



RESEARCH ARTICLE

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Efficacy Safety Score in Postoperative Patients With and Without Comorbidities: A Prospective Comparative Study

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ABSTRACT

Postoperative complications contribute significantly to global morbidity and mortality, occurring in approximately 3-25% of surgical patients. The Efficacy Safety Score (ESS) is a multidimensional postoperative assessment tool designed to support early identification of complications. However, limited evidence exists on how comorbidities, types of anesthesia, and categories of surgery affect ESS outcomes. The purpose of the study was to compare postoperative ESS between patients with and without comorbidities, anesthesia, and surgery types. A prospective comparative cohort study was conducted using consecutive sampling among 153 postoperative patients in two hospitals. Demographic, clinical characteristics, and ESS were collected within 24 hours post-surgery. Statistical analyses included independent t-tests and one-way ANOVA, reporting mean differences, 95% confidence intervals (CIs), and effect sizes. The results showed patients with comorbidities had significantly higher ESS scores than those without (mean difference = 1.50, 95% CI: 0.68–2.32, Cohen's d = 0.60, $p < 0.001$). General anesthesia was associated with higher ESS scores than regional anesthesia (mean difference = 0.96, 95% CI: 0.08–1.84, Cohen's d = 0.38, $p = 0.032$). ESS differed significantly across surgery types, with orthopedic procedures yielding the highest scores ($\eta^2 = 0.05$, $p = 0.018$). These findings indicate that the presence of comorbidity, anesthesia type, and surgical category significantly influence postoperative ESS. The ESS findings may be useful for postoperative risk stratification; however, further validation studies are required before routine clinical implementation.

Keywords: Efficacy safety score; postoperative, comorbidity; anesthesia; surgery type

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INTRODUCTION

Surgical procedures remain one of the most frequently performed medical interventions worldwide, with an estimated 330 million operations conducted annually across diverse healthcare settings (1). Despite advances in perioperative care, postoperative complications continue to contribute significantly to patient morbidity, prolonged hospitalization, increased healthcare costs, and preventable mortality (2). These previous studies elucidate that complications are especially prevalent among patients with pre-existing comorbidities, such as cardiovascular disease, diabetes mellitus, chronic kidney disease, and chronic respiratory conditions, which heighten surgical risk and impair recovery trajectories (3–5). Identifying patients at risk for poor postoperative outcomes is therefore essential for guiding resource allocation, clinical surveillance, and individualized postoperative management.

Several preoperative and intraoperative scoring systems, such as the American Society of Anesthesiologists Physical Status Classification (ASA-PS), POSSUM, and APACHE, have been widely used to estimate surgical risk and predict clinical outcomes (6,7). However, these conventional tools are inherently static and primarily focus on physiological status before or during surgery. They are insufficient for evaluating the dynamic postoperative recovery phase because they do not continuously measure the real-time balance between therapeutic benefits and adverse events. Consequently, they fail to capture the rapidly evolving clinical trajectory of patients within the critical first 24 hours post-surgery (8–10). To address this gap, the Efficacy Safety Score (ESS) was developed as a dynamic, composite bedside instrument. Unlike traditional predictive models, ESS offers the distinct advantage of simultaneously evaluating both recovery progress (“efficacy”) and clinical instability (“safety”) in real time, providing a more holistic and actionable assessment of the postoperative state.

The Efficacy Safety Score (ESS) has emerged as a potential integrative measure to evaluate postoperative patient status by combining indicators of recovery progress with markers of safety, such as complications and adverse events. To date, a limited number of primary validation studies have investigated the ESS, primarily focusing on general surgical, orthopedic, and abdominal surgery populations. Composite indices such as ESS may offer superior clinical utility by providing a more holistic assessment of postoperative outcomes compared to single-domain metrics. Despite these established psychometric properties, empirical evidence on ESS's performance in differentiating postoperative trajectories across specific clinical subgroups remains limited. In particular, its ability to distinguish outcomes between patients with and without comorbidities has not been adequately explored (4). Given that comorbid conditions substantially influence surgical outcomes, evaluating ESS across these two patient groups is crucial for determining its validity, sensitivity, and practical applicability in clinical decision-making.

To address this gap, the present observational study aims to: (1) compare ESS between patients with and without comorbidities and (2) determine whether anesthesia and surgery types significantly impact ESS among postoperative patients. The novelty of this study lies in simultaneously evaluating

ESS across comorbidity status, anesthesia type, and surgical category within a prospective clinical design. By examining group differences and assessing the association between ESS and major postoperative outcomes, this study seeks to determine whether ESS can function as a reliable postoperative evaluation tool. Establishing the discriminative capability of ESS may help clinicians identify high-risk patients earlier, optimize postoperative monitoring, and improve overall patient safety. This study represents an important step toward validating ESS as a practical and evidence-based metric within postoperative clinical care.

METHODS

Study Design and Setting

This study employed a prospective comparative study to evaluate the ESS among postoperative patients with and without comorbidities. The study was conducted across two hospitals in West Java Province between October to December 2025, comprising two government-affiliated tertiary referral hospitals. These institutions were selected to enhance the external validity of the findings, representing a combined bed capacity of over 800 beds and an average monthly surgical volume of approximately 300 procedures. The study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for reporting observational research (11).

Participants and Sampling

Participants were adult patients (≥ 18 years old) who underwent major elective or emergency surgery during the study period through a consecutive sampling technique. All eligible patients admitted to the postoperative care unit during the study period were consecutively invited to participate until the required sample size was achieved and the study period concluded. The surgical categories included orthopedic surgery (e.g., total knee/hip replacement, fracture fixation), gynecological surgery (e.g., vaginal or open hysterectomy, laparoscopic hysterectomy, cesarean section), and other procedures defined by the surgical service.

Inclusion criteria were:

1. Postoperative admission following major surgery.
2. Ability to undergo ESS assessment within the first 24 hours post-surgery.
3. Availability of complete clinical data for all study variables.

Exclusion criteria included:

1. Patients discharged, transferred, or deceased before ESS assessment.
2. Incomplete medical records or missing essential variables.
3. Patients refusing consent, when applicable.

Participants were categorized into two groups, comorbidity group vs non-comorbidity group.

Sample size estimation

Sample size was estimated using G*Power for a two-sample comparison of means (independent t-test). Parameters used were: two-tailed test, $\alpha = 0.05$, power = 0.80, allocation ratio = 1, and Cohen's $d = 0.50$ (medium effect) (12). G*Power output indicated 64 participants per group (total 128). To

account for an anticipated 5% attrition rate, the adjusted required sample was calculated, the ideal sample size is 135 sample.

Measurements

Demographic and clinical variables collected include age, gender, height (cm), weight (kg), Morse Fall Scale score, type of anaesthesia (general or regional), and type of surgery. Surgery categories were recorded and consist of orthopedic (e.g., total knee/total hip replacement; fracture fixation; other) and gynecological (e.g., vaginal/open hysterectomy; laparoscopic hysterectomy; vaginal repair surgery; cesarean section; other).

The ESS is a composite bedside instrument that integrates domains such as pain, nausea/vomiting, level of consciousness, oxygenation, and key vital signs to identify patients who may require additional clinical attention in the immediate postoperative period (10). The ESS yields a total score ranging from 0 to 15. Higher scores indicate a greater burden of postoperative symptoms, increased physiological instability, and a higher need for clinical intervention. A score of ≥ 8 is generally considered indicative of moderate to severe postoperative distress, warranting intensified monitoring. Face validity was confirmed by five clinical nurses who rated all items as clear and clinically appropriate. A panel of seven experts—including anesthesiologists, perioperative nurse specialists, and nurse researchers evaluated item relevance, yielding excellent content validity (I-CVI = 0.86–1.00; S-CVI/Ave = 0.94) and CVR values ranging from 0.71 to 1.00. Reliability testing in a pilot sample showed good internal consistency (Cronbach's $\alpha = 0.82$) and excellent interrater agreement between two trained assessors (ICC = 0.93, 95% CI: 0.88–0.97), supporting the ESS as a reliable tool for postoperative monitoring. ESS assessments will be recorded at 24 hours postoperatively.

Data collection procedures

All data collection is entirely observational and performed by trained bedside nurses. Training comprises a standardized manual and a minimum of two hours of combined didactic and practical instruction, including case vignettes and supervised practice. Nurses receive standardized training and a written manual covering item definitions and scoring procedures. Retraining was provided when interrater agreement during the pilot phase falls below predefined thresholds. ESS is recorded at 24 hours postoperatively. Demographic and clinical data extracted from medical records include age, gender, height, weight, comorbidity status (with/without), Morse Fall Scale, type of anaesthesia (general/regional), type of surgery (orthopaedic: total knee/hip, fracture fixation, other; gynaecological: vaginal/open hysterectomy, laparoscopic hysterectomy, vaginal repair, caesarean section, other), and ESS values. To assess interrater agreement, a subset of patients was independently scored by two nurses at the same time point; any distinct results were evaluated in a final consensus till the same voice.

Statistical analysis

Categorical variables will be reported as frequency (n) and percent (%); continuous variables as mean $\pm$ SD. Before analysis, assumptions of normality (Shapiro-Wilk test), homogeneity of variance (Levene's test), and independence were evaluated, and no significant violations were found.

Between-group comparisons (patients with vs without comorbidity and anesthesia type) for ESS used independent t-tests, reporting mean differences, 95% confidence intervals (CIs), and Cohen's d as the effect size. One-way ANOVA assessed ESS differences among surgery categories, reporting Eta-squared (η^2) as the effect size, followed by Tukey's HSD for post hoc comparisons. Two-sided $p < 0.05$ will be considered statistically significant. Analyses will be performed using SPSS 29 for Windows.

Ethical considerations

This study received ethical approval from Stikes Muhammadiyah Ciamis, approval number 143/KEPK-STIKESMUCIS/X/2025. All data were handled in accordance with institutional and international guidelines for patient confidentiality. For prospective data collection, written informed consent was obtained from all participants. For retrospective components, the requirement for consent was waived following institutional policies.

RESULTS

Participants characteristics

In table 1, a total of 153 postoperative patients were included in the study. Of these, 92 patients (60.1%) had at least one comorbidity, while 61 patients (39.9%) had no comorbidities. The overall mean age was 56.42 years (SD = 12.38). Patients with comorbidities were significantly older ($M = 60.15$, $SD = 10.84$) than those without comorbidities ($M = 50.84$, $SD = 12.95$), $t = 4.87$, $p < 0.001$.

No statistically significant difference was found in gender distribution between groups, $\chi^2 = 1.62$, $p = 0.203$. Orthopedic surgery was the most common procedure (48.4%), followed by gynecological surgery (34.6%) and other procedures (17.0%) (Table 1).

Type of anesthesia differed significantly by comorbidity status, $\chi^2 = 4.79$, $p = 0.029$, with a higher proportion of general anesthesia used in patients with comorbidities. Patients with comorbidities also showed significantly higher fall risk scores ($M = 2.72$, $SD = 1.18$) compared to those without comorbidities ($M = 1.93$, $SD = 1.27$), $t = 3.73$, $p < 0.001$ (Table 1).

Comparison of ESS Across Clinical Variables

Comorbidity Status

Patients with comorbidities demonstrated significantly higher ESS scores ($M = 8.43$, $SD = 2.50$) compared with those without comorbidities ($M = 6.93$, $SD = 2.52$). The mean difference was 1.50 (95% CI: 0.75 to 2.25), yielding a moderate effect size (Cohen's $d = 0.60$, $t = 3.58$, $p < 0.001$) (Table 2). This indicates that patients with preexisting conditions experienced greater postoperative physiological and safety concerns.

Type of Anesthesia

ESS scores differed significantly based on anesthesia type. Patients who received general anesthesia had higher ESS scores ($M = 8.21$, $SD = 2.57$) compared with those who received regional anesthesia ($M = 7.25$, $SD = 2.58$). The mean difference was 0.96 (95% CI: 0.12 to 1.80), with a small to moderate effect size (Cohen's $d = 0.37$, $t = 2.17$, $p = 0.032$) (Table 2). This indicates that general

anesthesia may be associated with increased postoperative symptoms or delayed recovery compared with regional approaches.

Type of Surgery

ESS scores varied significantly across surgery categories, $F = 4.12$, $p = 0.018$, with a small effect size ($\eta^2 = 0.05$). Post hoc comparison indicated that orthopedic surgery had the highest ESS mean ($M = 8.37$, $SD = 2.55$), followed by other surgeries ($M = 7.61$, $SD = 2.57$) and gynecological procedures ($M = 7.24$, $SD = 2.48$). The difference between orthopedic and other surgeries was not statistically significant (mean difference = 0.76, 95% CI: -0.25 to 1.77, adjusted $p = 0.185$) (Table 2). Orthopedic surgery patients, therefore, showed greater postoperative recovery challenges.

Table 1 Demographic and Clinical Characteristics of Participants (n = 153)

Variable	With Comorbidities (n = 92)	Without Comorbidities (n = 61)	Total (n = 153)	Test Statistic
Age, M (SD)	60.15 (10.84)	50.84 (12.95)	56.42 (12.38)	$t=4.87$, $p<0.001$
Height (cm), M (SD)	160.72 (7.34)	162.00 (8.57)	161.23 (7.89)	$t=1.01$, $p=0.313$
Weight (kg), M (SD)	65.40 (10.98)	63.34 (12.02)	64.58 (11.42)	$t=1.05$, $p=0.296$
Gender				$\chi^2=1.62$, $p=0.203$
Male	47 (51.1%)	25 (41.0%)	72 (47.1%)	
Female	45 (48.9%)	36 (59.0%)	81 (52.9%)	
Type of Anesthesia				$\chi^2=4.79$, $p=0.029$
General	65 (70.7%)	31 (50.8%)	96 (62.7%)	
Regional	27 (29.3%)	30 (49.2%)	57 (37.3%)	
Type of Surgery				$\chi^2=2.94$, $p=0.230$
Orthopedic	47 (51.1%)	27 (44.3%)	74 (48.4%)	
Gynecological	29 (31.5%)	24 (39.3%)	53 (34.6%)	
Other	16 (17.4%)	10 (16.4%)	26 (17.0%)	
Risk of Falls, M (SD)	2.72 (1.18)	1.93 (1.27)	2.41 (1.27)	$t=3.73$, $p<0.001$

Table 2 Comparison of ESS Scores Across Clinical Variables

Variable	ESS Mean (SD)	Mean Difference (95% CI)	Effect Size	Test Statistic
Comorbidity Status				
With comorbidities (n=92)	8.43 (2.50)	1.50 (0.75 to 2.25)	$d = 0.60$	$t=3.58$, $p<0.001$
Without comorbidities (n=61)	6.93 (2.52)			
Type of Anesthesia				
General (n=96)	8.21 (2.57)	0.96 (0.12 to 1.80)	$d = 0.37$	$t=2.17$, $p=0.032$
Regional (n=57)	7.25 (2.58)			
Type of Surgery				
Orthopedic (n=74)	8.37 (2.55)		$\eta^2 = 0.05$	$F=4.12$, $p=0.018$
Gynecological (n=53)	7.24 (2.48)			
Other (n=26)	7.61 (2.57)			

DISCUSSION

The present study examined the differences in ESS among postoperative patients with and without comorbidities and explored whether anesthesia type and surgical category influenced overall postoperative safety and recovery. The present study highlights those postoperative patients with comorbidities, those receiving general anesthesia, and those undergoing orthopedic procedures experience a substantially greater burden of postoperative symptoms and physiological instability, as

reflected by their elevated ESS. Rather than merely indicating statistical differences, these higher ESS scores signify a critical need for intensified clinical surveillance and tailored perioperative nursing care. Specifically, an elevated ESS in these subgroups suggests delayed recovery trajectories and an increased vulnerability to adverse events, underscoring the tool's potential utility in early risk stratification and guiding individualized postoperative monitoring protocols. These results align with prior evidence and provide important implications for perioperative nursing care, risk stratification, and early postoperative monitoring (4).

Consistent with existing literature, postoperative patients with comorbidities demonstrated significantly higher ESS scores than those without comorbidities. One biological potential explanation chronic comorbidities induce a state of systemic low-grade inflammation, endothelial dysfunction, and impaired immune responses, which collectively reduce physiological reserve and impair compensatory responses to surgical stress (13–15). Chronic illnesses, such as hypertension, diabetes, and respiratory disorders, have been shown to complicate postoperative recovery by increasing symptom burden, prolonging inflammation, and delaying functional mobility (16–18). Furthermore, patients with multiple comorbidities typically require more complex medication regimens, which may contribute to higher rates of postoperative dizziness, nausea, hypotension, or adverse drug event symptoms that contribute directly to a higher ESS (19,20). Thus, the elevated ESS scores among comorbid patients in this study likely reflect the combined effect of the compounded burden of biological vulnerability, reduced functional reserve, and increased postoperative symptomatology.

The findings also revealed significant differences in ESS based on anesthesia type, with general anesthesia associated with significantly higher scores. This is consistent with previous studies reporting that general anesthesia produces greater systemic effects, including respiratory depression, delayed recovery of consciousness, and increased postoperative nausea and vomiting, compared with regional anesthesia (19,21). Regional anesthesia has been associated with enhanced postoperative pain control and earlier mobilization, resulting in improved safety and recovery outcomes (22–24). The higher ESS scores observed among patients receiving general anesthesia may therefore reflect residual sedation, increased opioid requirements, and slower recovery trajectories. These findings underscore the importance of tailoring anesthesia techniques to patient risk profiles, especially in populations with known comorbidities.

Surgical type also played a significant role in postoperative recovery, with orthopedic surgery patients demonstrating the highest ESS scores. Orthopedic procedures, particularly joint replacements and fracture fixation, are associated with substantial tissue trauma, high postoperative pain intensity, and early mobility restrictions factors known to delay recovery and increase postoperative complications (25). Furthermore, these procedures often require prolonged immobilization and complex postoperative rehabilitation protocols. The combination of opioid-induced side effects (such as dizziness, nausea, and sedation), delayed functional mobility, and increased fall risk directly elevates the symptom burden and

physiological instability captured by the ESS. In contrast, gynecological surgeries, especially minimally invasive laparoscopic procedures, often result in lower pain scores, reduced analgesic consumption, and faster postoperative recovery (26,27). These patterns explain the lower ESS observed in gynecological patients within this study.

Overall, these findings highlight the value of ESS as a clinically meaningful tool to identify postoperative risk and recovery challenges. The results are consistent with the broader evidence emphasizing the importance of individualized perioperative care based on comorbidities, anesthesia selection, and surgical characteristics. For nursing practice, the findings suggest the need for intensified monitoring protocols for patients undergoing orthopedic procedures, those with multiple comorbidities, and those receiving general anesthesia. Targeted interventions such as enhanced recovery pathways, optimized multimodal analgesia, and early mobilization strategies may help reduce ESS scores and improve postoperative safety for high-risk groups.

Implication for Nursing Practice

The findings indicate that ESS is a practical tool for identifying postoperative patients who require intensified monitoring, particularly those with comorbidities, undergoing orthopedic surgery, or receiving general anesthesia. Thus, the early identification of high-risk patients, ESS may help clinical teams prioritize nursing interventions, such as enhanced recovery pathways and early mobilization strategies, potentially improving postoperative safety through more targeted surveillance. Its consistent performance across two hospitals suggests that ESS can standardize postoperative assessment and support individualized care planning, improve communication among clinical teams, and enhance early detection of complications.

Limitations and Strengths

This study included two hospitals, which may have differed in postoperative protocols and staffing, potentially influencing outcomes. First, although consecutive sampling was employed to minimize bias, the possibility of selection bias cannot be entirely ruled out. Second, the observational design prevents causal conclusions, and the absence of multivariable regression means we could not fully adjust for potential confounding variables such as ASA physical status, exact duration of surgery, or smoking status, which were not systematically recorded in the medical records. Third, analgesic medication data were unavailable, limiting the interpretation of ESS components related to pain and sedation. Fourth, ESS was measured only in the first 24 hours, and varying subgroup sizes may affect comparison precision. Finally, the generalizability of the findings may be limited to similar tertiary hospital settings, as postoperative protocols and staffing levels can vary significantly across different healthcare institutions.

For strengths with using two clinical settings increases generalizability, and prospective ESS assessments by trained nurses strengthen data accuracy. The inclusion of diverse surgery and anesthesia types improves clinical relevance, and the sample size provides adequate power for group comparisons.

CONCLUSIONS AND RECOMMENDATIONS

This study findings suggest that comorbidity status, anesthesia type, and surgery classification significantly influence postoperative ESS outcomes. Patients with comorbidities, those undergoing orthopedic procedures, and those receiving general anesthesia demonstrated higher ESS scores, reflecting greater postoperative care needs. These findings suggest the value of ESS as a practical, multidimensional assessment tool for guiding postoperative monitoring, prioritizing nursing interventions, and improving patient safety. However, diagnostic performance and predictive validity were not evaluated in this study; further multicenter prospective validation studies incorporating multivariable analyses and predictive performance measures are required before routine implementation in clinical practice. Therefore, integrating ESS into routine perioperative practice might enhance early risk detection and optimize recovery pathways.

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