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Development of an Objective Pain Scoring System and its Correlation with Visual Analogue Scale for Evaluation of Postoperative Pain in Patients Undergoing Elective off Pump Coronary Artery Bypass Grafting Surgery: A Prospective Observational Study

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ABSTRACT

Background: One of the most upsetting and frequent side effects after heart surgery is pain. Assessing the presence and intensity of pain, determining who needs assistance, and creating a treatment plan are essential components of effective pain management.

Objectives: To formulate an Objective Pain Score (OPS) based on MAP and Heart rate changes, for evaluation of post-operative pain in patients undergoing Elective Off pump Coronary artery bypass grafting surgery (CABG). We also aimed to correlate the OPS with visual analog scale (VAS) score as a tool in pain management.

Methods: A hospital based observational study was conducted at Post op Cardiac Surgery Recovery 1 and 2 in Fortis Escorts Heart Institute. The final sample size was 74. So, by rounding off, we decide to take a sample of 75. Consecutive type of non-probability sampling has been done in the study to include 75 patients undergoing Elective Off pump CABG under general anaesthesia at our hospital. Microsoft Excel 2021 was used for graphical depiction, SPSS Version 26.0 was utilized for the majority of the study, and G*Power software version 3.1.7 was used to calculate the sample size.

Results: Mean age of study group was 51.1 years with 30.7% cases over the age of 60 years. Out of the total 75 cases undergoing Elective Off pump CABG, 54.7% were females and 45.3% were males. ASA grade II and III was seen in 84% and 16% cases undergoing Elective Off pump CABG. Study showed the mean change in VAS score over the 24-hour post- operative period of cases undergoing Elective Off pump CABG. Our Study showed the mean change in objective pain score over the 24hour post-operative period of cases undergoing Elective Off pump CABG. An excellent correlation (r value >0.8) was observed in majority of the readings between mean VAS and objective pain score, throughout the post-op follow up duration of 24 hours.

Conclusion: OPS based on HR and MAP is a simple tool that requires little extra time to apply and causes no discomfort to patients. However, further research would be required to further establish the use of this scale as an objective measure of pain, given our limited sample size and homogeneous patient population.

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Introduction

The earliest views of pain are recognized to **Plato and Aristotle, who stated that "pain is like pleasure, is passion of the soul, that is, an emotion and the senses**". In line with this quote, The International association for the study of pain defines pain as "An unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage" [1]. Pain is one of most distressing and common after effect of the cardiac surgeries. All medical personnel's regard it's relief as one of their main duties. It is morally and ethically reprehensible to fail to alleviate pain. Sufficient pain management is seen as a fundamental human right. Every patient fervently desires pain relief, whether it is by medication, nerve injections, surgery, or any other method. Assessing the existence and intensity of pain, determining who needs assistance, and creating a treatment plan are essential components of effective pain management. Self-reporting is the foundation of the gold-standard pain assessment instruments used today, which need that a person comprehend outside data as well as convey their own experience [2]. Numerous self-reporting pain assessment instruments, such as the Visual Analog Scale (VAS), Verbal Rating Scale (VRS), and the most widely used numeric rating scale (NRS), have been developed and validated in patients with chronic pain [3-7].

These scales ask patients to rate their level of pain quantitatively, transforming a subjective emotion into a numerical value for pain assessment and long-term monitoring. Unfortunately, because the data is entirely patient-reported, these scales allow for bias and lack of impartiality even while they may appropriately emphasize the patient. Additionally, a number of factors, such as socioeconomic background, beliefs, and psychological state, can affect how the patient self-assesses their level of pain [8, 9].

Because both overusing opioids and undertreating pain can negatively impact recovery following surgery, it is necessary to investigate pain scoring methods that can remove the subjective element from the evaluation of pain. A stress response that includes elevated blood pressure, heart rate, pupil diameter, and plasma cortisol levels is linked to acute pain [10]. When people were exposed to unpleasant stimuli, their heart rates increased, according to early research on the physiological reaction to pain in a small group of healthy people [11].

Although blood pressure or heart rate have been used to objectively measure pain, no reliable research has been done to develop a post-operative pain score that is comparable to the visual pain score that is frequently used to measure pain in conscious patients. Currently, the majority of research has only estimated intraoperative pain using blood pressure or heart rate. A study is required to convert changes in Heart Rate (HR) or Mean Arterial Pressure (MAP) into a proxy for post-operative discomfort.

In present study, we thus aimed to formulate an Objective Pain Score (OPS) based on MAP and Heart rate changes, for evaluation of post-operative pain in patients undergoing Elective Off pump Coronary Artery Bypass Grafting Surgery (CABG). We also aimed to correlate OPS with VAS score as a tool in pain management.

Material and Methods

Study Area: Post op Cardiac Surgery Recovery 1 and 2 in Fortis Escorts Heart Institute.
Study Population: All the patients undergoing Elective Off CABG and meeting the inclusion criteria.
Study Design: A Prospective Observational Study and was conducted in accordance with declaration of Helsinki.

Sample Size Calculation

- Sample size was calculated with G*Power software ver. 3.1.7 by making following assumptions for a bivariate normal modal correlation, Figure 1.
- α-error – 5%
- β-error – 20%
- Power of study – 80%
- Correlation between scores – 0.5

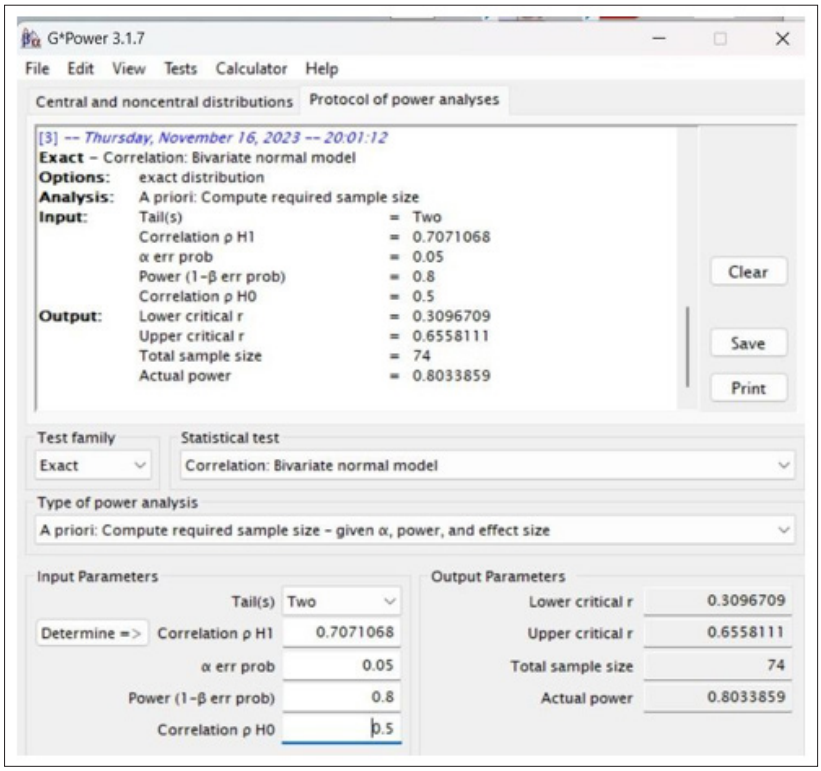

Figure 1: Sample size Calculation using G*Power Software ver. 3.1.7

The final sample size was 74. So, by rounding off, we decide to take a sample of 75. Consecutive type of non-probability sampling has been done in the study to include 75 patients undergoing Elective Off pump CABG under general anaesthesia at our hospital.

Study Duration: 3 months (January 2024 to March 2024)
Ethical Approval: The study was approved by Institutional Ethics Committee on 14 Dec 2023, No. IEC/2023/OAS/25.

Inclusion Criteria

- Age < 75 years
- Elective Off pump CABG under general anaesthesia.

Exclusion Criteria

- Chronic Pain patients
- Mechanical ventilation time longer than 12 hours after surgery conclusion
- Altered mental status and cognition deficit.
- Ramsay sedation scale score > 4
- Hemodynamic instability requiring inotropes
- Preoperative left ventricle EF lower than 30%
- Patients requiring re-intubation
- Excessive bleeding requiring re-exploration

Methodology

After agreement from hospital research and ethics committee, 75 patients fulfilling eligibility criteria, posted for elective off pump CABG were enrolled for the study. The intra-operative anaesthetic management of the cases was done according to departmental protocol for CABG.

Pain was measured after extubation by VAS. The VAS score of Zero or no pain complain was achieved with titrated dose of Buprenorphine, Inj. Paracetamol, Buprigesic patch, which is a routine protocol in our CTVS ICU.

For objective pain assessment, heart rate and MAP was monitored. Mean arterial pressure (MAP) was measured invasively and heart rate was monitored using standard vital sign monitor (Phillips MP 20). OPS defined five areas of pain control based on the target values of MAP and HR. Five control areas were defined as: profound pain control (0-2), excellent pain control (3-4), good pain control (5-6), inadequate pain control (7- 8) and negligible pain control (9-10), Figure 2.

AN OBJECTIVE PAIN SCORE (OPS)

	<25%	<20%	<15%	<10%	<5%	MAP	>5%	>10%	>15%	>20%	>25%
<30%	-10	-9	-8	-7	-6	-5	COMPENSATORY PHYSIOLOGIC RESPONSE				
<25%	-9	-8	-7	-5	-4	-4					
<20	-8	-7	-6	-5	-4	-3					
<15%	-7	-6	-5	-4	-3	-2					
<10%	-6	-5	-4	-3	-2	-1					
HR	-5	-4	-3	-2	-1	O	1	2	3	4	5
>10%	COMPENSATORY PHYSIOLOGIC RESPONSE					1	2	3	4	5	6
>15%						2	3	4	5	6	7
>20%						3	4	5	7	8	8
>25%						4	5	6	7	8	9
>30%						5	6	7	8	9	10

Figure 2: Objective Pain Score

Mean arterial blood pressure and heart rate during nil pain was noted as base line or zero point of OPS. VAS score was documented every 2 hours till 24 hours after extubation. Value of Objective Pain Score (OPS) was noted from the chart according to the value of heart rate and mean blood pressure every 2 hour. The values of OPS were then correlated with that of VAS score. Mean BP and heart rate can be affected by other factors. Increase in heart rate without increase in mean BP is hypovolemia and hence the previous score in the OPS chart was taken into account in these cases. Similarly decrease in heart rate without decrease in BP is vagal response and hence the previous score in the OPS chart was taken into account.

Statistical Analysis

A pre-made study proforma was used to record all of the data. Frequencies and percentages were used to depict qualitative data. Pearson's correlation coefficient was used for correlation analysis. A p-value of less than 0.05 was considered significant. Where appropriate, the results were displayed graphically. Microsoft Excel 2021 was utilized for graphical depiction, while SPSS Version 26.0 was utilized for the majority of the study.

Results

Mean age of study group was 51.1 years with 30.7% cases over the age of 60 years, shown in the Table 1 and Figure 3.

Table 1: Distribution of Study Groups as per age Group

Age group (yrs)	N	%
</=40	16	21.3%
41-60	36	48.0%
>60	23	30.7%
Total	75	100.0%
Mean age - 51.1 +/- 12.1 years		

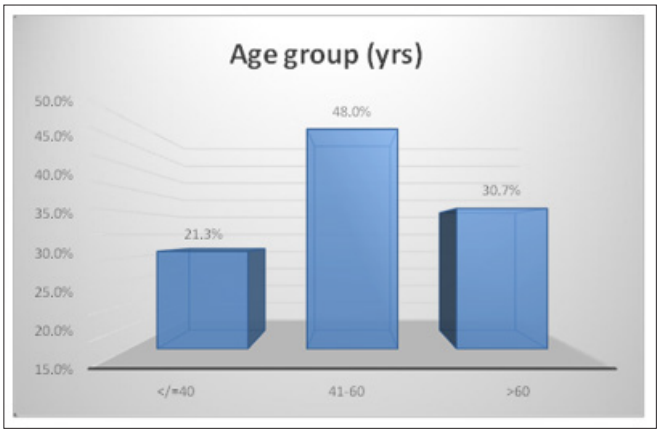

Figure 3: Distribution of study groups as per age group

Out of the total 75 cases undergoing Elective Off pump CABG, 54.7% were females and 45.3% were males, shown in Table 2 and Figure 4.

Table 2: Distribution of study groups as per gender

Gender	N	%
Female	41	54.7%
Male	34	45.3%
Total	75	100.0%

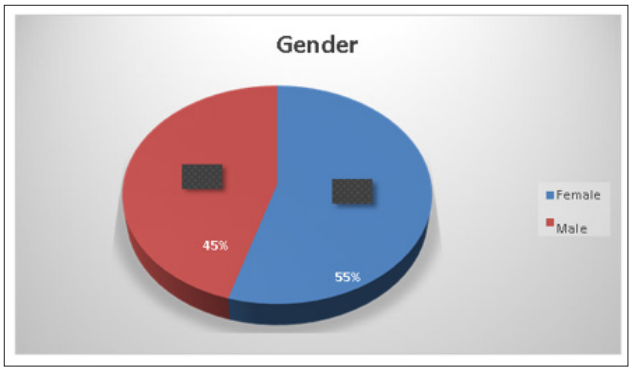

Figure 4: Distribution of Study Groups as per Gender

ASA grade II and III was seen in 84% and 16% cases undergoing Elective Off pump CABG, shown in Table 3 and Figure 5.

Table 3: Distribution of study groups as per ASA grade

ASA Grade	N	%
II	63	84.0%
III	12	16.0%
Total	75	100.0%

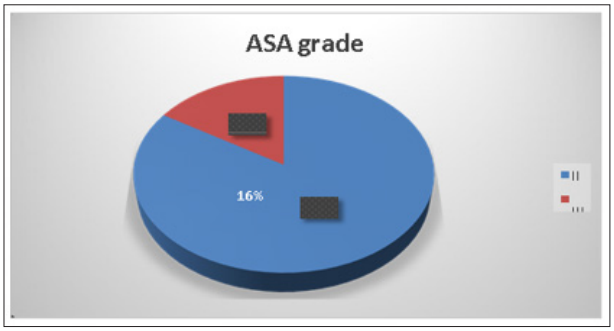

Figure 5: Distribution of study groups as per ASA grade

Above table showed the mean change in VAS score over the 24-hour post- operative period of cases undergoing Elective Off pump CABG, shown in Table 4 and Figure 6.

Table 4: Distribution of study groups as per mean VAS Score

VAS Score	Mean	SD
0 hr	0.00	0.000
2 hr	0.00	0.000
4 hr	0.37	0.487
6 hr	1.29	0.458
8 hr	2.43	0.498
10 hr	1.51	1.389
12 hr	0.73	0.963
14 hr	1.04	0.531
16 hr	2.25	0.572
18 hr	1.71	1.393
20 hr	1.05	1.025
22 hr	1.28	0.966
24 hr	2.07	0.794

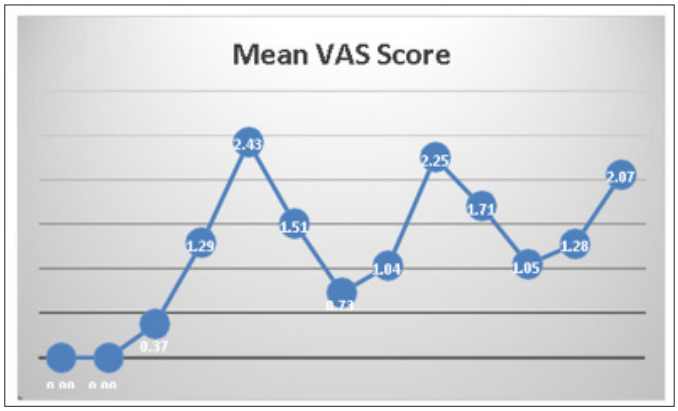

Figure 6: Distribution of Study Groups as per mean VAS Score

Above table showed the mean change in objective pain score over the 24hour post-operative period of cases undergoing Elective Off pump CABG shown in Table 5 and Figure 7.

Table 5: Distribution of Study Groups as per Mean Objective Pain Score

OPS	Mean	SD
0 hr	0.00	0.00
2 hr	0.00	0.00
4 hr	0.41	0.50
6 hr	1.35	0.60
8 hr	2.47	0.76
10 hr	1.67	1.34
12 hr	0.87	1.05
14 hr	1.09	0.68
16 hr	2.31	0.79
18 hr	1.76	1.32
20 hr	1.10	1.00
22 hr	1.34	1.13
24 hr	2.16	0.89

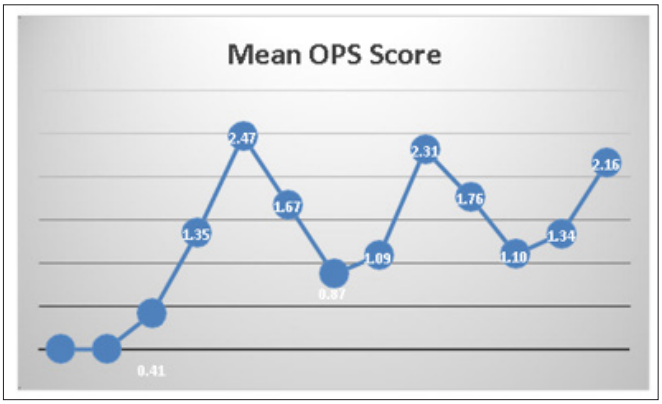

Figure 7: Distribution of Study Groups as per Mean Objective Pain Score

On observing the difference between mean VAS and objective pain score, we observed that in majority of the cases the difference between pain scores was <5%. OPS slightly overestimates the pain in comparison to VAS score, the difference was more evident (>10%) in lower pain score values i.e. VAS <1, shown in Table 6 and Figure 8.

Table 6: Difference between objective pain score and mean VAS Score across various time intervals

Time	VAS Score	OPS	df	%
4 hr	0.37	0.41	0.04	8.9%
6 hr	1.29	1.35	0.06	4.2%
8 hr	2.43	2.47	0.04	1.8%
10 hr	1.51	1.67	0.16	9.8%
12 hr	0.73	0.87	0.14	15.7%
14 hr	1.04	1.09	0.05	4.6%
16 hr	2.25	2.31	0.06	2.5%
18 hr	1.71	1.76	0.05	3.0%
20 hr	1.05	1.10	0.05	4.2%

22 hr	1.28	1.34	0.06	4.5%
24 hr	2.07	2.16	0.09	4.3%

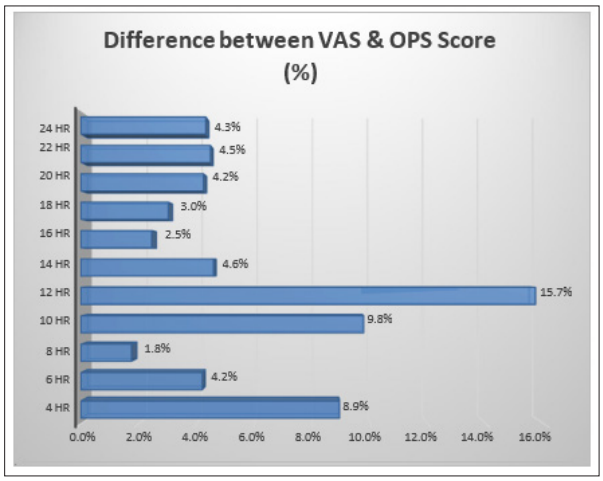

Figure 8: Difference Between Objective Pain Score and Mean VAS Score Across Various time Intervals

An excellent correlation (r value >0.8) was observed in majority of the readings between mean VAS and objective pain score, throughout the post-op follow up duration of 24 hours, shown in Table 7 and Figure 9.

Table 7: Correlation between objective pain score and mean VAS Score

Pearson's Correlation co-efficient		
VAS Score vs OPS	**r- value**	**p- value**
4 hr	0.80	<0.01
6 hr	0.89	<0.01
8 hr	0.91	<0.01
10 hr	0.85	<0.01
12 hr	0.74	<0.01
14 hr	0.92	<0.01
16 hr	0.94	<0.01
18 hr	0.91	<0.01
20 hr	0.88	<0.01
22 hr	0.86	<0.01
24 hr	0.87	<0.01

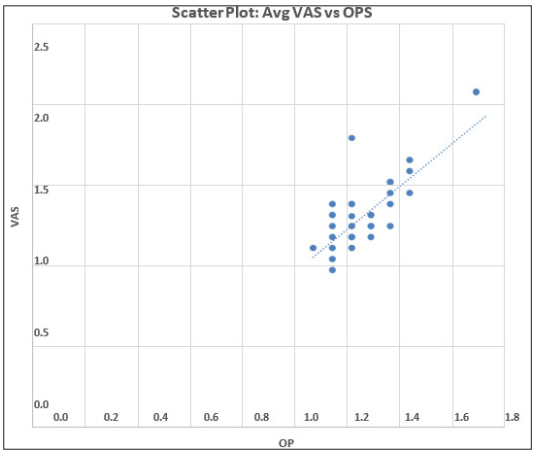

Figure 9: Correlation between objective pain score and mean VAS Score

Discussion

Pain is a prevalent and highly distressing consequence that often follows heart operations. Medical professionals consider providing alleviation as one of their primary responsibilities. "The failure to alleviate pain is morally and ethically unacceptable." Ensuring sufficient pain treatment is regarded as a fundamental entitlement of every individual. Every patient ardently wants to be free of pain, regardless of the approach-medication, nerve injections, surgery, or any other treatment. Evaluating the presence and severity of pain, determining which patients require intervention, and formulating a treatment plan are all essential components of successful pain management. The most dependable pain assessment methods now in use rely on self-reporting, which include a person analyzing outside data and sharing their own experiences [2].

Several pain assessment techniques that rely on self-reporting have been developed and verified for patients with chronic pain. These include the NRS, VRS, and VAS, which are the most often utilised [3-7]. These scales necessitate patients to assign a numerical value to their pain sensation, so transforming subjective experience into quantifiable metric for the purpose of pain assessment and long-term monitoring. Although these scales prioritise the patient's perspective, they are susceptible to bias and lack impartiality because they rely solely on patient-reported data. Furthermore, the patient's self- assessment of pain might be impacted by various factors, such as socio- economic status, beliefs, and psychological condition [8, 9].

It is necessary to investigate pain scoring techniques that can remove subjective element from pain assessment. This is important since the overuse of opioids and inadequate treatment of pain can negatively impact the recovery process after surgery. Acute pain is linked to stress response characterised by elevated heart rate, blood pressure, pupil diameter, and plasma cortisol levels [10]. Preliminary research conducted on a limited number of healthy individuals revealed that their heart rate increased in reaction to painful stimuli [11]. Heart rate and blood pressure have been utilised as objective measures to evaluate pain. However, there is a lack of strong research studies that have established a comprehensive "post-operative pain score" similar to commonly used visual pain score for assessing pain in conscious patients. Currently, the majority of research have only relied on either heart rate or blood pressure as indicators to assess intraoperative pain. A study is required to convert fluctuations in Mean Arterial Pressure (MAP) or Heart Rate (HR) into a surrogate measure of post-operative discomfort.

In this study, our objective was to develop an Objective Pain Score (OPS) using changes in Mean Arterial Pressure (MAP) and Heart rate to assess post- operative pain in patients who have elective off-pump CABG. Our objective was to establish a correlation between the OPS and VAS score as a pain management tool. Consecutive type of non-probability sampling will be done in the study to include 75 patients undergoing Elective Off pump CABG under general anaesthesia at our hospital. Pain was measured after extubation by VAS. The VAS score of Zero or no pain complain was achieved with titrated dose of Buprenorphine, Inj. Paracetamol, Buprigesic patch, which is a routine protocol in our CTVS ICU. For objective pain assessment, heart rate and Mean arterial pressure (MAP) was monitored. Mean arterial pressure was measured invasively and heart rate was monitored using standard vital sign monitor (Phillips MP 20). Mean arterial blood pressure and heart rate during nil pain was noted as base line or zero point of OPS. VAS score was documented every 2 hours till 24 hours after extubation. Value of objective pain score (OPS) was noted

from the chart according to the value of heart rate and mean blood pressure every 2 hour. Values of OPS were then correlated with that of VAS score. Mean age of study group was 51.1 years with 30.7% cases over the age of 60 years. Out of the total 75 cases undergoing Elective Off pump CABG, 54.7% were females and 45.3% were males. ASA grade II and III was seen in 84% and 16% cases undergoing Elective Off pump CABG.

On observing the difference between mean VAS and objective pain score, we observed that in majority of the cases the difference between pain scores was <5%. OPS slightly overestimates the pain in comparison to VAS score, the difference was more evident (>10%) in lower pain score values i.e. VAS <1. An excellent correlation (r value >0.8) was observed in majority of the readings between mean VAS and objective pain score, throughout the post-op follow up duration of 24 hours.

Till date very few studies have evaluated objective pain parameters or objective pain scales for assessment of acute or chronic pain [12]. compared the 4-point Objective Pain Score (OPS) to the Numeric Rating Scale (NRS) in order to confirm the OPS's efficacy in measuring immediate postoperative pain. A total of 1021 paired readings from 93 patients who had laparotomies and used patient-controlled analgesia were evaluated. The NRS and OPS reached a consensus over the entire spectrum of pain. There were a total of 25 instances of conflicts observed among a group of 8 patients. In all 25 instances, the choice to enhance pain relief favored the OPS method over the NRS method. The study determined that OPS readings were slightly higher than that of NRS (mean – 2.98 vs 2.23; median value – 3 vs 2) and is superior than the NRS in accurately characterising mild and moderate pain. It can also be employed to complement NRS in cases where it signifies mild or moderate discomfort. These findings are in accordance with present study data [13]. in another somewhat similar study compared objective Chronic Pain Behavioral Pain Scale for Adults (CBPS) and conventional NRS. The analysis of interrater reliability showed a moderate to good level of agreement between the CBPS scores of the nurse and researcher, with weighted kappa values of 0.59 and 0.65 for the pre- procedure and post-procedure assessments, respectively. The measurements showed a moderate positive correlation of 0.68 (95% CI 0.56–0.77) and 0.67 (95% CI 0.55– 0.77) between scores as observed by nurse and researcher. To summarize, present investigation found a strong association between the Objective Pain Score (OPS) and the Visual Analogue Scale. Both scores exhibited strong concordance across a broad spectrum of observations. The connection exhibited a considerably stronger association with higher values, specifically moderate to severe pain, compared to mild pain. Therefore, we can deduce that OPS, which relies on HR and MAP, is a user-friendly tool that does not cause any inconvenience to patients and requires just a little amount of extra time to administer. Nevertheless, due to the limited number of participants and the fact that they all belong to the same patient group, further research is necessary to confirm the effectiveness of this scale as an unbiased indicator of pain.

Summary

A hospital based observational study was conducted at Post op Cardiac surgery Recovery 1 and 2 in Fortis Escorts Heart Institute. Study aimed to formulate an OPS for evaluation of postoperative pain in patients undergoing Elective Off pump CABG. Consecutive type of non-probability sampling will be done in the study to include 75 patients undergoing Elective Off pump CABG under general anaesthesia at our hospital. Pain was assessed after extubation by VAS. The VAS score of Zero or no pain complain was achieved with titrated dose of Buprenorphine, Inj. Paracetamol, Buprigesic patch, which is a routine protocol in our CTVS ICU. For objective pain assessment, heart rate and MAP was monitored. Mean arterial pressure was measured invasively and heart rate was monitored using standard vital sign monitor (Phillips MP 20). Mean arterial blood pressure and heart rate during nil pain was noted as base line or zero point of OPS. VAS score was documented every 2 hours till 24 hours after extubation. Value of objective pain score (OPS) was noted from the chart according to the value of heart rate and mean blood pressure every 2 hour. The values of OPS were then correlated with that of VAS score. Following observations were made during the study:

- Mean age of study group was 51.1 years with 30.7% cases over the age of 60 years.
- Out of the total 75 cases undergoing Elective Off pump CABG, 54.7% were females and 45.3% were males.
- ASA grade II and III was seen in 84% and 16% cases undergoing Elective Off pump Coronary Artery Bypass Grafting Surgery (CABG).
- On observing the difference between mean VAS and objective pain score, we observed that in majority of the cases the difference between pain scores was <5%. OPS slightly overestimates the pain in comparison to VAS score, the difference was more evident (>10%) in lower pain score values i.e. VAS <1.
- An excellent correlation (r value >0.8) was observed in majority of the readings between mean VAS and objective pain score, throughout the post- op follow up duration of 24 hours.

Conclusion

Present study observed good correlation between Objective Pain Score (OPS) and Visual Analog Scale. Both the score showed good agreement over wide range of observations. When comparing moderate to severe pain to mild pain, the association was noticeably stronger for higher levels. Therefore, we draw the conclusion that OPS based on HR and MAP is a simple tool that requires little extra time to administer and causes little difficulty to patients. However, further research would be required to further establish the use of this scale as an objective measure of pain, given our limited sample size and homogeneous patient population.

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