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Association Between Surgical Apgar Score, Vital Parameters, And Post-Operative Complications In Adult General Surgical Procedures: A Prospective Observational Study

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Abstract
Background:
This Prospective Observational Study Aimed To Investigate The Relationship Between SAS And Various Parameters, Including Demographic Details, Surgical Characteristics, Complications, And Vital Parameters In Adult Patients Undergoing General Surgical Procedures.
Methods:
The Study Included 98 Adult Patients Who Underwent Intra-Abdominal Surgery At KCMCM Bharuch Between January 1, 2020, And December 31, 2022. Demographic Details, Surgical Characteristics, Vital Parameters (Lowest Heart Rate, Lowest Mean Arterial Pressure, Estimated Blood Loss), And Post-Operative Outcomes Were Collected. Surgical Apgar Score (SAS) Was Calculated Based On These Parameters, With Higher Scores Indicating Better Physiological Status. Statistical Analysis Was Performed Using Descriptive Statistics.
Results:
The Study Population Predominantly Comprised Middle-Aged Adults, With A Higher Proportion Of Males. Diabetes And Hypertension Were The Most Common Co-Morbidities. The Majority Of Surgeries Were Emergency Procedures, Lasting Less Than Or Equal To 120 Minutes. Post-Operative Outcomes Included No Complications, Major Complications (Such As Deep Surgical Site Infection And Renal Failure), And Non-Major Complications. A Significant Association Was Observed Between SAS And Major Complications, With Lower SAS Scores Correlating With A Higher Incidence Of Major Complications. Vital Parameters, Including Heart Rate, Mean Arterial Pressure, And Estimated Blood Loss, Showed Variations Across Different SAS Scores.
Conclusion:
This Study Highlights The Importance Of The Surgical Apgar Score In Predicting Post-Operative Complications In Adult Patients Undergoing General Surgical Procedures. Lower SAS Scores Were Associated With A Higher Incidence Of Major Complications. Vital Parameters Demonstrated A Correlation With SAS, Emphasizing The Relevance Of Monitoring And Optimizing Physiological Parameters During Surgery. Future Research Should Focus On Validating These Findings In Larger Cohorts And Exploring Interventions Targeting Specific Vital Parameters To Improve Surgical Outcomes.

Keywords: *Surgical Apgar Score, Post-Operative Complications, Vital Parameters, General Surgical Procedures, Prospective Observational Study.*

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I. Introduction

Intra-abdominal surgery is a common medical procedure performed worldwide to treat a variety of conditions affecting the abdominal cavity. It encompasses a range of surgical interventions, including organ resection, tumor removal, and repair of abdominal injuries. Annually, millions of individuals undergo intra-abdominal surgery, accounting for a substantial global prevalence of cases. However, despite advancements in surgical techniques and perioperative care, complications can arise following these surgeries, affecting a significant percentage of patients. The global incidence of complications after intra-abdominal surgery varies, with studies reporting rates ranging from 10% to 25% of cases, emphasizing the need for comprehensive data to assess and address the associated risks. (1) Furthermore, it is essential to examine the specific incidence of complications in India, where intra-abdominal surgery is most prevalent, and the percentage of complications differ based on local factors. (2) Post-operative mortality rates following intra-abdominal surgery remains a major

concern, as even with improvements in surgical practices, a certain percentage of patients still experience adverse outcomes.

Effective perioperative management of intra-abdominal surgery plays a critical role in minimizing the risk of complications, morbidity, and mortality. To aid in risk assessment and optimize patient outcomes, several risk scoring systems have been developed. These scoring systems aim to quantify the patient's preoperative condition, identify potential risks, and guide the healthcare team in making informed decisions. Also they play a crucial role in perioperative management of intra-abdominal surgery by aiding in risk stratification and identifying patients at higher risk of morbidity and mortality. (3)

American Society of Anesthesiologists (ASA) Physical Status Classification is one of the most widely used risk scoring systems that categorizes patients into classes based on their overall physical health and comorbidities. The classes range from ASA I (healthy patient) to ASA V (moribund patient). While this system provides a general assessment of the patient's health status, it may not account for specific surgical risks or the patient's physiological reserve. (4) Charlson Comorbidity Index (CCI) is another risk scoring systems that assesses comorbidities and assigns a score based on the presence and severity of various medical conditions. It considers factors such as heart disease, diabetes, liver disease, and cancer. However, it does not account for the impact of specific comorbidities on surgical outcomes, and it does not include patient's functional status or the complexity of the surgical procedure. (5)

Surgical Apgar Score (SAS) is considered to be a promising tool as it evaluates intraoperative variables such as estimated blood loss, lowest mean arterial pressure, and lowest heart rate. By evaluating blood loss and hemodynamic stability, the SAS reflects the adequacy of tissue perfusion and oxygenation, which are vital for minimizing surgical stress and preventing complications. (6) SAS provides a simple and practical assessment of intraoperative risk and it primarily focuses on immediate intraoperative outcomes and does not account for preoperative or postoperative factors. There is still variability in its generalizability across different surgical specialties and its validation in larger prospective studies are warranted. Hence the objective of this study is to assess the predictive value of the Surgical Apgar Score (SAS) in determining the risk of postoperative complications in patients undergoing general surgical procedures, with a specific focus on intra-abdominal surgery. The study aims to evaluate the association between SAS scores and the occurrence of postoperative complications, including Anastomatic Leak, deep SSI, organ failure and mortality. By analyzing the SAS as a predictive tool, the study seeks to provide valuable insights into the clinical utility and reliability of SAS in risk stratification and improving perioperative management for patients undergoing intra-abdominal surgery.

II. Material and Methods

Study Design:

This study was designed as a prospective observational study conducted at KCMCM Bharuch, focusing on adult patients undergoing emergency and elective general surgical procedures.

Study Population:

The study included all adult patients who underwent intra-abdominal surgery under general epidural or spinal anesthesia. The study period spanned from January 1, 2020, to December 31, 2022. Patients who underwent surgeries under local anesthesia without intensive monitoring and follow-up were excluded. The sample size comprised 98 patients admitted to Kiran C Patel Medical College and Research Institute and Hospital.

Data Collection:

Intraoperative data was collected, including the lowest heart rate, lowest mean arterial pressure (MAP), and blood loss. The Surgical Apgar Score (SAS) was calculated based on these intraoperative parameters. The SAS is determined by assigning points (0-2) for each parameter, with a higher score indicating better physiological status. Patients were classified into three risk groups based on their SAS scores: low risk (8-10), medium risk (5-7), and high risk (0-4).

Patient Characteristics:

Patient characteristics such as age, sex, type of surgery (emergency or elective), and ASA (American Society of Anesthesiologists) class were obtained and recorded. ASA class is a measure of a patient's overall health status, ranging from I (normal healthy patient) to V (moribund patient not expected to survive without surgery).

Follow-up and Outcome Measures:

Postoperative outcomes were followed up until 30 days after surgery. In-hospital postoperative major complications and mortality were recorded. The follow-up visits were scheduled on postoperative day 1, day 3,

day 5, and every other day until discharge, death, or the 30th postoperative day. Clinical notes were reviewed, and patient-reported symptoms were recorded to identify any postoperative complications or death.

Outcome Measures:

The main outcomes of the study were the development of major postoperative complications or death. Major complications were assessed based on clinical definitions, using the criteria defined by the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP). (7) These included pneumonia, deep surgical site infection, organ/space surgical site infection, wound dehiscence, acute kidney injury, cardiac arrest, anastomotic leak, unplanned intubation, septic shock, and Clavien class III and IV complications. (8)

Data Analysis:

Data were entered into EPI-DATA 4.2 and analyzed using STATA version 16. Descriptive statistics such as means, standard deviations, medians, interquartile ranges, and proportions were used to summarize the data.

III. Results:

A total of 98 patients participated in the study and their demographic details are presented in Table no: 1. The age distribution of the patients revealed that 7 (7.14%) were in the age group of 18-25 years, 10 (10.20%) were in the age group of 26-35 years, 46 (46.93%) were in the age group of 36-45 years, 20 (20.40%) were in the age group of 46-55 years, and 15 (15.30%) were in the age group of 56-60 years. In terms of gender 73 (74.49%) were male and 25 (25.51%) were female. Among the patients, 32 (32.65%) had diabetes, 30 (30.61%) had hypertension, 20 (20.40%) had hypertension, 10 (10.20%) had Asthma and COPD and 8 (8.16%) had renal failure. As per the findings majority of the patients were in the age group of 36-45 and higher proportion of male participant. In case of co-morbidity diabetes and hypertension were the most prevalent disease among the patients.

Table 1: Demographic details about the patients

Parameter	**No. of Patients N (%)**
Age	
18-25	7 (7.14)
26-35	10 (10.20)
36-45	46 (46.93)
46-55	20 (20.40)
56-60	15 (15.30)
Gender	
Male	73 (74.49)
Female	25 (25.51)
Co-Morbidity	
Diabetes	32 (32.65)
Hypertension	30 (30.61)
Cardiac Disease	20 (20.40)
Asthma	10 (10.20)
Chronic Obstructive Pulmonary Disease	10 (10.20)
Renal Failure	8 (8.16)

Table 2 presents the characteristics of the operations performed and the corresponding outcomes. Out of the total patients 77 (78.57%) underwent emergency operation and 21 (21.43%) underwent elective operations. Regarding the duration of operation, 69 (70.40%) operation lasted less than or equal to 120 minutes while 29 (29.60%) lasted longer than 120 minutes. The most common type of operation performed was verseus perforation (29.59%) followed by Cholecystectomy (21.42%) and intestinal obstruction (18.36%). Other operation performed were gangrenous bowel (8.16%), Anastomatic leak (9.18%), Peritonitis (3.08%). The outcomes following the surgeries varied among the patients. The majority of patients (52.04%) experienced no complications. However, [14.28%] of patients unfortunately experienced death, while others experienced complications such as deep surgical site infection (12.24%), renal failure (18.36%), anastomatic leak (8.16%), aspiration (3.06%), cardiac failure (2.04%), and multiple organ dysfunction (6.12%).

Table 2: Characteristics of operation performed and the corresponding outcomes

Parameter	**No. of Patients N (%)**
Nature of Operation	
Emergency	77 (78.57)
Elective	21 (21.43)
Duration of Operation	
Less than or equal to 120 minutes	69 (70.40)
Longer than 120 minutes	29 (29.60)
Type of Operation	
Verseus Perforation	29 (29.59)
Intestinal Obstruction	18 (18.36)
Gangrenous Bowel	8 (8.16)
Anastomatic Leak	9 (9.18)
Peritonitis	3 (3.08)
Perforated Appendicitis	10 (10.20)
Cholecystectomy	21 (21.42)
Post-Operative Outcomes	
No Complication	51 (52.04)
Death	14 (14.28)
Deep Surgical Site Infection	12 (12.24)
Renal Failure	18 (18.36)
Anastomatic Leak	8 (8.16)
Aspiration	3 (3.06)
Cardiac Failure	2 (2.04)
Multiple Organ Dysfunction	6 (6.12)

Figure 1 represents the relationship between age and three different rates: recovery rate, complication rate, and death rate. The graph uses three coloured lines to depict these rates. The blue line represents the recovery rate, indicating the percentage of patients who successfully recovered from the surgical procedures. As age increases, the recovery rate generally shows a decreasing trend. This suggests that older patients may have a slightly lower likelihood of complete recovery compared to younger patients. The orange line represents the complication rate, which represents the percentage of patients who experienced post-operative complications. The graph indicates that the complication rate tends to increase with age. This implies that older patients may have a higher risk of developing complications following the surgical procedures. The grey line represents the death rate, indicating the percentage of patients who unfortunately passed away after the surgery. Similar to the complication rate, the death rate also shows an upward trend with increasing age. This indicates that older patients have a higher likelihood of mortality following the surgical procedures.

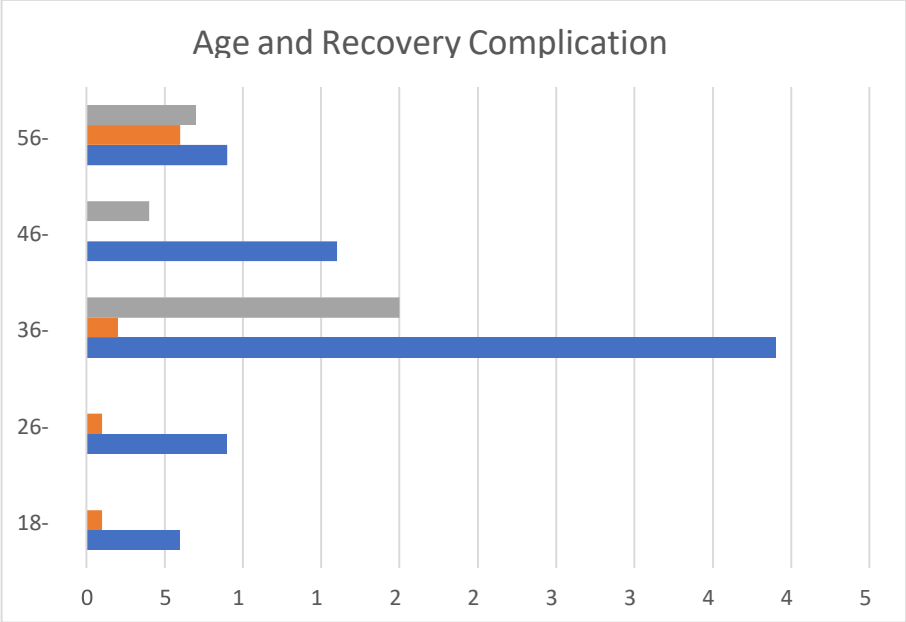

Figure 1: Age and Recovery Complication Deaths
Blue Line- Recovery Rate, Orange- Complication Rate, Grey- Death Rate

Table 3 represents the relationship between surgical apgar score and complications. The complications were divided in to two categories: major complications and minor complications. Total of 39 patients had major complications while 59 patients had minor complications. In case of major complications, 11 (28.20%) patients had 0-2 surgical apgar score, 20 (51%) had 3-4 score, 1 (2.56%) patient in each had 5-6 and 7-8 surgical apgar score. In case of non-major complications, 51 (86%) patients had surgical apgar score 5-6 while 6 (10.16%) patients had 7-8 and 2 (3.84%) had 9-10 surgical apgar score.

Table 3: Relationship between Surgical Apgar score and Complication

Surgical Apgar Score	**No of Complication (%)**
Major Complications	
0-2	11 (28.20)
3-4	20 (51)
5-6	1 (2.56)
7-8	1 (2.56)
Total	39 (100)
Non-Major Complications	
5-6	51 (86)
7-8	6 (10.16)
9-10	2 (3.84)
Total	59 (100)

The study investigated the relationship between Surgical Apgar Score and several key factors during surgery shown in Table no: 4. Analysis of the data revealed that the lowest heart rate recorded during the surgical procedure influenced the Surgical Apgar Score assigned to patients. Patients with a heart rate greater than 85 beats per minute (bpm) were categorized with a score of 0, while those with a heart rate ranging from 76 to 85 bpm received a score of 1. As the heart rate further decreased, the score increased, with 31.63% of patients falling in the 66-75 bpm category (score of 2), and 26.53% falling in the 56-65 bpm category (score of 3). A small proportion of patients, 10.20% each, had the lowest heart rate below 55 bpm, resulting in a score of 4. Another factor examined was the lowest mean arterial pressure (MAP) observed during the surgical procedure. Patients with a MAP falling within the range of 40-54 mmHg were assigned a score of 1, indicating compromised blood pressure. A larger proportion of patients, accounting for 45.91%, had a MAP ranging from 55-69 mmHg, corresponding to a score of 2. The highest score of 3 was assigned to patients with a MAP of 70 mmHg or higher, denoting a more favorable blood pressure status. Additionally, the estimated blood loss during surgery was considered in relation to the Surgical Apgar Score. Patients with blood loss exceeding 1000 milliliters (ml) received a score of 0, while those with a blood loss between 601-1000 ml were assigned a score of 1. A considerable percentage of patients, 37.75%, experienced a blood loss ranging from 101-601 ml, resulting in a score of 2. On the other hand, the majority of patients (58.16%) had a blood loss equal to or below 100 ml, which was associated with the highest score of 3, indicating minimal blood loss during the procedure.

Table 4: Relationship between Surgical Apgar score and Vital Parameters

Surgical Apgar Score	**Points**	**No of Patients (%)**
Lowest Heart Rate		
Hear Rate		
>85	0	10 (10.20)
76 – 85	1	21 (21.42)
66 – 75	2	31 (31.63)
56 – 65	3	26 (26.53)
<55	4	10 (10.20)
Lowest Mean Arterial Pressure		
MAP		
40 – 54	1	2 (2.04)
55 – 69	2	45 (45.91)
≥ 70	3	51 (52.04)
Estimated Blood Loss		
Blood Loss in ml		

>1000	0	2 (2.04)
601 – 1000	1	2 (2.04)
101 – 601	2	37 (37.75)
≤ 100	3	57 (58.16)

The data presented in Table 5 represents the distribution of the Total Surgical Apgar Score. A total of 11 cases, accounting for 11.22% of the sample, had a Total Surgical Apgar Score ranging from 0 to 2. There were 20 cases, representing 20.40% of the sample, with a score falling within the range of 3 to 4. Eight cases, making up 8.16% of the sample, had a score between 5 and 6. Additionally, 14 cases, accounting for 14.28% of the sample, received a score within the range of 7 to 8. The majority of cases, 45 in total, had a Total Surgical Apgar Score ranging from 9 to 10, representing the highest proportion at 45.91% of the sample. These results indicate that the majority of patients in the study had Total Surgical Apgar Scores of 9 to 10, suggesting relatively positive surgical outcomes. However, it is worth noting that there were also cases with lower scores, indicating a higher risk of complications or poorer surgical performance. Overall, the distribution of Total Surgical Apgar Scores provides valuable information for assessing the overall surgical quality and outcomes in the study population.

Table 5: Total Surgical Apgar Score

Score	**Frequency**
0 – 2	11 (11.22)
3 – 4	20 (20.40)
5 – 6	8 (8.16)
7 – 8	14 (14.28)
9 – 10	45 (45.91)

IV. Discussion

The Surgical Apgar Score (SAS) is a valuable tool used to assess the physiological status of patients undergoing surgery and has been shown to have prognostic value in predicting postoperative complications and mortality. It is calculated based on three intraoperative parameters: lowest heart rate, lowest mean arterial pressure (MAP), and estimated blood loss. The SAS assigns points (0-2) for each parameter, with a higher score indicating better physiological status. By categorizing patients into risk groups based on their SAS scores, clinicians can identify those at higher risk of developing complications and experiencing adverse outcomes. In our study, we collected data from a total of 98 adult patients undergoing intra-abdominal surgery under general epidural or spinal anesthesia. The demographic details of the patients revealed a diverse age distribution, with the majority falling in the age range of 36-45 years (46.93%). As the study was carried out in a single centre, we had a higher proportion of younger population compared to earlier reported study. (9, 10) The gender distribution showed a higher proportion of male patients (74.49%) compared to females (25.51%). These findings align with general trends observed in surgical patient populations. (11).

Co-morbidities play a crucial role in determining surgical outcomes, and in our study, we assessed the presence of various co-morbid conditions among the patients. Patient's with higher degree of comorbidity has a strong and independent impact on the postoperative outcomes following surgery and the odd ratio of dying within 90 days after surgery is 8 times greater in patients with a high comorbidity score. (12) The most prevalent co-morbidities were diabetes (32.65%) and hypertension (30.61%), followed by cardiac disease (20.40%), asthma (10.20%), chronic obstructive pulmonary disease (10.20%), and renal failure (8.16%). These co-morbidities are known to increase the risk of complications and can impact the overall health status of patients. Consistent results were obtained in previous studies which has identified diabetes and hypertension as the most prevalent comorbid condition among the patient population and significant risk factors for adverse surgical outcomes. (13, 14)

Regarding the operation characteristics, we found that a large proportion of surgeries in present study were performed as emergency procedures (78.57%) compared to elective surgeries (21.43%). Moreover, the majority of operations had a duration of less than or equal to 120 minutes (70.40%). In terms of the type of operation, the most common procedures included verseus perforation (29.59%), intestinal obstruction (18.36%), and cholecystectomy (21.42%). These findings are consistent with the literature, which has reported a higher prevalence of emergency surgeries and specific surgical indications such as perforation and obstruction. (15, 16)

In present study, we also evaluated the post-operative outcomes in terms of complications and mortality. Among the patients, 52.04% experienced no complications, while 14.28% succumbed to mortality. Other notable post-operative complications included deep surgical site infection (12.24%), renal failure (18.36%), and anastomotic leak (8.16%). These findings are similar to previous studies that have highlighted the occurrence of

similar complications such as infection, renal failure, and anastomotic leak following surgery that increases the risk of mortality among patients. (17, 18)

In this study, the relationship between the Surgical Apgar Score and the occurrence of complications was investigated and the results demonstrated a clear association between the Surgical Apgar Score and the incidence of both major and non-major complications. On analyzing major complications, which are typically more severe and impactful, it was observed that patients with lower Surgical Apgar Scores (0-2) had a higher proportion of complications (28.20%). As the Surgical Apgar Score increased, the occurrence of major complications decreased, with 51% of patients with a score of 3-4 experiencing complications. (19) Only a small proportion of patients with scores of 5-6 (2.56%) or 7-8 (2.56%) had major complications. These findings suggest a strong inverse relationship between the Surgical Apgar Score and the likelihood of major post-operative complications. In contrast, when examining non-major complications, which are generally less severe but still impactful, the distribution of complications differed. The majority of patients with a Surgical Apgar Score of 5-6 (86%) experienced non-major complications. The occurrence of non-major complications decreased among patients with higher Surgical Apgar Scores, with 10.16% of patients with a score of 7-8 and 3.84% of patients with a score of 9-10 experiencing such complications. This indicates a similar trend of decreasing non-major complications as the Surgical Apgar Score improves, although there is a higher prevalence of non-major complications overall compared to major complications. The results of this study align with previous research investigating the relationship between the Surgical Apgar Score and complications. Several studies have demonstrated that a lower Surgical Apgar Score is associated with an increased risk of complications, including major adverse events and surgical site infections. (20, 21)

The study examined the relationship between the Surgical Apgar Score and vital parameters, including lowest heart rate, lowest mean arterial pressure (MAP), and estimated blood loss. The findings revealed a clear associations between the Surgical Apgar Score and these parameters. The lowest heart rate decreased as the Surgical Apgar Score increased, indicating that patients with better outcomes had lower heart rates during surgery. Similarly, higher Surgical Apgar Scores were linked to higher mean arterial pressures, suggesting improved outcomes with higher pressures. Additionally, as the Surgical Apgar Score increased, estimated blood loss decreased, indicating a correlation between better outcomes and lower blood loss. An inverse relationship was observed between the Surgical Apgar Score and the lowest heart rate and blood loss suggests that patients with better intraoperative conditions, as reflected by higher scores, tend to have lower heart rates and experience less blood loss. In contrast, the positive relationship between the Surgical Apgar Score and the lowest mean arterial pressure indicates that patients with better surgical outcomes tend to have higher mean arterial pressures during the operation. Consistent trend in Apgar score was observed in previous study as well confirming the validity of the scoring system. (22, 23)

V. Conclusion

Surgical Apgar Score serves as a valuable tool in assessing surgical outcomes and predicting post-operative complications. This study demonstrated significant associations between the Surgical Apgar Score and various parameters, including complications, vital parameters (such as heart rate, mean arterial pressure), and estimated blood loss. The findings highlight the importance of optimizing surgical performance and monitoring vital parameters during surgery to improve patient outcomes. Relatively lower sample size may limit the generalizability of our findings. However, a larger, multicenter study focused on specific patient population would provide more robust evidence.

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