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Original Research

Management of Placenta Accreta Spectrum in a High-Risk Saudi Cohort: A Retrospective Clinical Audit of a Standardized Multidisciplinary Management Protocol

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Abstract

Background: Placenta accreta spectrum (PAS) is a serious obstetric complication with an increasing prevalence. This retrospective study evaluated a multidisciplinary management protocol in Saudi Arabia to assess clinical outcomes associated with a risk-stratified approach in high-risk pregnancies. **Methods:** This retrospective clinical audit reviewed 36 cases of prenatally diagnosed PAS managed at King Khalid University Hospital between 2021 and 2025. Data were collected to evaluate the implementation of a standardized multidisciplinary management protocol involving obstetrics, gynecologic oncology, anesthesia, and the blood bank for the care of high-risk patients. Clinical outcomes, including massive transfusion protocol (MTP) activation, surgical morbidity, and intensive care unit (ICU) utilization, were audited to assess the pathway's effectiveness across varying levels of surgical complexity. **Results:** The cohort (median age, 37.5 years) presented with a significant obstetric risk profile, with 75% having undergone two or more prior Cesarean sections (CSs). The audit identified the number of prior CSs as an important indicator of surgical complexity, with high-complexity cases (≥3 prior CS) showing higher median blood loss (2.80 L vs. 1.90 L) and an increased proportion of MTP activation (15.8% vs. 11.8%). Furthermore, anesthetic management was successfully risk-stratified, with general anesthesia (GA) utilized for more complex cases to optimize hemodynamic control. Despite these differences in clinical acuity, the protocol was associated with stable quality of care, showing no significant differences in transfusion requirements or ICU admissions between anesthetic groups ($p > 0.05$). **Conclusions:** This study suggests that the management of PAS benefits from a shift from reactive, emergency-based interventions to a proactive, multidisciplinary approach. By prioritizing elective surgical planning, standardized imaging, and coordinated multidisciplinary involvement, institutions standardized clinical management pathways for high-risk patients. These descriptive observations serve as a preliminary institutional framework for enhancing proactive resource allocation within high-risk obstetric populations.

Keywords: placenta accreta spectrum; cesarean sections; clinical audit; multidisciplinary care; maternal outcomes; institutional protocol

1. Introduction

Placenta accreta spectrum (PAS) disorders represent one of the most challenging complications in contemporary obstetrics, defined by the abnormal and invasive attachment of the placenta to the uterine myometrium [1]. Once considered rare, the global incidence of PAS has increased significantly over recent decades, paralleling the worldwide rise in Cesarean section (CS) rates [2]. This condition is a major cause of severe maternal morbidity, often leading to devastating, life-threatening hemorrhage during the peripartum period [3]. As a result, the management of PAS requires extensive healthcare resources, including large-volume blood transfusions, urgent surgical procedures, and specialized intensive care support [4].

In Saudi Arabia, the burden of PAS has increased markedly, with increased Cesarean section rates [5]. Regional data highlight this crisis. A decade-long study by AlQasem et al. [6] found that 30.5% of patients with major placenta previa showed evidence of PAS on antenatal imaging. Additional studies from major centers, including a 13-year review by Abduljabbar and baseline data from

Mansour, documented similar rates of complex placental abnormalities [7,8]. These cases often require emergency hysterectomy and intensive care, emphasizing the growing burden on the healthcare system.

The modern management of PAS relies on a multidisciplinary approach involving obstetricians, anesthesiologists, neonatologists, and interventional radiologists [9]. Early prenatal diagnosis with advanced ultrasonography and magnetic resonance imaging (MRI) facilitates the assessment of placental invasion, allowing clinicians to plan specialized perioperative strategies [10]. These include balancing traditional CS hysterectomy with conservative, uterine-preserving techniques, while selecting appropriate anesthetic modality, such as neuraxial or general anesthesia, to ensure maternal hemodynamic stability and minimize blood loss [11].

This study aimed to comprehensively analyze the prenatal diagnosis, anesthetic management, and surgical intervention for PAS disorders at King Khalid University Hospital. Utilizing a retrospective institutional dataset, we evaluated maternal clinical risk factors, blood transfusion requirements, perioperative complications, and immediate neonatal outcomes to optimize multidisciplinary management care pathways and improve safety profiles for high-risk obstetric patients.

2. Patients and Methods

2.1 Study Design and Setting

A retrospective clinical audit was conducted at King Khalid University Hospital, a tertiary referral center in Riyadh, Saudi Arabia. In this setting, a retrospective clinical audit was used as a quality improvement methodology to assess previous clinical performance against predefined components of the institutional standardized care pathway. The study examined the reliability with which care delivery adhered to the standardized, multidisciplinary institutional PAS protocol from January 2021 to December 2025. The study was approved by the King Saud University Medical City Institutional Review Board (IRB No.: 26-437), and the requirement for informed consent was waived due to the use of de-identified, retrospective data.

To evaluate protocol implementation across varying levels of surgical complexity, the audit focused on four core operational elements of the institutional care pathway:

Preoperative Optimization: Standardized placental mapping with ultrasound (US) or MRI, pre-incision placement of invasive monitoring devices (radial arterial catheters and central venous catheters) in high-acuity cases, and the availability of 6 units of cross-matched packed red blood cells (PRBCs) and 6 units of fresh frozen plasma (FFP) in the operating room before anesthesia induction.

Anesthetic Stratification: Clinical triage and selection of the main anesthesia method (either GA with rapid sequence induction [RSI] or neuraxial anesthesia with conversion to GA when required) based on preoperative disease severity markers and the extent of myometrial invasion.

Hemostatic and Fluid Resuscitation: Following the real-time viscoelastic testing protocol, rotational thromboelastometry/thromboelastography (ROTEM/TEG) instead of empirical volume replacement, including a standard dose of 1 g tranexamic acid (TXA) before skin incision (with a second dose if blood loss exceeds 1.5 L), and a standardized approach to fibrinogen replacement and correction of systemic ionized calcium levels.

Postoperative Disposition: Assessment of postoperative transfer to the intensive care unit (ICU) or high-dependency unit (HDU), implementation of regional nerve blocks (transversus abdominis plane/quadratus lumborum [TAP/QL]) for opioid-sparing multimodal pain management, and following objective criteria for safe delayed extubation.

2.2 Inclusion and Exclusion Criteria

All obstetric patients with a clinical, intraoperative, or histopathological diagnosis of PAS who delivered at or after 24 weeks of gestation during the study period were screened. To ensure diagnostic consistency, all cases were classified and graded according to the International Federation of Gynecology and Obstetrics (FIGO) consensus guidelines for PAS [12]. Diagnostic confirmation required either: (1) macroscopic intraoperative grading of tissue restructuring during direct uterine exposure in cases undergoing conservative management, or (2) definitive histopathological confirmation of chorionic villi directly invading the myometrium in cases undergoing planned or emergency Cesarean hysterectomy. Patients were included if PAS was confirmed by at least one of these standardized diagnostic criteria.

2.3 Data Extraction and Variables Assessed

Maternal clinical characteristics, prenatal findings, anesthetic management, and neonatal outcome data were systematically extracted from the institutional electronic health documentation system and recorded using a standardized data extraction template. Variables were organized into four core domains.

2.3.1 Maternal Demographics and Risk Factors

Maternal age (years), nationality, gravidity, parity, body mass index (BMI) at delivery (kg/m^2), prior CSs, and history of uterine surgeries such as dilation and curettage (D&C).

2.3.2 Prenatal and Diagnostic Data

Gestational age at delivery (weeks + days), presence of placenta previa, prenatal US markers indicative of PAS (e.g., loss of retroplacental zone, placental lacuna hypervascularity on color Doppler), MRI performance, and specific MRI findings.

2.3.3 Perioperative, Obstetric, and Anesthetic Management

Anesthesia type (general or neuraxial), timing of delivery (elective or emergency CS), primary surgical approach (Cesarean hysterectomy or conservative techniques), uterine incision type (lower segment or classical), use of uterotonics, TXA, activation of massive transfusion protocol (MTP), conservative surgical procedures (e.g., internal iliac artery or uterine artery ligation), and total operative time (min). Furthermore, surgical complexity was evaluated beyond prior uterine incisions by recording specific anatomical and invasion characteristics, including the depth of placental penetration (accreta, increta, or percreta) and the presence of gross intraoperative visceral involvement (e.g., direct bladder or parametrial invasion).

2.3.4 Safety and Neonatal Outcomes

Postpartum hemorrhage (PPH) diagnosis, estimated blood loss (EBL, L), blood transfusions (units of PRBCs), intraoperative complications (e.g., bladder injury), postoperative complications, maternal ICU admission and stay (days), total postpartum hospital stay (days), and maternal mortality. Neonatal outcomes included birth weight (grams), Apgar scores at 1 and 5 min, neonatal intensive care unit (NICU) admission, and perinatal mortality.

2.4 Institutional PAS Management and Anesthetic Protocol

All patients with PAS were managed according to a standardized, multidisciplinary protocol involving four core specialties throughout the perioperative period. The Maternal-Fetal Medicine and Obstetrics team handled prenatal screening, US evaluation, and scheduled elective delivery between 34+0 and 35+6 weeks, while coordinating activation of the multidisciplinary surgical team as needed. The Gynecologic Oncology and Placenta Accreta team served as the primary surgical unit, managing pelvic dissections, performing planned Cesarean hysterectomies or uterine-sparing vascular ligation procedures, as well as addressing complex bladder or visceral dissections. The Obstetric Anesthesia team established pre-incision invasive arterial and venous monitoring, selected the anesthetic technique based on risk (GA with rapid induction or neuraxial anesthesia), and directed postoperative pain management. The Transfusion Medicine and Blood Bank team ensured immediate access to uncrossed-matched blood products and cross-matched 6 units of PRBCs and FFP before surgery, adjusting blood component replacement in real time guided by viscoelastic testing.

2.4.1 Preoperative Optimization and Resource Allocation

The anesthesia team performed comprehensive preoperative assessments. Preoperative care adhered to standardized clinical protocols. Most of the patients underwent standardized placental mapping with US and topographic MRI. High-acuity cases exhibited invasive monitoring lines and large-bore access established before induction. Before surgery, the attending team confirmed the availability of the required blood products and essential perioperative resources.

To maximize clinical reproducibility, the management of patients with suspected PAS followed a standardized, sequential multidisciplinary workflow. The key decision nodes, referral thresholds, and structural pathways are organized in Fig. 1.

2.4.2 Anesthetic Management

GA with rapid sequence induction (RSI) was the main approach used to ensure airway protection, manage abdominal movement during complex pelvic surgery, and allow for robust hemodynamic control. Induction involved propofol or etomidate, combined with neuromuscular blockade from succinylcholine or high-dose rocuronium. Maintenance employed a balanced technique, limiting volatile anesthetic gases to $\leq$0.5 minimum alveolar concentration (MAC) before delivery to reduce the risk of uterine atony, followed by transition to a propofol-remifentanil infusion after delivery. Vasopressors like norepinephrine and phenylephrine were pre-loaded into smart infusion pumps for prompt, proactive blood pressure management.

2.4.3 Coagulation and Fluid Optimization Sequence

Resuscitation was directed by real-time viscoelastic profiles that were reviewed dynamically during active dissection. Fibrinogen concentrate, cryoprecipitate, and calcium chloride were administered to maintain specific physiological targets, together with structured dosing of TXA and strict regulation of core temperature.

2.4.4 Postoperative Disposition and Multimodal Analgesia

Following the surgical procedure, patients were moved straight to the ICU or high-dependency unit. Somatic analgesia was administered through regional nerve blocks to reduce the risks associated with neuraxial intervention, especially in cases of potential coagulopathy. Mechanical ventilation weaning was performed according to established hemodynamic and physiological extubation criteria.

2.4.5 Sample Size Justification

PAS is a rare and potentially life-threatening obstetric complication, making large-scale prospective studies challenging. Despite its low occurrence, this five-year retrospective review of 36 confirmed cases is a valuable cohort for a single tertiary referral hospital. Although the sample size limits the development of complex multivariable predictive models, it provides a thorough audit of the hospital's adherence to a high-risk, standardized multidisciplinary management protocol. These findings offer important insights into how advanced hemostatic resuscitation and anesthetic techniques are applied in real-world settings for high-risk obstetric patients.

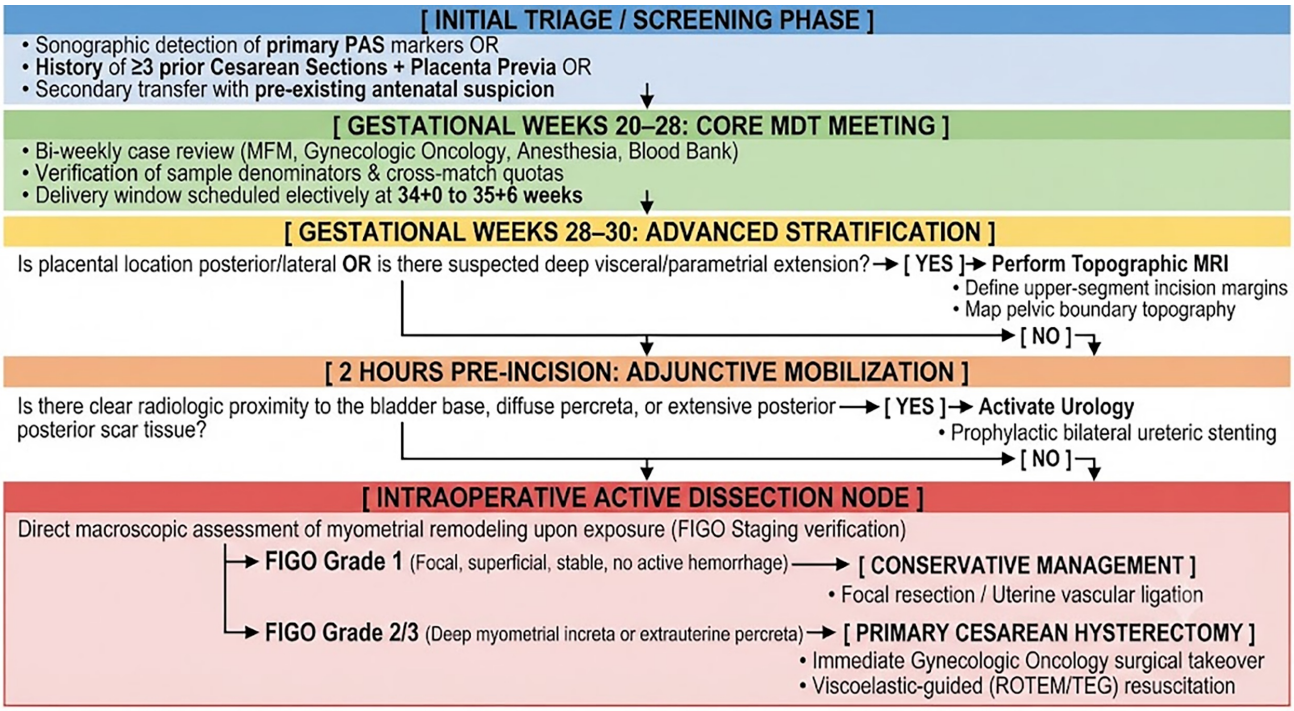

Fig. 1. Chronological clinical flowchart documenting the institutional standardized multidisciplinary management protocol for suspected PAS disorders. The workflow outlines referral thresholds, advanced imaging pathways, adjunctive urological mobilization, and the intraoperative decision-making tree driving uterine preservation versus definitive surgery. PAS, placenta accreta spectrum; MRI, magnetic resonance imaging; FIGO, International Federation of Gynecology and Obstetrics; ROTEM, rotational thromboelastometry; TEG, thromboelastography.

2.5 Data Analysis

Diagnostic Performance Evaluation: Standard diagnostic performance metrics (e.g., sensitivity, specificity, positive predictive value, and negative predictive value) were computed for each radiologic parameter based on the final intraoperative or histopathological confirmation. Nonetheless, since this cohort is a highly selected, high-risk tertiary referral population with an inherently high pretest probability of disease and no true-negative screening controls, these metrics are shown primarily for institutional diagnostic quality assessment rather than as measures of overall screening performance.

Comparative analyses of outcomes across anesthetic groups used independent *t*-tests and chi-square tests. Importantly, these univariate comparisons are inherently subject to confounding by indication, as anesthetic selection was driven primarily by baseline clinical acuity and suspected invasion depth rather than by random assignment. Due to the sample size constraints (n = 36), multivariable adjustment for this selection bias was precluded; hence, these comparative *p*-values are presented as descriptive institutional metrics rather than unconfounded measures of relative protocol efficacy.

Quantitative analysis was performed using IBM SPSS Statistics version 28.0 (IBM Corp., Armonk, NY, USA). Continuous variables (e.g., blood loss, operative time, and hospital stay) were assessed for normality with the Shapiro-Wilk test and Q-Q plots. Due to non-normality or skewness, data are summarized with median (interquartile range, IQR) and mean (± standard deviation, SD). Categorical variables (e.g., MTP activation, ICU admission, or visceral injuries) are presented as counts (n) and percentages (%). Comparisons between anesthetic groups (Primary GA vs. Successful Neuraxial) and surgical complexity (Standard-Risk vs. High-Complexity) used *t*-tests or Mann-Whitney U tests, depending on variance heterogeneity, as tested by Levene's test. Categorical differences were analyzed with Pearson's chi-square or Fisher's exact test when cell counts were low. All tests were two-tailed, with significance set at $p < 0.05$. Missing data were omitted during database filtering, requiring no imputation in the final analysis.

3. Results

3.1 Institutional PAS Volume and Incidence

Fig. 2 depicts the retrospective selection process at King Khalid University Hospital from 2021 to 2025. Out of 16,595 deliveries, 6188 (37.3%) involved CSs. Of these, 52 maternal records were identified via institutional registries and ICD codes for detailed review. After excluding 16 cases due to early gestation or incomplete clinical records, 36 patients with confirmed PAS were included in the final analysis.

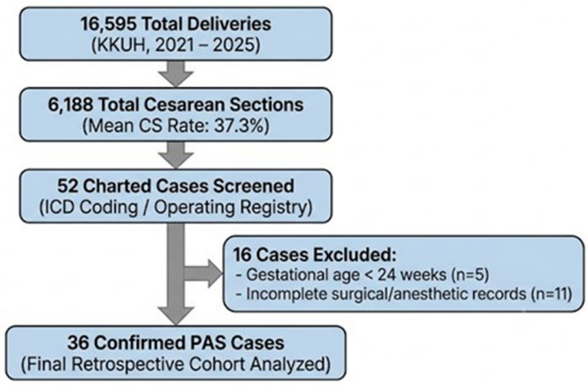

Fig. 2. Flowchart illustrating patient identification, screening, exclusion, and final cohort selection for the PAS study. KKUH, King Khalid University Hospital; CS, Cesarean section; ICD, International Classification of Diseases; PAS, placenta accreta spectrum.

Severity Profile Matrix: Stratification of the final cohort (n = 36) according to the FIGO clinical and histopathological classification revealed a high-acuity distribution of myometrial invasion. Superficial placenta accreta (FIGO Grade 1) was confirmed in 44.4% (n = 16) of cases, deep placenta increta (FIGO Grade 2) in 27.8% (n = 10), and advanced placenta percreta (FIGO Grade 3) in 13.9% (n = 5). For the remaining 13.9% (n = 5) of the cohort, definitive macroscopic clinical staging was documented intraoperatively, while formal histopathological processing was omitted ("not done") due to successful conservative uterine preservation with zero local myometrial tissue excision. Fig. 3 shows the growing institutional burden of PAS cases at King Khalid University Hospital over the five-year study (2021–2025). During this period, the annual CS rate rose from 31.0% to 41.3%, while the institutional incidence of PAS increased from 1.06 to 3.70 cases per 1000 deliveries. These temporal trends highlight the need for a standardized, multidisciplinary management protocol, as the increasing case complexity demands more institutional resources and specialized obstetric care.

3.2 Patient Profiles and Clinical Utilization of Prenatal Imaging

Table 1 summarizes the clinical and obstetric profiles of the 36 patients included in this study. The cohort was characterized by advanced maternal age (median, 37.5 years), high parity (median, 4), and a significant history of uterine procedures, with 75.0% of patients having undergone two or more previous CSs. Placenta previa was present in 91.7% of cases, reflecting the high surgical complexity of the cohort. Overall, these findings show that our tertiary center primarily manages a high-risk, multiparous patient population, supporting the need for extensive multidisciplinary resources and proactive, risk-stratified management tailored to this patient group.

Table 1. Clinical characteristics of the PAS cohort (n = 36).

Characteristic	Value
Maternal age, years, median (IQR)	37.5 (23–44)
Nationality, n (%)	
Saudi	33 (91.7%)
Non-Saudi	3 (8.3%)
Gravidity, median (IQR)	5 (1–12)
Parity, median (IQR)	4 (0–9)
Gestational age at delivery, weeks, mean ± SD	35.3 ± 1.3
Preterm birth <37 weeks, n (%)	31 (86.1%)
Term birth ≥37 weeks, n (%)	5 (13.9%)
Placenta previa, n (%)	
Yes	33 (91.7%)
No	3 (8.3%)
History of D&C, n (%)	
Yes	6 (16.7%)
No	30 (83.3%)
Prior CS, n (%)	
0	4 (11.1%)
1	5 (13.9%)
2	8 (22.2%)
3	6 (16.7%)
4	9 (25%)
≥5	4 (11.1%)

CS, Cesarean section; IQR, interquartile range.

Table 2a details the agreement between prenatal imaging findings and the final intraoperative or histopathological diagnosis. In this cohort, US markers and MRI showed inconsistent sensitivity and specificity, highlighting the challenges of preoperatively evaluating placental invasion depth in complex cases. Due to these limitations, our institutional management protocol does not rely on a single imaging method. Instead, prenatal imaging was used as an initial screening tool to facilitate multidisciplinary preoperative planning. Final surgical strategies were primarily based on intraoperative findings and real-time clinical judgment. This emphasizes the importance of a standardized, high-acuity surgical protocol applicable for all levels of placental invasion, regardless of preoperative imaging findings.

Histopathological Stratification and Operational Protocol Correlations

Cross-tabulation of these pathologically confirmed and clinically staged FIGO categories with preoperative acuity indicators and maternal clinical characteristics revealed distinct profiles across the cohort (Table 2b). Greater placental invasion depth was strongly associated with repeated uterine scarring. Among patients with placenta percreta, 60.0% (n = 3/5) had a history of ≥3 CSs, compared with 70.0% (n = 7/10) of those with placenta increta. Furthermore, severe anatomical morbidity lines, including intraoperative bladder injury and MTP activations,

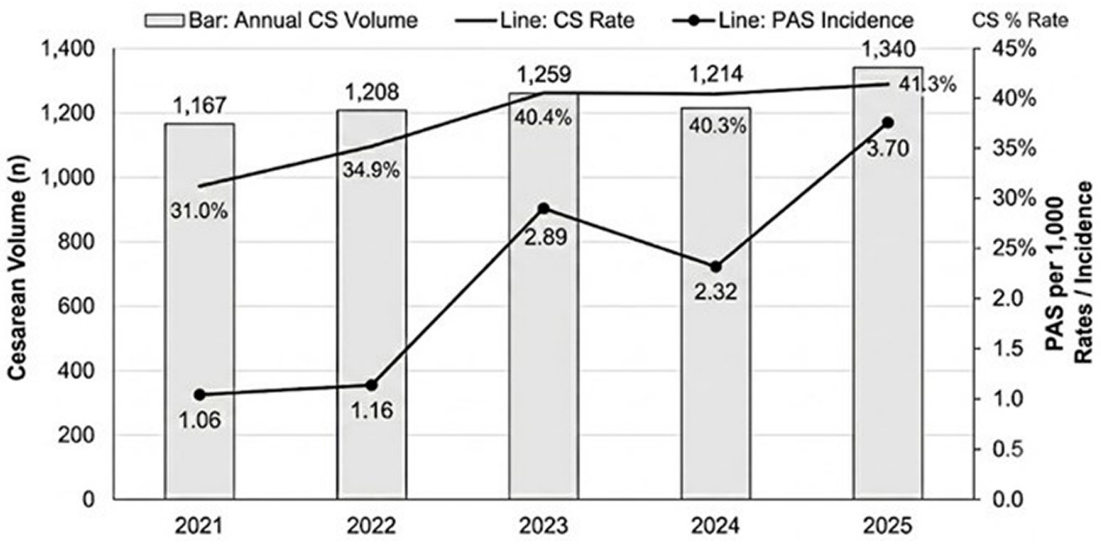

Fig. 3. Annual trends in CS volume and rate in relation to PAS incidence per 1000 deliveries (2021–2025). CS, Cesarean section; PAS, placenta accreta spectrum.

Table 2a. Clinical utilization of prenatal imaging in surgical planning.

Imaging parameter	Available (n)	Sensitivity	Specificity	PPV	NPV
Loss of clear zone	11	100.00%	0.00%	90.91%	0.00%
Abnormal lacunae	6	100.00%	0.00%	83.33%	0.00%
Color Doppler hypervascularity	19	69.23%	33.33%	69.23%	33.33%
Prenatal MRI interpretation	29	86.36%	14.29%	76.00%	25.00%

PPV, Positive Predictive Value; NPV, Negative Predictive Value; MRI, magnetic resonance imaging.

were highly correlated with deeper placental invasion. In contrast, successful primary regional blocks and conservative uterine preservation were predominantly observed in patients with superficial placenta accreta or those without histopathological confirmation.

3.3 Anesthetic Stratification and Clinical Outcomes

Table 3 presents maternal clinical outcomes based on the institution's risk-based anesthetic management strategy. At our tertiary center, anesthetic choices are tailored to disease severity, with GA being favored for patients with suspected deep myometrial invasion or significant uterine scarring, whereas neuraxial anesthesia is used for lower-risk cases. Although GA was employed for the more complex cases, our standardized, multidisciplinary protocol ensured that key outcomes, including EBL, transfusion needs, and ICU admission rates, did not differ significantly between groups. These data indicate that care delivery remained highly consistent across the audited risk levels. However, given the retrospective, single-arm nature of this clinical audit, these findings reflect protocol standardization rather than a demonstrable reduction in baseline maternal morbidity.

As detailed in Table 3, median clinical indicators tracked lower than their respective means, reflecting the typical right-skewness of high-acuity surgical data. The median EBL was 2.50 L (IQR: 1.50–4.25 L) in the primary GA cohort versus 2.10 L (IQR: 1.50–3.75 L) in the successful neuraxial group. Similarly, the median transfusion burden was 3.0 units vs. 2.0 units, respectively, demonstrating stable distribution parameters across both groups ($p > 0.05$). Proportional categorical distributions for low-frequency outcomes, including maternal ICU admission (n = 1, 8.3%) and MTP activation (n = 1, 8.3%) within the regional cohort, were evaluated using Fisher's exact test. No statistically significant differences were identified despite the baseline clinical differences between groups.

One additional patient initially managed with neuraxial anesthesia required intraoperative conversion to GA due to progressive surgical extension. To avoid confounding the primary anesthetic group comparison, this case was excluded from the main analysis and reported descriptively. The patient had an EBL of 4.0 L, required transfusion of 8 units of PRBCs, had a total operative time of 110 min, and required immediate postoperative maternal ICU admission.

Patients with 0 to 1 prior CS were divided between the primary GA group (21.7%) and the successful neuraxial anesthesia group (33.3%, n = 4/12). Those with 2 to 3 previous CSs comprised 30.4% of the primary GA group and 50.0% of the successful neuraxial group (n = 6/12). Pa-

Table 2b. Pathological depth correlations with surgical triage and clinical outcomes (n = 36).

Clinical and outcome parameters	Placenta accreta pathology (n = 16)	Placenta increta pathology (n = 10)	Placenta percreta pathology (n = 5)	Histopathology not available (n = 5)
Primary surgical approach, n (%)				
Cesarean hysterectomy	15 (93.8%)	10 (100.0%)	5 (100.0%)	0 (0.0%)
Conservative management	1 (6.2%)	0 (0.0%)	0 (0.0%)	5 (100.0%)
Surgical complexity stratum, n (%)				
Standard-risk (0–2 prior CS)	6 (37.5%)	3 (30.0%)	2 (40.0%)	3 (60.0%)
High-complexity (≥3 prior CS)	10 (62.5%)	7 (70.0%)	3 (60.0%)	2 (40.0%)
Anesthetic triage choice, n (%)				
Primary GA	11 (68.8%)	8 (80.0%)	4 (80.0%)	0 (0.0%)
Neuraxial (spinal/epidural)	5 (31.2%)	2 (20.0%)	1 (20.0%)	5 (100.0%)
Key clinical outliers, n (%)				
Intraoperative bladder injury	5 (31.3%)	1 (10.0%)	5 (100.0%)	0 (0.0%)
MTP	2 (12.5%)	2 (20.0%)	1 (20.0%)	0 (0.0%)
Immediate maternal ICU admission	2 (12.5%)	2 (20.0%)	2 (40.0%)	0 (0.0%)

ICU, intensive care unit; GA, general anesthesia; MTP, massive transfusion protocol.

Table 3. Clinical outcomes stratified by anesthetic management strategy (n = 36).

Clinical parameter	Primary GA (n = 23)	Successful neuraxial anesthesia (n = 12)	*p*-value
EBL (L), median (IQR)	2.50 (1.50–4.25)	2.10 (1.50–3.75)	0.481a
PRBC transfused units, median (IQR)	3.0 (2.0–6.5)	2.0 (0.0–5.0)	0.299a
MTP, n (%)	4 (17.4%)	1 (8.3%)	0.621b
Total operative time, min, median (IQR)	150.0 (110.0–210.0)	135.0 (97.5–182.5)	0.378a
Immediate maternal ICU admission, n (%)	5 (21.7%)	1 (8.3%)	0.384b
Total postoperative hospital stay, days, Median (IQR)	6.0 (4.0–10.5)	5.5 (4.0–9.0)	0.850a

a, *p*-value calculated using the non-parametric Mann-Whitney U test to protect against non-normal, right-skewed clinical distribution variances. b, *p*-value calculated using Fisher's exact test due to lower expected cell counts (n <5). One additional case initiated under regional block that required intraoperative conversion to GA is excluded from the comparative statistical columns above and reported separately in accordance with the protocol. EBL, estimated blood loss; IQR, interquartile range; PRBC, packed red blood cells; MTP, massive transfusion protocol; ICU, intensive care unit; GA, general anesthesia.

tients with ≥4 prior CSs accounted for 47.8% under primary GA and 16.7% in the successful neuraxial group (n = 2/12). Crucially, intraoperative conversion from neuraxial anesthesia to GA was required in only a single case presenting with 2 prior CSs, yielding an institutional conversion rate of 7.7% (1/13 attempted regional blocks) due to intraoperative surgical extension. Consistent with our risk-based protocol, more patients with ≥4 previous CSs were managed with GA rather than neuraxial techniques, indicating that our clinical triage effectively identified higher-risk patients with extensive uterine scarring and directed them toward airway and hemodynamic management [Data not tabulated].

3.4 Surgical Complexity and Protocol Resource Scaling

To evaluate the operational scalability and resource responsiveness of our multidisciplinary protocol, outcomes were stratified and statistically compared based on historical surgical complexity thresholds defined by prior CSs (Table 4). Inferential analysis was utilized to evaluate the divergence in severe structural tissue morbidity between the cohorts. Intraoperative bladder injuries occurred in 42.1% (n = 8/19) of the high-complexity group (≥3 prior CSs), compared to 17.6% (n = 3/17) in the standard-risk group. While clinically demonstrating a higher burden of anatomical morbidity in the high-complexity tier. This difference did not reach statistical significance (Fisher's exact test, $p = 0.155$) within this limited sample size.

Continuous measures of resource utilization also reflected increased clinical demands in the high-complexity group. Median EBL was higher in the high-complexity group compared to the standard-risk group (2.80 L vs. 1.90 L); however, this difference did not reach statistical significance ($p = 0.245$). Similarly, total operative time (median, 155.0 min vs. 120.0 min, $p = 0.184$) and immediate postoperative maternal ICU length of stay (median, 7.0 days vs. 5.0 days, $p = 0.312$) increased proportionally with surgical complexity, as assessed with non-parametric Mann-Whitney U test. These inferential metrics confirm that, although the protocol effectively standardized systemic hemostatic outcomes across both risk tiers ($p > 0.05$ for transfusion and length-of-stay), it successfully anticipated and scaled specialists to manage severe anatomical complications.

Table 4. Clinical outcomes and resource utilization stratified by surgical complexity.

Clinical parameter	Standard-risk (0–2 prior CS) (n = 17)	High-complexity (≥3 prior CS) (n = 19)	*p*-value
EBL, Liters, median (IQR)	1.90 (1.35–2.90)	2.80 (1.60–4.60)	0.245a
MTP activation, n (%)	2 (11.8%)	3 (15.8%)	1.000b
Intraoperative bladder injury, n (%)	3 (17.6%)	8 (42.1%)	0.155b
Maternal ICU length-of-stay, days, median (IQR)	5.0 (3.5–7.0)	7.0 (4.0–11.5)	0.312a
Total operative time, min, median (IQR)	120.0 (90.0–165.0)	155.0 (110.0–245.0)	0.184a

a, *p*-value computed using the non-parametric Mann-Whitney U test due to right-skewed clinical data distribution. b, *p*-value computed using Fisher's exact test to account for low-frequency cell counts (n <5). EBL, estimated blood loss; IQR, interquartile range; CS, Cesarean section; MTP, massive transfusion protocol; ICU, intensive care unit.

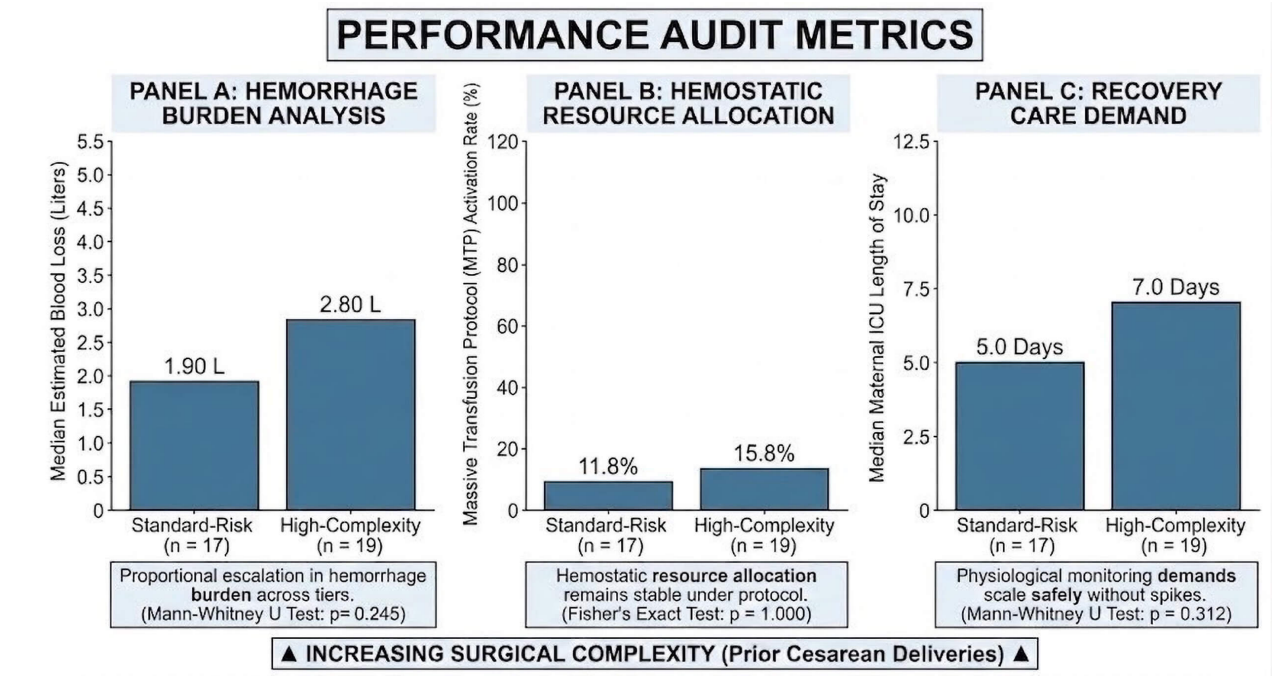

Fig. 4. Performance audit metrics stratified by surgical complexity. (A) Median EBL. (B) MTP activation rates. (C) Median maternal ICU length-of-stay. Corresponding nonparametric and small-sample inferential significance analysis were included. EBL, estimated blood loss; MTP, massive transfusion protocol; CS, Cesarean section.

Fig. 4 demonstrates how the institutional PAS management protocol adapts to increasing surgical complexity by categorizing clinical outcomes according to complexity strata. As the number of previous CSs increased, clinical burden showed a corresponding upward trend, reflected by higher median EBL (2.80 vs. 1.90 L, $p = 0.245$) and an increased proportion of MTP activations (15.8% vs. 11.8%, $p = 1.000$). This descriptive analysis shows that the multidisciplinary approach aligns with higher-acuity anatomical risk, enabling protocolized tracking and proportional allocation of specialized resources across varying levels of obstetric complexity.

3.5 Neonatal Outcomes and Transitional Profiles

Pediatric clinical indicators and transitional outcomes for the 36 neonates are summarized in Table 5. Reflecting the institutional strategy of planned late preterm delivery to prevent the risk of catastrophic maternal hemorrhage, the mean gestational age at delivery was 35.3 ± 1.3 weeks, resulting in a baseline preterm delivery rate of 86.1% (n = 31). Due to this high rate of therapeutic prematurity, the overall NICU admission rate was 52.8% (n = 19), primarily requiring short-term respiratory support or monitoring. Neonatal transition data demonstrated immediate, transient neonatal depression in a minority of cases, with a 1-min Apgar score ≤5 observed in 19.4% (n = 7) of newborns. However, standardized multidisciplinary neonatal resuscitation was highly effective, with 94.4% (n = 34) of neonates achieving a normal 5-min Apgar score ≥7. Importantly, no cases of perinatal mortality (0%) were recorded across the five-year study period.

4. Discussion

4.1 Principal Findings and Interpretation

Our analysis of 16,595 deliveries at King Khalid University Hospital from 2021 to 2025 shows that increas-

Table 5. Neonatal outcomes and clinical safety indicators (n = 36).

Neonatal parameter	Value
Birth weight (grams), mean ± SD	2673.6 ± 461.2
Gestational age at delivery (weeks), mean ± SD	35.3 ± 1.3
Preterm birth (<37 weeks), n (%)	31 (86.1%)
1-min Apgar score ≤5, n (%)	7 (19.4%)
5-min Apgar score ≥7, n (%)	34 (94.4%)
NICU admission, n (%)	19 (52.8%)
Perinatal mortality rate, n (%)	0 (0.0%)

NICU, neonatal intensive care unit.

ing CS rates coincide with an increasing institutional incidence of PAS, reaching 3.70 cases per 1000 deliveries in 2025. Importantly, this single-center trend should be interpreted with caution and should not be generalized as a true population-wide epidemiological spike. As a major tertiary referral center, our institution is subject to referral patterns that influence case distribution. During the five-year study period, the establishment of a standardized multidisciplinary protocol likely contributed to increased referral of high-risk, prenatally diagnosed cases of abnormal placentation from community and secondary centers, resulting in an artificial concentration of regional PAS cases within our cohort. The cohort reflects the clinical profile of the general Saudi population, consisting mostly of older pregnant women (median age, 37.5 years) with high parity and significant uterine scarring.

Given the limitations of prenatal imaging, which showed variable sensitivity and specificity in our cohort, imaging was primarily used as an initial screening tool to support preoperative planning. Perioperative management therefore emphasized consistency of intraoperative care through risk-stratified anesthetic planning, point-of-care viscoelastic testing, and protocolized hemostatic resuscitation.

We reviewed our results to assess how effectively this protocol adapted to increasing surgical complexity. Stratification according to surgical complexity—specifically the number of previous CSs—demonstrated that institutional resource allocation increased with surgical complexity. In patients with ≥3 prior CS, additional multidisciplinary resources were used to manage the higher physiologic and hemodynamic challenges associated with these higher-complexity cases.

Our anesthetic triage strategy aligned with baseline clinical risk stratification; however, its interpretation must directly account for confounding by indication. Primary GA was preferentially allocated to cases presenting with high suspected surgical complexity (e.g., ≥4 prior CSs or deep myometrial invasion). Consequently, the GA cohort represented a fundamentally higher-acuity population at baseline than the neuraxial anesthesia group. Notably, despite this marked difference in baseline clinical severity, perioperative outcomes, such as EBL, transfusion requirements, and total hospital length-of-stay, showed no statistically significant differences between the two groups ($p > 0.05$). Rather than proving equivalence between the two anesthetic modalities, this stability in outcomes suggests that the protocol's scalable hemostatic resuscitation strategy and specialized surgical framework successfully managed the expected excess morbidity associated with the high-acuity GA cohort. These findings indicate favorable perioperative outcome profiles across a high-risk patient population without a disproportionate increase in adverse maternal outcomes.

4.2 Comparison with Previous Studies

Our findings support the increasing burden of PAS in Saudi Arabia, aligned with previously reported regional longitudinal data. A clear association between rising CS rates and PAS prevalence has been reported. Abduljabbar et al. [7], in a review of 55,862 deliveries from 2001–2013, reported a CS rate of 20.3% and a placenta previa rate of 4.1 per 1000 deliveries, while Mansour and Mousa [8] found a PAS incidence of 0.6% in Madinah during 2016–2017. Alqasem et al. [6], in an analysis of 54,341 deliveries from 2012–2021, highlighted a high proportion of major PAS cases occurring in women with previous CS. At King Khalid University Hospital (2021–2025), the CS rate increased to 41.3%, while the institutional incidence of PAS reached 3.70 per 1000 deliveries. Overall, these studies indicate that as surgical volume increases, obstetric complexity increases, underscoring the need for standardized, multidisciplinary PAS management nationwide.

Comparative analysis of three Saudi studies [6,7,8] shows a consistent clinical profile for PAS and placenta previa (PP). Our cohort (median age, 37.5 years) and Alqasem et al. [6] (mean age, 33.3 years) reflect an aging obstetric population, similar to that reported by Mansour and Mousa [8] (mean age, 34.3 years). High parity was also a shared characteristic, with our cohort exhibiting a median gravidity of 5 and parity of 4, comparable to Alqasem et al. [6]. Most patients are Saudi nationals (around 91%). Prior CS was the main risk factor, with 75% of our cohort having a history of ≥2 prior CSs, higher than reported by Abduljabbar et al. [7]. Historical data indicate a trend toward planned preterm delivery (86.1% in our cohort), driven by proactive management. Repeated surgeries and trauma are reshaping PAS severity and treatment across Saudi Arabia.

Diagnostic accuracy for PAS varies across Saudi studies, with sensitivity and specificity differing by imaging modality. In the present cohort, prenatal MRI interpretation showed a screening sensitivity of 86.36% and a specificity of 14.29%. In contrast, specific US markers, such as loss of the clear zone and abnormal lacunae, exhibited high screening sensitivities of 100.00%, reflecting the referral nature of our pre-selected cohort. These structural discrepancies underscore the diagnostic challenges inher-

ent to retrospective single-center data. Critically, because our cohort consists exclusively of high-risk cases referred with strong prior suspicion of abnormal placentation, the dataset suffers from a profound mathematical restriction of variance (i.e., a near-total absence of true negatives). Consequently, the calculated screening specificities and predictive values are inherently reduced and must be interpreted as institutional quality-tracking metrics rather than generalizable diagnostic performance characteristics. This statistical limitation reinforces our primary clinical conclusion: neither imaging modality provides definitive preoperative certainty, and therefore a standardized multispecialty intraoperative management pathway is required for all suspected cases, irrespective of radiologic grading.

Managing PAS poses a significant global obstetric challenge, with our cohort requiring high-acuity care, consistent with international findings. Blood loss and transfusion volume are key indicators of surgical complexity. Our median blood loss, which ranged from 1.90 L in standard-risk cases to 2.80 L in high-complexity cases, closely aligns with the 1.98 L reported in a large Egyptian cohort [13], as well as the 1.5 L median reported in a U.S. study [14]. Conversely, a Greek tertiary cohort experienced a higher mean blood loss of 3.77 L, indicating more advanced cases involving extensive pelvic dissection [15].

High surgical burdens lead to significant blood bank usage. The Egyptian group averaged 8.74 units of PRBCs [13], whereas the Greek study reported a median of 4 RBC units, along with notable needs for FFP [15]. Although there are minor differences in surgical approaches, such as prophylactic balloon catheterization in the U.S. [14] versus pelvic vascular ligation in Greece and Turkey [15,16], the literature shows a universal agreement: technology alone cannot replace a coordinated, multidisciplinary team. Effective collaboration among obstetrics, gynecologic oncology, anesthesia, and the blood bank team is crucial for reducing severe maternal complications and ensuring stable perioperative outcomes.

Beyond macrostructural imaging, contemporary evidence highlights the growing clinical utility of early biochemical risk stratification. Specifically, a recent study demonstrated that elevated first-trimester serum levels of PAPP-A and free β-human chorionic gonadotropin (β-hCG), alongside a significantly reduced mean platelet volume (MPV), may serve as early noninvasive serum biomarkers of invasive placentation in pregnancies complicated by placenta previa. These biomarkers may provide complementary molecular blueprint to help guide timely perioperative team assembly [17].

Our findings confirm that the most reliable predictor of safety is not just the chosen surgical technique, but the implementation of a standardized, elective, and risk-stratified protocol. Shifting from the reactive, emergency-prone approaches observed in some high-morbidity groups to the structured, multidisciplinary care model highlighted in our research, allows institutions to better reduce the life-threatening risks of hemorrhage and visceral injury associated with the PAS. This comparison shows that although geographical differences may influence surgical preferences, the fundamental need for early diagnosis and coordinated specialist care remains the universal standard for enhancing maternal and perinatal outcomes.

4.3 Clinical Implications

This study indicates that the rising burden of PAS in our cohort is correlated with advanced maternal age and a high prevalence of repeated CSs. A proactive, risk-based approach using advanced imaging and multidisciplinary teams, including obstetricians, oncologists, and urologists, is warranted to replace reactive emergency procedures. Standardized clinical pathways are designed to help plan for surgical challenges, mitigating the risks of severe maternal hemorrhage, visceral injury, and prolonged ICU utilization. This evidence-based strategy aims to improve maternal and neonatal safety in high-risk obstetric centers.

4.4 Strengths and Limitations

The strengths of this study include its comprehensive five-year assessment of PAS cases, its focus on region-specific risk factors, and the implementation of a multidisciplinary team to standardize high-risk surgical management. Nevertheless, several limitations should be acknowledged. The retrospective study design limits causal inference regarding the effects of specific surgical techniques and long-term outcomes. Additionally, reliance on medical records may lead to underreporting of subtle intraoperative complications. Although the cohort size reflects regional high-risk cases, it is relatively small compared to larger international cohorts, limiting our overall statistical power. As such, we were unable to perform multivariable regression analysis or propensity score matching to adjust for profound baseline confounding. Furthermore, our nonsignificant univariate comparisons are inherently subject to an elevated risk of Type II errors, suggesting that the study was underpowered to exclude true clinical differences between the anesthetic cohorts. Additionally, a key limitation was the reliance on the number of prior CSs as the primary index for surgical complexity stratification. Although a high number of previous CS was strongly associated with uterine scarring, it represents only an incomplete proxy for overall surgical complexity. Surgical difficulty is determined by complex anatomical factors, such as the topographic location of placental implantation, the extent and depth of local myometrial invasion (e.g., focal vs. diffuse percreta), and the presence of direct visceral involvement, particularly bladder invasion, which occurred in several high-acuity cases within our cohort. Future protocols should incorporate an integrated surgical complexity score combining prior surgical history with intraoperative invasion grading. Furthermore, the study was not designed to fully account for interoper-

ator variability in surgical expertise or for subtle temporal changes in institutional protocols that may have occurred during the study period.

4.5 Recommendations for Future Research

Our study suggests that the number of prior CSs is a key marker of increased blood loss and the likelihood of MTP activation. Future research should focus on large-scale, prospective multicenter studies to validate this risk-stratification approach. Studies should also aim to establish standardized imaging criteria that directly correlate prenatal US and MRI findings with intraoperative surgical complexity and blood bank resource use. Due to diagnostic variability observed in our single-center cohort, multicenter registries are needed to develop predictive models combining previous CS count with standardized radiologic severity scores. This may facilitate a transition from empirical risk assessment to more precise, data-driven preoperative planning in tertiary referral centers. In addition, long-term comparative studies are necessary to evaluate maternal and reproductive outcomes associated with conservative uterus-preserving techniques vs. planned Cesarean hysterectomy in women with multiple prior CSs.

5. Conclusions

This study demonstrates that the management of PAS should shift from reactive, emergency-based interventions toward a proactive, multidisciplinary model of care. Emphasis on elective surgical planning, standardized imaging assessment, and coordinated involvement of specialized clinical teams may significantly mitigate the life-threatening risks of hemorrhage and visceral injury. These evidence-based improvements serve as a practical institutional framework for enhancing maternal and perinatal safety within high-risk obstetric populations.

Availability of Data and Materials

The datasets used and analyzed during the current study are available from the corresponding author upon reasonable request.

Author Contributions

JB, MBD, NAy, and ASAA designed and conceived the clinical audit and research study. RJA, SN, MA, MAA, NAm, MFZB, and AAA performed the research, established the retrospective database, and extracted the clinical metrics from the institutional health documentation systems. JB, MBD, RJA, and AAA oversaw the anesthetic architecture data and viscoelastic coagulation profiling. NAy, SN, MA, MAA, MFZB, and ASAA managed the surgical complexity matrices, histopathological tracking data, and visceral complication details. JB, NAy, and ASAA analyzed the data and performed the inferential statistical operations. All authors contributed to the critical editorial revisions and drafting of the manuscript. All authors have read, verified, and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

The study was conducted in accordance with the Declaration of Helsinki and its relevant ethical principles. The study received approval from the King Saud University Medical City Institutional Review Board, IRB No.: 26-437, with informed consent waived due to the use of de-identified, retrospective data.

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Conflicts of Interest

The authors declare no conflicts of interest.

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