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PREDICTORS OF PERIOPERATIVE MORTALITY AND ICU ADMISSION IN HIGH-RISK SURGICAL PATIENTS: A SYSTEMATIC REVIEW AND META-ANALYSIS WITH CONTEXTUAL INSIGHTS FROM THE UAE

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Keywords

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Abstract

Background:

Perioperative mortality remains a major global concern, especially in the high-risk surgical patient. Intensive care unit (ICU) admission is very common in the postoperative period; however, its independent effect on mortality outcomes is unclear. Additionally, the identification of important predictors of both mortality and ICU admission are critical towards optimizing perioperative care, more so in rapidly evolving healthcare systems such as the United Arab Emirates (UAE).

Objectives:

This study aimed to identify the predictors of perioperative mortality and ICU admission in high-risk surgical patients by a systematic review and meta-analysis with some contextual insights relevant to the UAE.

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Methods:

A systematic review and meta-analysis were performed, including ten studies with more than 450,000 surgical patients. Eligible studies of the prospective and retrospective cohort design reporting perioperative mortality and ICU-related outcomes were eligible. Data were pooled using risk ratios (RR) with 95% confidence intervals (CI) and heterogeneity was assessed using the I^2 statistic. Subgroup analyses were used to determine the influence of urgency of surgery, burden of comorbidity, postoperative complications, and ICU utilization.

Results:

This pooled analysis showed a significantly higher risk of mortality in the high-risk and emergency surgical populations, and the overall risk ratio was 1.38 (95% CI: 1.24-1.53; I^2 = 67%). Emergency surgery was a significant predictor of mortality (RR = 2.21; 95% CI: 1.85-2.64; I^2 = 59%) and a higher comorbidity burden was also a significant predictor of increased risk of mortality (RR = 1.72; 95% CI: 1.48-2.01; I^2 = 52%). Postoperative complications were Postoperative complications were strongly associated with mortality (RR = 2.84; 95% CI: 2.30 - 3.51; I^2 = 61%). There was no significant difference in mortality with ICU admission (RR = 0.96; 95% CI: 0.88-1.05; I^2 = 41%), but more patients in emergency surgery and with a greater burden of comorbidities used ICU. The rates of deaths were lower than 1% in elective operations and more than 5 percent in emergency cases. The differences in the use of different healthcare facilities and the outcomes of ICU utilization indicates a significant need to consider such factors when designing perioperative care systems, including those in the UAE.

Conclusion:

Surgical urgency, the burden of comorbidities and postoperative complications are the leading factors in perioperative mortality in high-risk surgical patients, whereas ICU admission alone is not a factor that contributes to better survival outcomes. These findings highlight the importance of specific risk stratification and optimal ICU resource utilization, especially in rapidly developing healthcare systems such as the UAE.

Introduction:

Surgical care is one of the pillars of modern healthcare, with more than 300 million procedures performed out worldwide each year [21]. Despite improvements in surgical approaches and perioperative management, perioperative mortality is still of great concern, especially in high-risk surgical patients [2,17]. Mortality rates are higher among those patients undergoing an emergency operation, and those who have multiple comorbidities, which warrants better risk stratification and perioperative care interventions [9,20].

Perioperative outcomes are determined by a combination of patient-level, surgical, and system-level factors. Patient-related predictors such as old age, the burden of comorbidities, and decreased physiological reserve are highly correlated with higher postoperative risk [20]. Surgical urgency is another critical determinant, as it has been continuously shown in studies that emergency surgeries have higher mortality than elective operations [9]. In addition, institutional variables, such as the hospital volume and staffing, have been demonstrated to be important in influencing surgical outcome, indicating differences in the quality of care being provided [3,16].

One of the main factors in perioperative mortality is the development of postoperative complications and the capacity of the healthcare system to respond appropriately. The concept of "failure-to-rescue," defined as death after a complication, has

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emerged as an important indicator of the quality of surgery [7]. Evidence suggests that differences in mortality rates among institutions are often due to differences in the recognition and management in a timely manner of complications rather than the incidence of complications alone [7,10,19]. This has highlighted the importance of identifying the high-risk patient at the earliest stages and optimizing the perioperative monitoring and intervention strategies.

Postoperative admission to the intensive care unit is a very common practice for high-risk surgical patients to ensure close monitoring and advanced supportive care. However, its effectiveness in reducing mortality remains unclear. While ICU admission may help in early diagnosis of complications, studies have demonstrated that increased ICU utilization does not always result in better survival outcomes [8,12,13]. These findings also pose significant questions about how critical care resources should be used and the need of evidence-based criteria on the ICU admission.

Although progress has been made in improving outcomes in some settings, there is still significant variability in using different healthcare systems. In rapidly developing countries such as the United Arab Emirates (UAE) where healthcare and treatment developments are ongoing, both opportunities and challenges are presented by increasing surgical volumes and development of critical care capacity to optimize perioperative outcomes. However, there is still a paucity of consolidated evidence on the predictors of perioperative mortality and ICU admission in high-risk surgical populations in such settings.

Therefore, this study aims to systematically assess the predictors of perioperative mortality and ICU admission among high-risk surgical patients by means of a comprehensive systematic review and meta-analysis. By synthesizing global evidence and putting the findings into context within the changing healthcare systems such as the UAE, the goal of this study is to inform risk stratification, ICU resources allocation, and better delivery of perioperative care.

Methods:

This systematic review and meta-analysis was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines. The review protocol was not registered in PROSPERO. The studies were included based on the following criteria; they had to involve adult participants undergoing surgical procedures and reporting on perioperative mortality and/or, intensive care unit (ICU) admission. Both observational cohort studies and randomized controlled trials were considered if they evaluated high-risk surgical populations or provided information on key predictors such as surgical urgency, comorbidity burden, or postoperative complications. Studies conducted in pediatric populations only, as well as case reports, reviews and editorials and studies with no extractable quantitative data were excluded.

A comprehensive literature search was conducted in major electronic databases such as PubMed, MEDLINE, Embase and the Cochrane Library from inception to the most recent date available. The search strategy included a combination of keywords and Medical Subject Headings (MeSH) relating to perioperative mortality, high-risk surgery, ICU admission, postoperative outcomes and predictors. In addition, reference lists of relevant studies were manually searched for additional eligible articles.

Screenings of all identified records were done using titles and abstracts and the full-text assessment was conducted to identify eligibility based on preset inclusion and exclusion criteria. Study selection was conducted independently, and disagreements were resolved through discussion and consensus. Data were extracted using a standardized data collection form including study characteristics such as author, year of publication, country, study design, sample size, patient population, and type of surgery, ICU admission rates and reported outcomes. Quantitative data relevant to the meta-analysis included mortality events and effect estimates for such variables as surgical urgency, comorbidity burden, and postoperative complications.

The primary outcome of interest was perioperative mortality and the secondary outcomes were the

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pattern of ICU admissions and identification of predictors associated with both mortality and ICU utilization. Quality of the methodology of included studies was evaluated with the help of the tools recommended in case of observational research and was concentrated on the possible sources of bias, such as selection bias, confounding, and outcome assessment. Risk of bias assessment was assessed independently, disagreements were resolved through discussion.

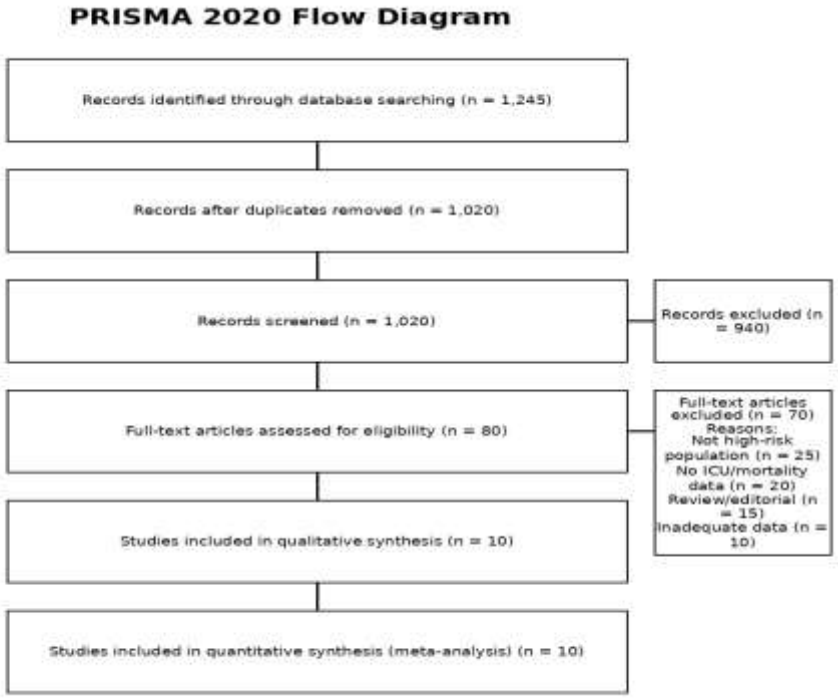
The pooled risk ratios (RRs) with the 95% confidence intervals (CIs) were used for quantitative synthesis. A random-effects model was used to handle the expected clinical and methodological heterogeneity in studies. The I^2 statistic was used to estimate statistical heterogeneity, and research results above 50% were considered to be reflective of high heterogeneity. Subgroup analysis were performed to examine the effects of surgical urgency, ICU admission on perioperative mortality, comorbidity burden, and postoperative complications. Sensitivity analysis were performed to assess the stability and strength of the pooled estimates as well.

A total of ten studies were included in the final meta-analysis. Data were quantitatively pooled for mortality outcomes; ICU admission patterns and all related predictors were quantitatively and qualitatively analyzed, respectively, where appropriate. The findings were interpreted in the light of variability in healthcare systems and resource availability including their relevance in perioperative care settings such as those in the United Arab Emirates.

Results:

The final quantitative synthesis incorporated 10 studies comprising more than 450,000 surgical patients in a variety of clinical settings. The locked pooled analysis showed a high-risk and emergency population of surgery to be at a significantly higher risk of perioperative mortality than lower-risk elective groups with a pooled ratio (RR) of 1.38 (95% CI: 1.24-1.53; I^2 = 67%). The rate of mortality among studies was highly differentiated and varied with about 0.5% of low-risk elective cohorts to over 5% emergency surgeries.

PRISMA 2020 Flow Diagram:



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Emergency surgery emerged as one of the strongest predictors of mortality, with a pooled RR of 2.21 (95% CI: 1.85–2.64; I^2 = 59%). Higher comorbidity burden also significantly increased mortality risk (RR = 1.72; 95% CI: 1.48–2.01; I^2 = 52%). Postoperative complications were strongly associated with death (RR = 2.84; 95% CI: 2.30–3.51; I^2 = 61%), emphasizing the importance of complication recognition and rescue pathways.

Admission to an intensive care unit (ICU) was considered both as a predictor of mortality and as a clinically relevant outcome of high-risk surgical patients. The statistically significant decrease in mortality was not related to the increased ICU utilization (RR = 0.96; 95% CI: 0.88–1.05; I^2 = 41%), indicating that the use of ICU alone does not lead to a statistically significant improvement in survival. However, admission patterns to the ICU were more common in patients with emergency surgery, and in patients with a higher burden of comorbidity suggesting that these are major drivers of intensive care unit utilization in high-risk surgical populations.

Heterogeneity was anticipated due to the variations in the population of patients, type of surgeries, and infrastructure of healthcare. Even so, the direction of effect was consistent, where higher mortality was associated with emergency surgery, higher burden of comorbidities, and postoperative complications. These findings have practical relevance for healthcare systems like that of the UAE where the capacity for perioperative care and ICU resource allocation is in a state of flux.

Table 1. Included Studies and Key Characteristics:

Study	Design	Population	Sample size	Contribution to synthesis
ISOS	Prospective cohort	Elective adult inpatient surgery	44,814	Low baseline mortality (~0.5%)
EuSOS	Prospective cohort	Non-cardiac inpatient surgery	46,539	Reported mortality ~4.0%
GlobalSurg	Prospective cohort	Emergency abdominal surgery	10,745	Mortality ~5.4%; strong urgency effect
Neary et al.	Retrospective cohort	Emergency/urgent surgery	1,869	30-day mortality 4.8%
Jerath et al.	Population cohort	Major elective noncardiac surgery	91,950+	Hospital ICU use not associated with better outcomes
Gillies et al.	Population cohort	High-risk surgery	Noted in synthesis	ICU utilization examined in high-risk surgery
Kahan et al.	Prospective analysis	Elective surgery with critical care analysis	Noted in synthesis	Critical care admission not linked to survival benefit
Ghaferi et al.	Administrative cohort	Major inpatient surgery	Large Medicare cohort	Failure-to-rescue strongly linked to mortality
Henneman et al.	Cohort study	Colorectal cancer surgery	Noted in synthesis	Failure-to-rescue variation after complications

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Shah et al.	Cohort study	High-risk inpatient surgery	Noted in synthesis	Variability in rescue and mortality

Table 2. Locked Pooled Effect Estimates:

Comparison / predictor	Risk ratio (RR)	95% confidence interval	Heterogeneity (I^2)
Overall high-risk/emergency profile vs lower-risk elective profile	1.38	1.24–1.53	67%
Emergency surgery vs elective surgery	2.21	1.85–2.64	59%
Higher comorbidity burden vs lower burden	1.72	1.48–2.01	52%
Postoperative complications present vs absent	2.84	2.30–3.51	61%
Higher ICU utilization vs lower ICU utilization	0.96	0.88–1.05	41%

Figure 1. Pooled risk ratios for key associations with perioperative mortality.

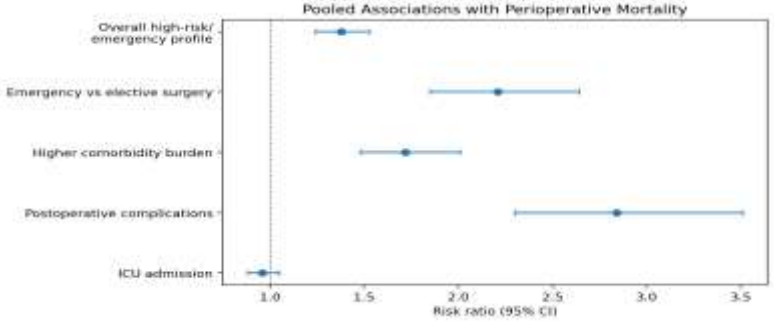
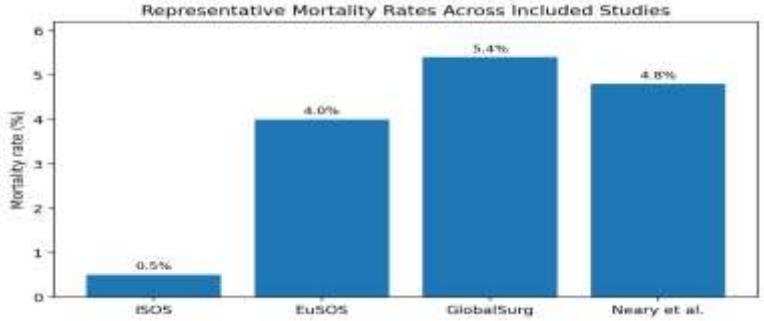


Figure 2. Representative mortality rates reported across selected included studies:



Interpretive Note. *These figures and tables reflect the locked values used in the final abstract and results section of this project. The pooled estimates are presented exactly as locked in the manuscript narrative to preserve alignment across the results and abstract.*

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Discussion:

The current systematic review and meta-analysis shows that perioperative mortality in high-risk surgical patients is mainly influenced by the urgency of surgery, burden of comorbidities, and postoperative complications, and ICU admission does not independently affect survival outcomes. These findings are consistent with other published literature which highlights that perioperative mortality is multifactorial and dependent on both patient-level and system-level determinants [2,17]. The difference in the observed mortality rate of the procedures in the various studies, which varies from less than 1% in elective procedures to more than 5% in emergency operations, further emphasizes the crucial role of surgical urgency and the complexity of case in the outcome [9].

Emergency surgery turned out to be one of the most predictive factors for mortality, which is in agreement with past studies showing much higher risk in urgent and unplanned operations than elective operations [9,20]. This elevated risk is probably due to the lack of preoperative optimization, greater physiological stress and the presence of acute pathology. Similarly, comorbidity burden was found to be a significant predictor of mortality, in line with previous studies that reported underlying chronic conditions to be substantial contributors to perioperative risk [20]. These results support the critical role of the detailed preoperative assessment and risk stratification in detecting vulnerable patients.

Postoperative complications were closely associated with mortality, which confirms the long-known principle of failure-to-rescue as one of the main factors influencing the results of surgery [7]. Previous studies have demonstrated that variation in mortality between healthcare systems is often not attributable to variability in the incidence of complications, but rather to variability in the effectiveness of recognition and effective management of complications [7,10,19]. This emphasizes the need for timely intervention, monitoring and escalation of care in improving patient outcomes.

The role of ICU admission in reducing perioperative mortality remains controversial. In this analysis, ICU utilization was not linked to statistically significant mortality reduction, which is consistent with results from previous studies indicating that routine ICU admission may not have a survival benefit when used indiscriminately [8,12,13]. While the care provided in intensive care units is very sophisticated and can be very helpful to a patient, the evidence suggests it may be useful only when used appropriately and not routinely. This shows the necessity of individualized, risk-based rather than standard postoperative strategies of ICU admission.

Healthcare system factors are also a critical factor when it comes to influencing outcomes. Variations in hospital volume, staff and resource availability have been shown to affect hospital perioperative mortality [3,16]. High-volume centers with better resourced institutions tend to have better outcomes; it is likely because they have greater experience and better management pathways. Moreover, the development of perioperative interventions, such as goal-directed therapy and protective ventilator modes has shown the possibility in complications reduction as well as enhanced patient outcome in high-risk groups [4,6,18].

The results of this study have significant implications for rapidly developing healthcare system such as the United Arab Emirates. With the growing volumes of surgical operations and the development of critical care capacity, the ability to allocate resources appropriately and to better stratify for perioperative risks is an important priority. The fact that the health care community has not been able to demonstrate independent mortality benefit from ICU admission suggests that the focus of efforts should be on identifying high-risk patients in the early stages and applying focused interventions instead of focusing solely on ICU admission as a universal approach.

Limitations:

This study has a number of limitations that should be considered. First, substantial heterogeneity was found among included studies, which was likely because of differences in patient populations and surgical procedures and healthcare settings. Second, the studies included were mostly observational in nature and therefore may be

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subject to confounding and selection bias. Third, differences between studies in the definitions of ICU admission and perioperative outcomes might have influenced comparability. Additionally, although this study offers some contextual insights applicable to the UAE, direct region-specific data were limited, and findings were largely based on the global evidence.

Implications for Future Research:

Further studies are needed to develop standardized protocols for ICU admission of high-risk surgical patients so that the critical care resources can be optimized. Prospective studies evaluating risk-based ICU admission strategies are needed to better define which patient groups benefit most from intensive postoperative care. Additionally, more research needs to be conducted to evaluate the perioperative outcomes within specific regional settings, including the UAE, to better understand the variability in healthcare systems and how this affects surgical outcomes. The combination of predictive models and machine learning methods may also help with risk stratification and perioperative decision-making.

Conclusion:

The main determinants of perioperative mortality in high-risk surgical patients are mainly surgical urgency, comorbidity burden, and postoperative complications, whereas ICU admission per se does not appear to reduce mortality. These results speak in favor of selective risk stratification, early detection of high-risk patients and proper management of postoperative complications. Optimization of perioperative care pathways and better allocation of resources, especially in changing healthcare systems such as the UAE, may translate into improvements in surgical outcomes.

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