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RESEARCH ARTICLE

"A COMPARATIVE STUDY OF COGNITIVE FUNCTION, PRE-OPERATIVE AND POST-OPERATIVE, IN PATIENTS UNDERGOING VALVULAR HEART SURGERY"

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Abstract

"Neurological complications linked to cardiac surgery have been acknowledged since the early days of the field.". Neurological dysfunction includes a spectrum which ranges from neurocognitive dysfunction to cerebrovascular accidents. Cognition is defined as a process of perception, memory and information processing which allows the individual to acquire knowledge, solve problems & plan for future. Cognitive dysfunction is thus an impairment of these processes.

Introduction:-

"Neurological complications linked to cardiac surgery have been acknowledged since the early days of the field.". Neurological dysfunction includes a spectrum which ranges from neurocognitive dysfunction to cerebrovascular accidents. Cognition is defined as a process of perception, memory and information processing which allows the individual to acquire knowledge, solve problems & plan for future. Cognitive dysfunction is thus an impairment of these processes.

Post-operative cognitive dysfunction (POCD) has been documented after major surgeries both cardiac and non-cardiac. With improvement in surgical & anaesthesia techniques survival after major surgeries cardiac as well as non-cardiac has improved & thus post-operative comorbidities have gained major attention which includes POCD, which may affect quality of life of patients after surgery. The incidence of POCD after cardiac surgeries worldwide as indicated by previous studies ranges from 5 to 40 percent within the first post-operative week. Indian population data is not accurately available for POCD.

Over the years, the patient demographics for cardiac surgery have evolved, with a growing proportion of elderly individuals undergoing increasingly intricate procedures. Between 2001 and 2010, the average age of cardiac surgery patients rose from approximately 64 to 67 years. Additionally, the prevalence of pre-existing neurological conditions among these patients nearly doubled, increasing from 1.4% in 2001 to around 2.8% in 2010. The complexity of procedures has also increased, evidenced by a nearly 20% decline in isolated valvular heart surgeries over the same period. Remarkably, despite the rise in patient risk factors, mortality rates slightly declined from 4.0% in 2001/2002 to 3.1% in 2010/2011, according to the National Cardiac Surgery Audit (UCL, 2012).

Postoperative cognitive dysfunction (POCD) can manifest in various forms, ranging from temporary issues with memory and visuospatial skills to more severe outcomes like delirium and dementia. However, the most frequent concern in the initial weeks following valvular heart surgery is memory impairment. Awareness of these cognitive symptoms among patients, families, and healthcare providers prompted numerous studies assessing different aspects of cognitive function before and at multiple intervals after surgery.

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Verbal, visual & tactile perceptions, intellectual performance like calculation & retention, speaking etc. forms constellation of features in early post-operative period while affection of thought processes like insight may be affected in the long term. Pre-operative co-morbidities like diabetes, hypertension, and history of stroke are associated with an increased risk of POCD as documented by previous studies. Patients with impaired cognition pre-operatively or those having neurological diseases are at increased risk of POCD. An early assessment of cognitive function, after the surgical stress & effect of anaesthesia wean off, may be useful in early diagnosis of any cognitive changes if present. If there are any changes which may affect the cognitive functions of the patient, timely remedial measures may be instituted.

Consequently, it is critically important to identify both the cause and severity of brain injury that may result in complications ranging from mild cognitive deficits to severe stroke.

This study aims to evaluate the cognitive function of patients undergoing valvular heart surgery with the use of cardiopulmonary bypass, both before and after the procedure.

To assess POCD, the study employs the Hindi Mini-Mental Scale, a quick screening tool that examines multiple cognitive domains including attention/orientation, memory, fluency, language, and visuospatial abilities. This scale is considered effective in distinguishing cognitively healthy individuals from those with mild dementia.

Aim & Objectives:-

Aim:-

To test the occurrence of early post-operative cognitive dysfunction after valvular heart surgery using bypass machine in patients having normal cognitive function pre-operatively.

Objectives:-

1. To assess the cognitive function of patients undergoing valvular heart surgery using cardio-pulmonary bypass one day prior to surgery.
2. Reassessment of patient's cognitive functions 72 hours post-operatively.
3. To compare the patient's pre-operative assessment of cognitive function before surgery with their post-operative assessment.

Pathophysiology

The precise mechanisms underlying postoperative cognitive dysfunction (POCD) are still not fully understood. Previous research has primarily concentrated on identifying risk factors linked to the early onset of POCD. Table 1 outlines variables that have been associated with early or intermediate POCD. Among patient-related baseline or predisposing factors, advanced age and lower educational attainment were highlighted as primary contributors in an early investigation conducted by the International Study on Postoperative Cognitive Dysfunction (ISPOCD). A later study by Johnson et al., which focused on a subset of the original ISPOCD population, found that alcohol consumption was also a significant predisposing factor. Additionally, preoperative cognitive impairment has been linked to an increased risk of POCD.

The potential genetic susceptibility to POCD remains unclear, as current research has yielded inconsistent results. Variations in study methodologies—particularly differences in how delirium and cognitive function are assessed, the timing of these assessments, and the characteristics of patient populations—may account for discrepancies in findings across studies. Several contributing factors have been implicated in the development of POCD.

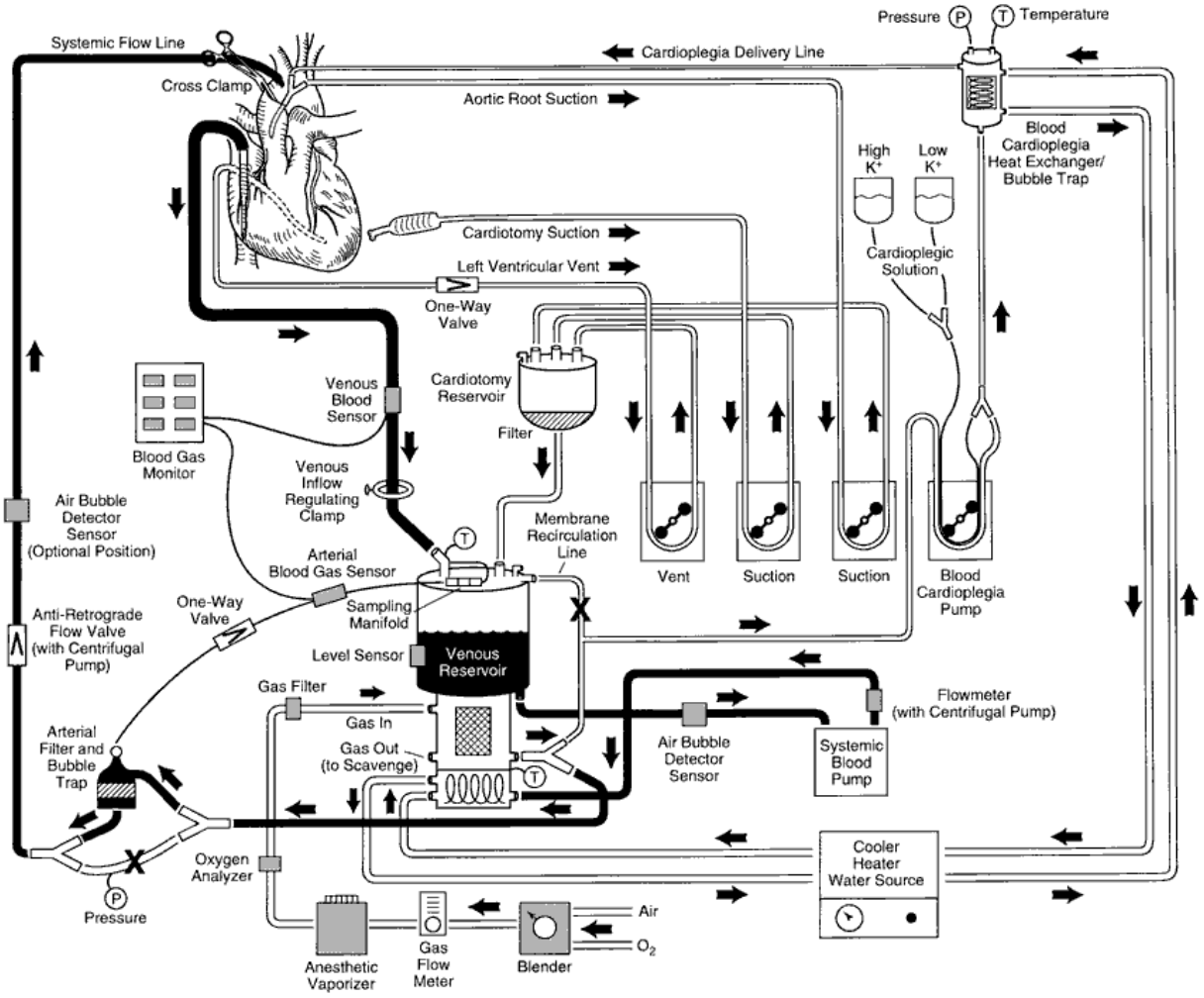


TABLE 2

Risk factors for postoperative cognitive dysfunction (POCD)

	Risk factors
Patient	advanced age; pre-existing cerebral, cardiac, or vascular disease; preoperative mild cognitive impairment (MCI); low educational level; history of alcohol abuse
Operation	extensive surgical procedure, intra- or postoperative complications, secondary surgery
Anesthesia	long-acting anesthetic, marked disturbance of homeostasis, organ ischemia due to hypoxia and hypoperfusion, intra- or postoperative anesthesiological complications

Valvular Heart Surgery And POCD

The most recognized mechanism of brain injury during valvular heart surgery involves the generation of micro emboli. These are produced through surgical manipulation of the heart and aorta, cardiotomy suctioning, and the use of the cardiopulmonary bypass (CPB) circuit itself. Intraoperative detection of micro emboli is possible via transcranial Doppler sonography, where they appear as high-intensity transient signals. These micro emboli may obstruct cerebral microvasculature, thereby reducing blood flow and oxygen delivery to the brain.

Certain stages of cardiac surgery are associated with an increased risk of embolic events. For example, aortic cannulation and clamping during CPB heighten the frequency of these high-intensity signals, particularly when significant atheroma is present in the ascending aorta. Notably, a significant portion—about 81%—of micro emboli are released during the removal of the aortic cross-clamp. The use of cardiotomy suckers to recover shed mediastinal blood introduces additional embolic risks, including lipid and tissue fragments that may re-enter the circulation and travel to the brain.

Moreover, the CPB circuit itself is a source of particulate and air emboli. Although filters are used before the blood is returned to the patient, aiming to reduce embolic load, their effectiveness in preventing POCD remains unclear. Cell salvage techniques, which involve filtering and washing red blood cells before re-infusion, may also help, but there is no definitive evidence that they provide neurological benefits or reduce POCD. In fact, they may interfere with coagulation processes. Despite these insights, no clear correlation has been found between the number of micro emboli and the extent of brain damage observed through imaging or the incidence of POCD.

In parallel with research on risk factors, recent efforts have sought to uncover the underlying mechanisms of POCD. Valvular heart surgery triggers a complex systemic response, including neuroinflammation. Both systemic and central nervous system inflammation can significantly influence patient outcomes. Blood loss and tissue damage may provoke immune responses that initiate inflammation, which is thought to be a contributing factor to POCD.

Preclinical data supports this hypothesis, implicating inflammatory mediators such as interleukin-1β in the development of POCD. However, the clinical implications of these findings remain uncertain. Future research employing translational and multidisciplinary approaches is necessary to clarify the inflammatory contribution to POCD.

Over the past decade, numerous studies have reported acute cognitive changes in adults following major surgeries. While most evidence suggests these early impairments are temporary, the long-term significance of POCD remains under discussion. Some data indicate that patients with early POCD are more likely to face complications after hospital discharge. Additionally, it is unclear whether such patients had pre-existing mild cognitive impairment, possibly contributing to a more rapid cognitive decline, independent of the surgical or anesthetic effects.

Looking ahead, large-scale, longitudinal studies are needed to better understand the pathophysiology of POCD in both the early and late postoperative stages. In conclusion, while multiple risk factors have been identified, the exact mechanisms responsible for POCD are yet to be fully determined.

Materials and Methods:-

Study Design:

It is a cross-sectional study.

Ethics:

The study initiated after obtaining necessary permission from the institutional ethics committee. It is done only after obtaining informed consent from the study participants who fulfill the inclusion criteria for the study.

Study Population:

The study population consisted of 110 patients of age group 25-65 years who underwent Valvular Heart Surgery using cardiopulmonary bypass machine who fulfilled the criteria for participation in the study.

Place of Study:

Cardiovascular & thoracic surgery ward & recovery room in a tertiary care hospital in the Metropolitan city in Maharashtra.

Duration of Study:-
Study was conducted over a period of one year.

Details of study procedure:

- The study was conducted after the approval of the InstitutionalEthics committee.
- Each patient was visited one day prior to surgery in the wards.
- The procedure to be done was explained to the patient in their understandable language and a written informed consent obtained for participation in the study.
- A structured questionnaire that is Hindi Mini Mental Scale was used to know pre-operative cognitive function of the patient.
- Same questionnaire was used 72 hours after operation and results compared to assess the cognitive dysfunction in study subjects in the postoperative period.
- Training to apply and interpret Hindi Mini Mental Scale was taken from Neuropsychologist.

Sampling Method:-

Study population selected by non-probability convenience sampling method.

Inclusion criteria:

- Patients undergoing Valvular Heart Surgery with use of bypass machine intra-operatively.
- Patients in whom anaesthesia is reversed & patients extubated at or before 24 hours of surgery.
- Age: 25 – 65 years
- Sex: Male and Female
- On pump time, less than two hours
- Patients years of education more than 4 years and able to comprehend the test

Exclusion criteria:

- Refusal by the patient
- Patients having significant neurological deficit pre-operatively
- Patients with known psychological illness or those with cognitive dysfunction at baseline assessment.
- Patients having difficulty in talking or affected speech.
- Patients on any sedation at or after 24 hours of surgery.

D. Sample size calculation

Sample size was calculated by using the Formula[64]

$$\text{Sample size (n)} = Z2\,(1-\alpha/2) \times \frac{P * Q}{d^2}$$

Considering variations in POCD prevalence in different studies for early cognitive dysfunction, prevalence of POCD (P) was considered as 7% as observed in the study [67]
P= 7%
Q=100-P = 93%
Z is the value of Z score at 95% confidence interval = 1.96
d= Absolute precision required on either side of the proportion (in percentage points) = 5 percentage points

Calculated sample size: N=99.99= 100
Therefore N= 100, so sample size is taken as 110 considering dropouts (10%).

Tool for study:

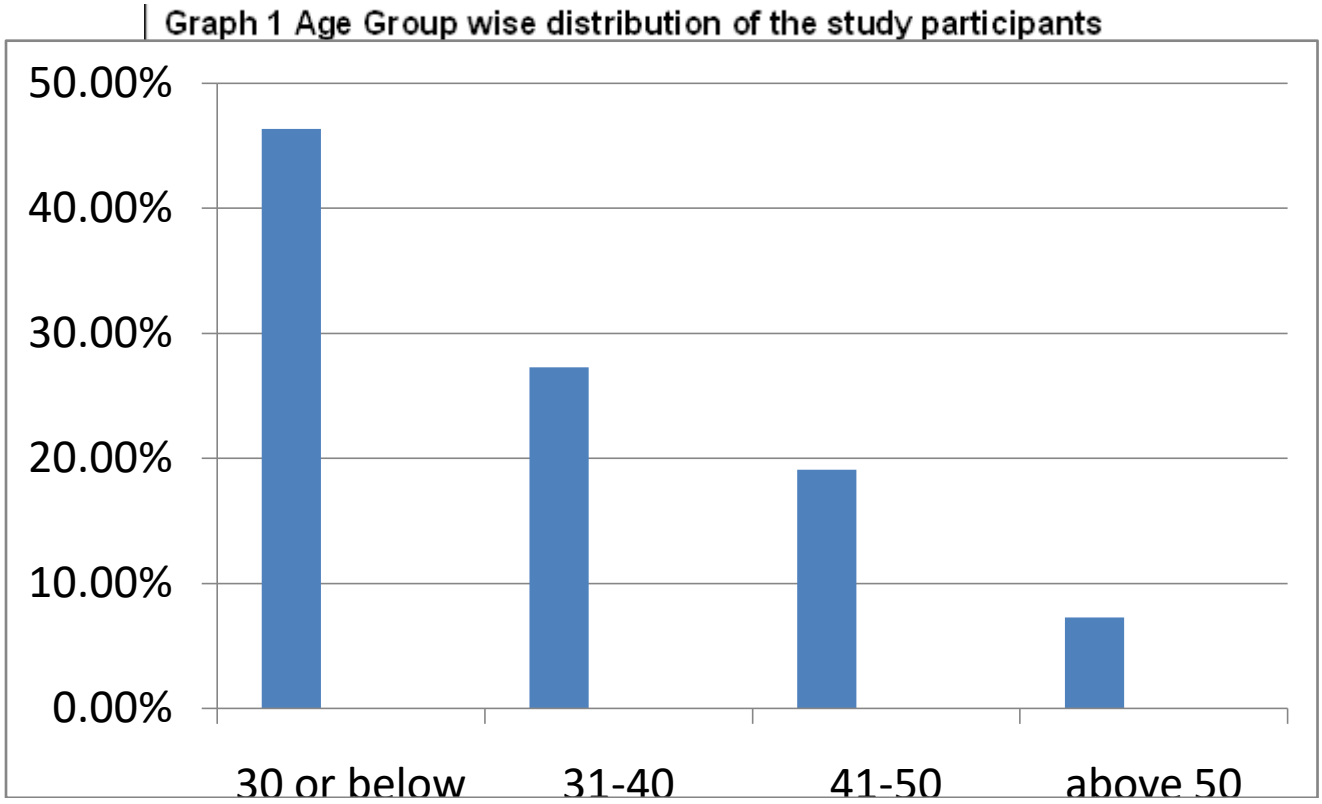
- Hindi Mini Mental Scale is a rapid screening battery, including five subscales to explore different cognitive domains: attention/ orientation, memory, fluency, language and visuospatial ability.
- HMMS is considered useful in discriminating cognitively normal subjects from patients with mild dementia.
- HMMS was used one day prior to surgery and only those patients were included in study who had normal HMMS scores that are less than -1.5 standard deviation for years of education.
- The repeat assessment was done on 72 hours of surgery and value less than -1.5 standard deviation for years of education is taken as normal while value more than -1.5 standard deviation is indicative of POCD
- Post-surgery score was compared with the baseline score & any significant difference if present was noted.

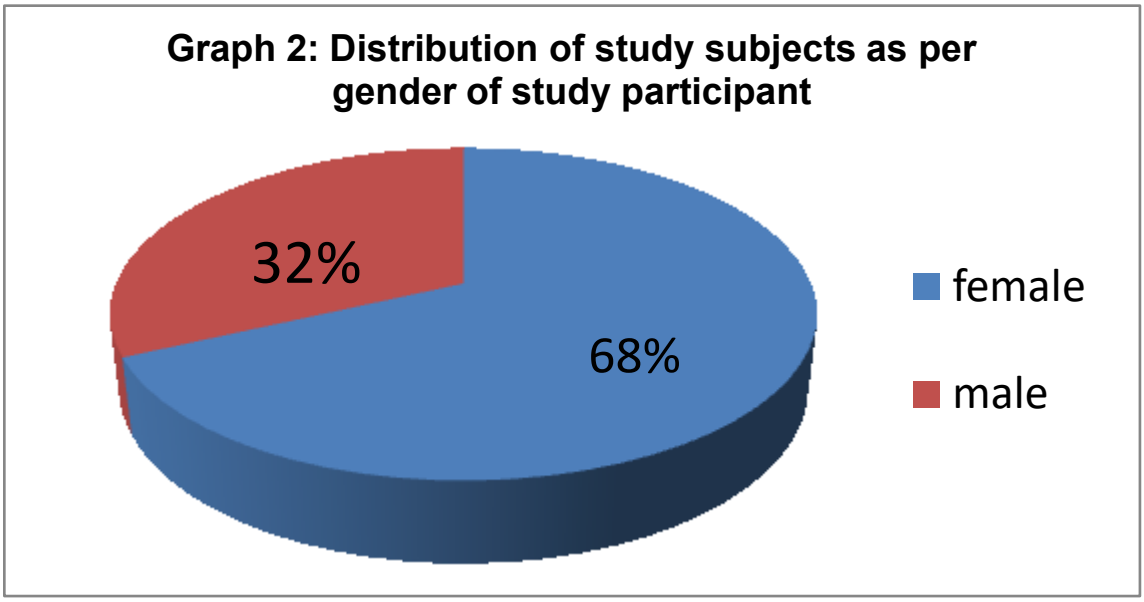
Results and Observations:-

Table 1: - Age Group wise distribution of the study participants.

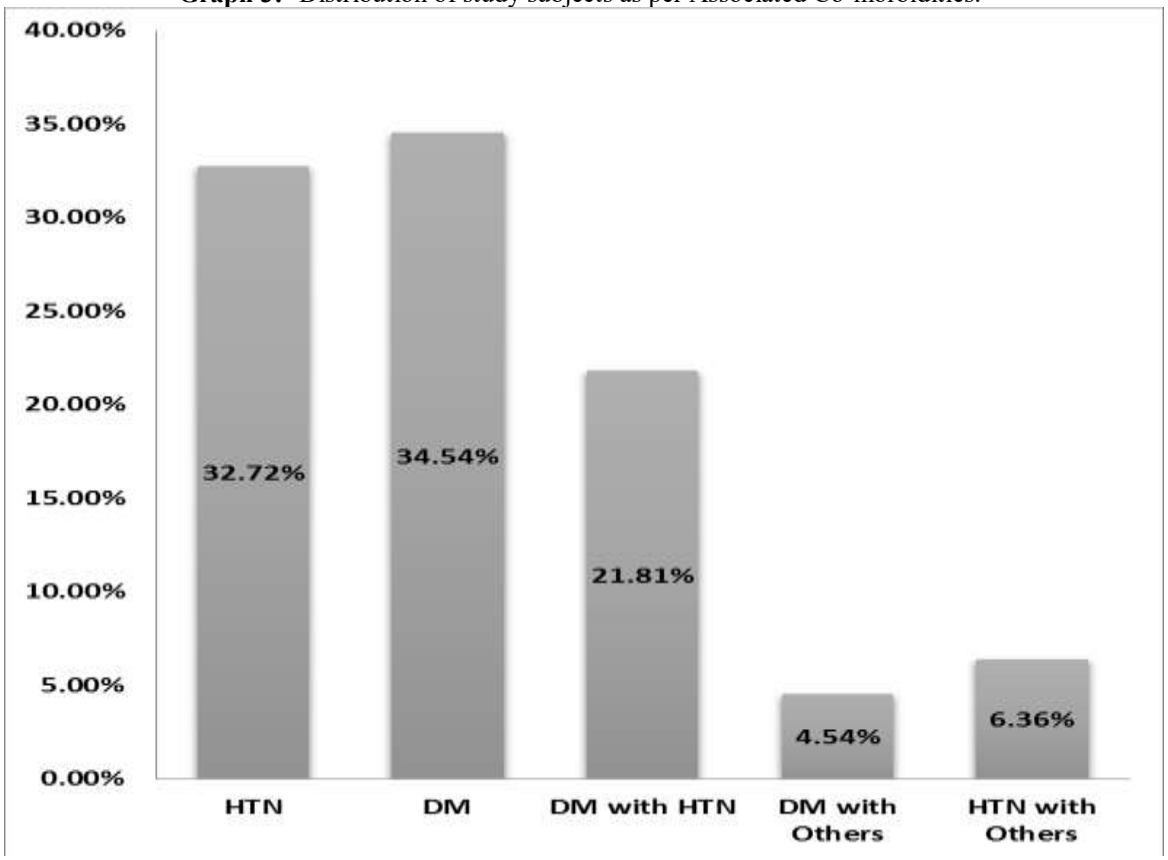
Sr. no	Age group (years)	No. of study participant
1	30 years or below	51 (46.36%)
2	31-40	30 (27.27%)
3	41-50	21 (19.09%)
4	Above 50	8 (7.27%)

The above table shows the age wise distribution of study subjects. A total of 110 cases were studied out of which 51 were below 30 years of age comprising 46.36% of study subjects, 30 were between 31 to 40 years of age comprising 27.27% of the study group.21 subjects that is 19.09% of study group population was of 41 to 50 years and 8 (7.27%) were above 50.





Graph 3:- Distribution of study subjects as per Associated Co-morbidities.



Graph 4:- Distribution of study subject as per duration of associated co-morbidities

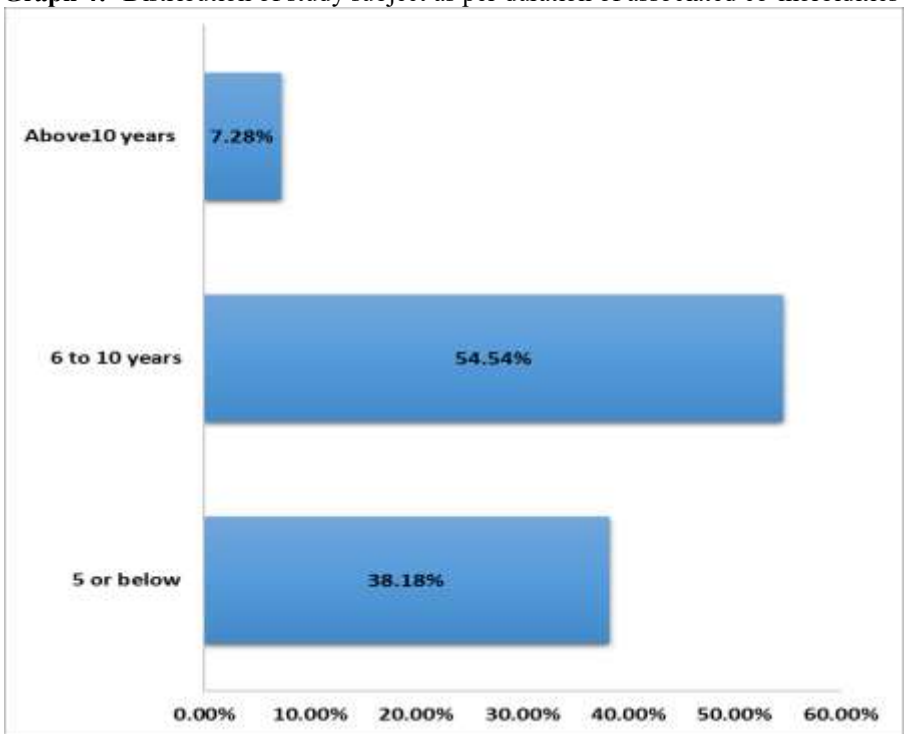


Table 2:- Distribution of study subjects as per presence of POCD.

Sr. No.	Presence of POCD	No. of Study Participants
1	Yes	02(1.82%)
2	No	108(98.18%)
Total		**110**

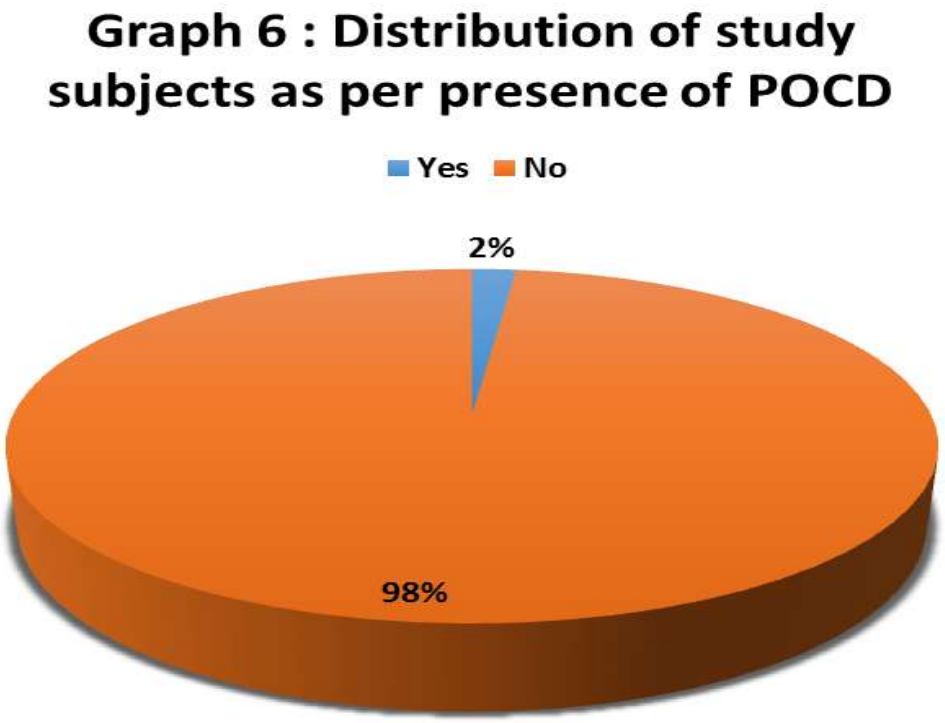
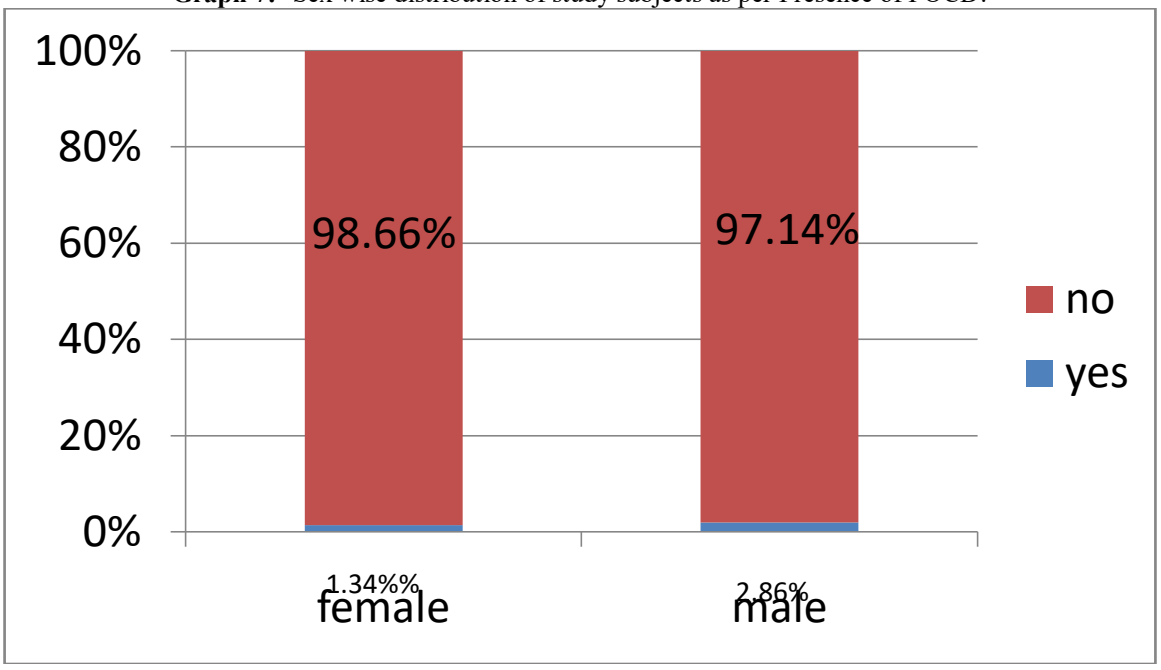


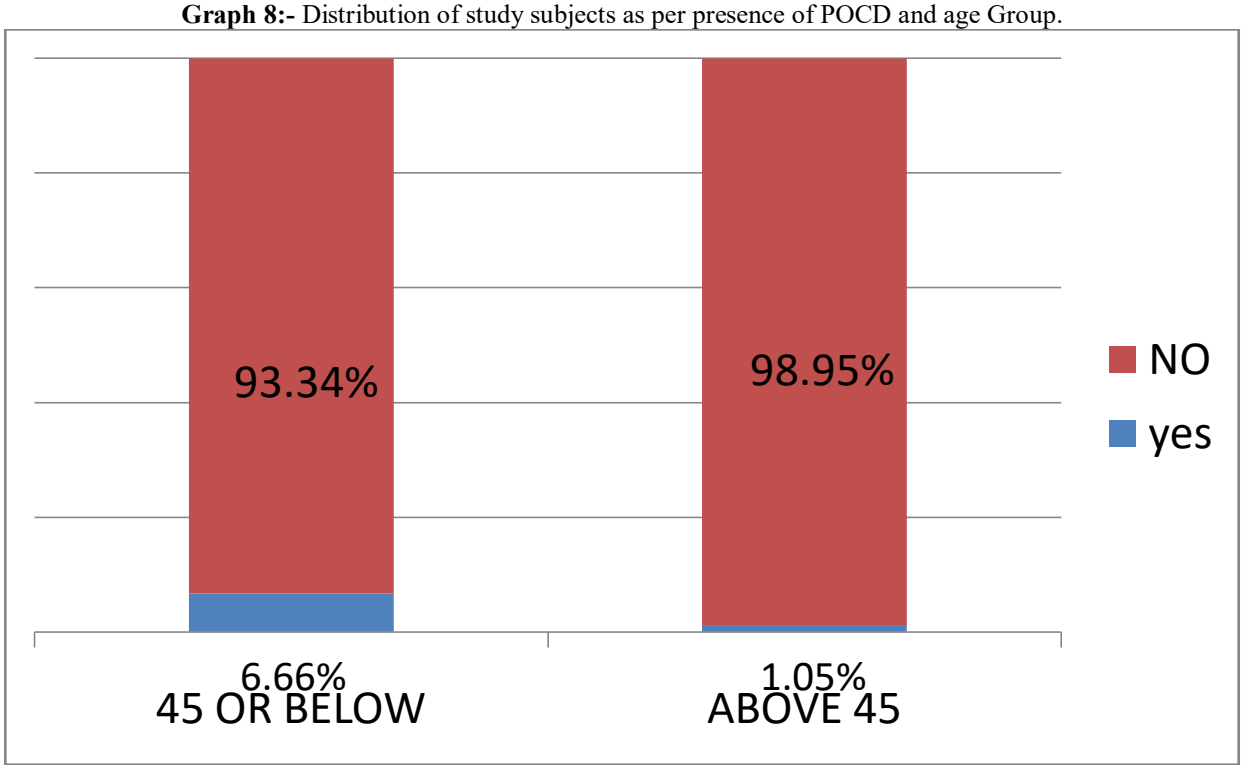
Table 3:- Sex wise distribution of study subjects as per presence of POCD.

Sr. No.	Sex	Presence of POCD		Total
		Yes (%)	No (%)	
1	Female	01(1.34)	74(98.66)	**75**
2	Male	01(2.86)	34(97.14)	**35**
	Total	02(1.85)	108(98.15)	**110**

Graph 7:- Sex wise distribution of study subjects as per Presence of POCD.



Graph 8:- Distribution of study subjects as per presence of POCD and age Group.



Discussion:-

Postoperative Cognitive Dysfunction (POCD) has been observed following both cardiac and non-cardiac major surgeries. As advancements in surgical and anesthetic techniques have improved survival rates after cardiac procedures, attention has increasingly turned toward postoperative complications, including POCD, which can negatively impact patients' quality of life. Global studies have reported POCD incidence rates between 5% and 40% within the first postoperative week following cardiac surgery. Since preoperative cognitive decline is considered a contributing factor to POCD, this study focused on comparing the cognitive status of patients before and after valvular heart surgery.

Although the pathogenesis of neurological complications following valvular surgery is complex, accumulating evidence indicates that pre-existing conditions like cerebrovascular disease and cognitive impairment play a significant role in both short- and long-term neurological outcomes. Neuropsychological testing remains the primary method for detecting cognitive decline after cardiac surgery. This involves assessing multiple cognitive domains—such as memory, attention, language, executive functions, and motor skills—before and after surgery. However, discrepancies in reported incidence rates of cognitive decline are often due to the lack of a standardized definition for POCD.

In this study, the Hindi Mini Mental Scale (HMMS)a validated cognitive screening tool—was used to assess preoperative cognitive status. A total of 110 patients were evaluated, with HMMS administered 24 hours prior to surgery. Only individuals with normal cognitive function were included. The test was repeated 72 hours after surgery, and a score drop of ≥1.5 standard deviations from baseline was used to define POCD.

Among the 110 patients, 8 (7.27%) were over 50 years old, 21 (19.06%) were aged 41–50, 30 (27.27%) were aged 31–40, and 51 (46.36%) were 30 years or younger, making the younger age group the majority. This age distribution reflects the prevalence of cardiovascular conditions requiring valvular intervention in younger populations. Only patients aged 25–65 were studied, as individuals over 65 are independently at higher risk for cognitive impairment.

Of the study participants, 75 (68.18%) were female and 35 (31.82%) males. This gender difference reflects the higher incidence of valvular heart disease in females. Comorbidity analysis showed that 36 patients (32.72%) had hypertension alone, 38 (34.54%) had diabetes alone, and 24 (21.81%) had both. A small proportion had other combinations of comorbidities. Diabetes was the most prevalent comorbidity, followed by hypertension and combined diabetes-hypertension.

Patients with a history of stroke, cerebrovascular accidents, psychiatric disorders, memory impairments like dementia, or speech disorders were excluded to avoid confounding results.

Results:-

Out of 110 patients, only 2 (1.82%) were found to have POCD. The remaining 108 (98.18%) showed no signs of cognitive dysfunction postoperatively. The HMMS, which provides a 31-point score through a questionnaire format, was used to assess and compare cognition. This straightforward tool has been validated for cognitive screening.

Gender-wise analysis showed 1 of 75 female patients (1.34%) and 1 of 35 male patients (2.86%) developed POCD. A chi-square test gave a value of 0.310 and a p-value of 0.5774, indicating no statistically significant relationship between gender and POCD incidence.

Age-wise, one POCD case was in a patient under 45 years and the other above 45. Among 15 patients aged above 45, one (6.66%) developed POCD. In the 45 and under group, only one patient (1.05%) showed POCD. A chi-square test yielded a value of 0.223 and a p-value of 0.6365, again indicating no significant association between age and POCD.

Reassessment was done at 72 hours post-surgery, as this allows for anesthetic effects and surgical stress to subside. This timing also coincides with the usual discharge from CVTS recovery to the word in uncomplicated cases, making it an appropriate checkpoint for early cognitive assessment.

Both POCD cases involved patients with long-standing diabetes and hypertension, both over 55 years of age—factors associated with increased risk. These patients also had longer cardiopulmonary bypass (CPB) times, which may contribute to POCD development. In contrast, patients without POCD tended to be younger, had fewer or more recent comorbidities, shorter CPB durations, and benefited from newer oxygenator technologies, which may reduce embolic risk.

Conclusion:-

This study found no significant correlation between POCD and gender, age, or comorbidity duration. The incidence of POCD was low (1.82%), which may be due to the strict inclusion criteria: only patients with normal preoperative cognitive function aged 25–65 and without neurological or psychiatric history were selected. Additionally, a consistent definition for POCD was applied using a validated screening tool (HMMS with -1.5 SD threshold). Compared with previous studies (e.g., Newman et al.), which included older age groups and larger samples, this study's smaller sample size may explain the lower POCD incidence and lack of statistically significant associations. Future research with larger sample sizes could provide more robust insights.

Summary

This cross-sectional comparative study was carried out at a tertiary care hospital to examine the incidence of postoperative cognitive dysfunction (POCD) in patients with normal preoperative cognitive function undergoing valvular heart surgery using cardiopulmonary bypass (CPB). A total of 110 participants who met the eligibility criteria were enrolled after obtaining written informed consent. The study also received approval from the institutional ethics committee.

- A total of 110 patients with normal cognitive status before surgery were assessed, of whom 2 developed POCD 72 hours postoperatively, yielding an incidence rate of 1.82%.
- One male and one female developed POCD, corresponding to an incidence of 1.34% among females and 2.86% among males. However, a chi-square test revealed no statistically significant association between gender and the occurrence of POCD.
- In the age group of 45 years or younger, one patient (1.05%) developed POCD, while the incidence was 6.6% in those older than 45 years. The relationship between age and POCD was not statistically significant.
- Among participants with comorbidities present for five years or less, the incidence of POCD was 2.38%, whereas it was 1.47% in those with comorbidities for more than five years. This difference was not statistically significant.
- Both patients who developed POCD have received eight years of formal education. Due to the small number of such cases, no statistical test was applied to assess the impact of educational levels.
- Overall, the study found a low incidence (1.82%) of POCD among patients who had normal cognitive function prior to surgery.

Conclusion:-

POCD is one of the important morbidities in patients undergoing Valvular Heart Surgery; it can limit the neurological function of the subject significantly affecting memory, reasoning, thought process and mathematical calculations. Neuropsychological tests to determine preoperative cognitive function should be included in the preoperative examination of the patients undergoing Valvular Heart Surgery to screen those with impaired cognition, as they are at an increased risk of developing POCD.

As Per our study POCD prevalence is not significant in subjects having normal cognitive function preoperatively.

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