirium among frail patients. This was comparable with the study done by Jung *et al.* which showed that 54.1% patients undergoing cardiac surgery met modified fried criteria for frailty whereas 51.9% met SPPB definition and frail patients were at increased risk of developing post-operative delirium.[15]

Limitations

Patients with age of >55 years were not included. Patients undergoing emergency cardiac surgery were excluded. A prolonged cardiopulmonary bypass time of more than 2 h was not included. Patients coming to a single institute were studied. Multi-institute study with a broader geographical distribution and a larger sample size should be conducted.

CONCLUSION

In our study, we found that, in patients undergoing cardiac surgery, delirium was more frequently seen in patients who were preoperatively frail, thus proving that frailty can be used as an effective tool for predicting patients prone to post-operative delirium.

All the four methods used for identifying and quantifying frailty were effective. The Fried frailty criteria (87.27%) and SPPB (87.95%) had higher negative predictive value and could be used for frailty assessment.

The elements of frailty like weaker handgrip strength and slowness of gait speed were most important predictors of post-operative delirium.

35 item frailty index method helps in quantifying the frailty as patients with higher frailty index were more prone for post-operative delirium.

We can conclude that, frailty is an important predictor of post-operative delirium and all the methods used for assessing frailty are effective and frailty assessment should be carried out routinely in pre-operative period in patients undergoing cardiac surgery so that effective strategies can be implemented to manage post-operative delirium which is most common cause for mortality and morbidity in patients undergoing cardiac surgery, thus also reducing cost to health system.

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