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Need for better risk models in very elderly surgery: evaluating ACS-NSQIP in patients ≥85 years

SYMPTOMATIC CHOLELITHIASIS

- Pancreatitis
- Cholecystitis
- Cholangitis
- Biliary colic

TREATMENT OF CHOICE

Laparoscopic cholecystectomy

↓

IS IT SAFE FOR ELDERLY PATIENTS?

WHAT TOOLS CAN WE USE TO GUIDE DECISION-MAKING?

STUDY POPULATION

Patients ≥ 85 years of age who underwent cholecystectomy for symptomatic cholelithiasis

ACS-NSQIP RISK CALCULATOR

The predictions of this calculator were compared with the actual results collected from each patient.

STATISTICAL ANALYSIS

- Discrimination: AUC
- Calibration: Brier Score, Spiegelharter test, d-values.

ACS-NSQIP is a **useful tool** for predicting post-operative complications in elective surgery

Good calibration and discrimination

In emergency surgery, the model underestimated the actual risk

XXX, et al.

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Need for better risk models in very elderly surgery: evaluating ACS-NSQIP in patients ≥ 85 years

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ABSTRACT

Background: cholecystectomy is the treatment of choice for symptomatic cholelithiasis, although its safety in very elderly patients remains a cause for concern. Accurate risk prediction tools are essential to guide decision-making in this vulnerable population.

Methods: a retrospective cohort study was conducted that included patients ≥85 years of age who underwent cholecystectomy for symptomatic cholelithiasis in a tertiary hospital. Clinical and surgical variables were collected, and postoperative complications were classified according to Clavien-Dindo. The American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) risk calculator was applied to each patient. Discrimination was evaluated using the area under the curve (AUC) and calibration using the Brier score, Spiegelhalter test, standardized differences (d-values), and overlap between observed and predicted probabilities.

Results: eighty-five patients were included, 65 (76.5%) elective and 20 (23.5%) urgent. Overall morbidity was 32.9% and mortality was 4.7%, both significantly higher in urgent surgery (60% and 15%) than in elective surgery (24.6% and 1.5%). The ACS-NSQIP showed good discrimination in the overall cohort for any complication (AUC 0.741) and serious complications (AUC 0.760), with satisfactory performance for cardiac complications, surgical site infection, and mortality, but limited performance for renal failure and sepsis. In elective surgery, calibration was adequate, with concordance between observed and predicted outcomes. In urgent surgery, the model markedly underestimated the actual risk, especially for complications (60% vs. 17%) and mortality (15% vs. 3.3%).

Conclusions: in patients ≥85 years of age, ACS-NSQIP adequately predicts risk in elective cholecystectomies but underestimates morbidity and mortality in urgent surgery. The incorporation of frailty parameters and geriatric assessment could improve perioperative decision-making in this high-risk population.

Keywords: Cholecystectomy. Elderly. Postoperative complications. ACS-NSQIP. Emergency surgery.

INTRODUCTION

Laparoscopic cholecystectomy (LC) is the treatment of choice for symptomatic cholelithiasis (1). The aging of the population, coupled with the increased incidence of gallstones related to advanced age, inevitably leads to consideration of a greater number of surgical interventions in elderly patients for cholelithiasis. According to the findings of the MICOL study (the Multicenter Italian Study on Cholelithiasis), the prevalence of gallstones at age 70 was 15% and 24%, and at age 90 it was 24% and 35% in men and women, respectively. In addition, the prevalence increased to 80% in institutionalized individuals aged 90 years or older(2). The treatment of general surgical pathologies in elderly patients, including cholelithiasis, often presents more complex medical-surgical scenarios than in the general population(3,4). In fact, conservative and non-surgical approaches, such as transduodenal endoscopic drainage or percutaneous drainage (cholecystostomy), are becoming increasingly common in high-risk patients (5,6). For this reason, there is growing interest in incorporating other clinical factors into decision-making, in addition to the severity of the disease. For example, the latest 2018 revision of the Tokyo Guidelines includes the Charlson Comorbidity Index (CCI) and the American Society of Anesthesiologists (ASA) Classification as indicators for selecting the most appropriate treatment for acute cholecystitis (7,8). Guidelines that focus on these data related to cholecystectomy in elderly patients are often based on limited series(3,9).

Several postoperative complication prediction scales have been used to predict the risk of postoperative complications following acute cholecystitis (Chole-Risk, CHOLE-POSSUM (PS) physiological scores, mFI, or severity grade according to the Tokyo guidelines)(8,10–12). Although some guidelines have attempted to provide management recommendations, most of these scales are generic and do not specifically address biliary disease pathology in elderly patients(9). In 2004, the

American College of Surgeons launched the National Surgical Quality Improvement Program (ACS-NSQIP) to collect real-time quality data from hospitals to improve patient care, reduce surgical complications and morbidity, and provide tools for decision-making. Although not specific, it has calibrated models for cholecystectomy (laparoscopic and open, urgent and elective). It can also predict complications after cholecystectomy, such as wound infection, pneumonia, mortality, etc. The relevance of this score lies in the fact that it includes a specific section for the elderly population ((13,14).

The objective of our study was to evaluate the ability of the ACS-NSQIP score to correctly predict postoperative complications in a cohort of elderly patients undergoing cholecystectomy at our center.

MATERIALS AND METHODS

Study design and sample selection

A retrospective, observational study was conducted in a tertiary hospital, including all patients over 85 years of age who underwent cholecystectomy for symptomatic cholelithiasis between January 2022 and December 2025. Patients with acalculous cholecystitis, those treated with non-surgical procedures (percutaneous cholecystostomy and/or endoscopic drainage), as well as those with incomplete medical records or follow-up of less than 90 days were excluded. The final sample included 85 patients, of whom 65 underwent elective surgery and 20 underwent emergency surgery.

Clinical and analytical variables

Demographic variables (age, sex), clinical variables (comorbidities, ASA classification, Charlson index), and surgical variables (type of surgery, urgent or elective nature, need for conversion to open surgery, and hospital stay) were analyzed. Postoperative complications were systematically recorded and classified according to the Clavien-Dindo classification at 30 days postoperatively(15). Specific complications (surgical site infection, sepsis, cardiac complications, renal failure, bile leakage, intra-abdominal collections, among others) were also analyzed, as well as mortality and hospital readmission at 30 days.

Postoperative complications were identified through a standardized adjudication process. Two investigators (LD. J. and C.H.) independently reviewed the electronic medical record and recorded all complications occurring within 30 postoperative days. A senior reviewer (E.L.), blinded to the ACS-NSQIP predicted risk estimates, evaluated discrepancies and assigned the final classification. Complications were categorized according to the Clavien–Dindo classification.

ACS-NSQIP test

The predictive capacity of postoperative complications was evaluated using the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) score. This program is a multicenter, prospective database designed to improve the quality of surgical care through the standardized collection of clinical variables and 30-day outcomes.

For each patient in the cohort, clinical and surgical data were manually entered into the official ACS-NSQIP online calculator *(https://riskcalculator.facs.org/RiskCalculator/)*, obtaining an individualized risk estimate. The tool provides predictions for multiple outcomes: overall morbidity, serious complications, mortality, hospital readmission, reoperation, and specific complications (surgical site infection, sepsis, renal failure, cardiac complications, pneumonia, and need for discharge to a social health center).

The actual complications in the sample were collected individually and classified according to Clavien-Dindo, subsequently establishing two categories of analysis: any complication and serious complications, in accordance with the categorization used by ACS-NSQIP. This correspondence allowed for direct comparison between the events observed in the cohort and the probabilities predicted by the scale.

Serious complications according to ACS-NSQIP were considered to be cardiac arrest, myocardial infarction, pneumonia, progressive renal failure, acute renal failure, pulmonary embolism, venous thrombosis, reoperation, deep surgical site infection, sepsis, unplanned intubation, urinary tract infection, and evisceration.

Ethical issues

All procedures performed on human participants were in accordance with the ethical standards of the research committee, the 1964 Declaration of Helsinki and its subsequent amendments, or comparable ethical standards. Our Pharmacological Research Ethics Committee approved the study.

Statistical analysis

Quantitative variables were expressed as mean (and standard deviation) or median (and interquartile range), depending on the distribution of the variable. Qualitative variables were described as absolute frequencies and percentages. The comparison between elective and emergency surgery patients was performed using the χ^2 test or Fisher's exact test for qualitative variables, and Student's t-test or Mann-Whitney U test for quantitative variables. The discriminative capacity of the ACS-NSQIP model was evaluated in two dimensions. Discrimination was analyzed using ROC curves and calculation of the area under the curve (AUC) with 95% confidence intervals. Calibration was examined using Spiegelhalter's Z statistic, the Brier score, and the standardized difference (d-value) between the observed and predicted probabilities, together with the percentage overlap between the two distributions. Spiegelhalter's Z evaluates whether the model systematically under- or overestimates risk; non-significant values ($p>0.05$) indicate acceptable calibration. The d value quantifies the magnitude of miscalibration: values close to zero reflect good agreement, whereas values above approximately 0.1–0.2 denote clinically relevant deviations. Positive d values indicate underestimation of risk, while negative values suggest overestimation.

A p-value <0.05 was considered statistically significant, and all ranges were calculated for a 95% confidence interval. SPSS version 25.0 *(SPSS Inc., Chicago, IL, USA)* and R v4.2.2 *(R Foundation for Statistical Computing, Vienna, Austria)* statistical packages were used for statistical analysis. Although the study is retrospective by design, all variables were obtained from structured electronic medical records and the institution's prospective surgical database, where perioperative information is routinely and comprehensively collected. As a result, missing data were minimal (<5%) and limited to non-clinical administrative fields. No systematic pattern of missingness was identified, and therefore a complete-case analysis was performed.

RESULTS

Baseline characteristics

Clinical and demographic characteristics are shown in Table 1. The mean age of the cohort was 87.9 years (± =2.3), with no differences between elective and emergency patients. The majority were women (61.2%), with distribution between groups.

At baseline, almost half of the patients had a Charlson index ≥5, with a higher proportion in the emergency surgery group (60% vs. 41.5%). The ASA classification reflected greater severity in this same group, with 75% ASA III–IV compared to 44.6% in the elective group (p=0.02).

Among comorbidities, hypertension (68.2%) and diabetes mellitus (30.6%) were the most frequent, with no significant differences between groups. Ischemic heart disease (14.1%), heart failure (10.6%), chronic obstructive pulmonary disease (11.8%), and chronic kidney disease (8.2%) were present in lower proportions, with similar distributions between elective and emergency patients.

Postoperative complications (Table 1)

Overall morbidity was 32.9%, significantly higher in urgent procedures (60.0%) than in elective procedures (24.6%; p=0.003). Serious complications were recorded in 14.9%, also more frequent in the urgent group (30% vs. 9.2%; p=0.020). Among specific complications, the most common were cardiac complications (9.4%) and surgical site infection (9.4%), with a higher incidence of cardiovascular events in urgent surgery (20% vs. 6.2%). Other complications such as renal failure (5.9%), intra-abdominal collections (5.9%), bile leaks (2.4%), or reoperation (1.2%) were observed in a lower proportion and without significant differences between groups.

The Clavien-Dindo classification showed a predominance of mild complications (grade I: 13.5%), although urgent procedures had a higher proportion of serious complications. Overall mortality was 4.7%, with significant differences between groups (15% in urgent vs. 1.5% in elective; p=0.039).

Overall performance of ACS-NSQIP (Figure 1)

In the entire cohort, ACS-NSQIP showed adequate discriminatory power for predicting postoperative complications, with an AUC of 0.741 (95% CI: 0.63–0.85) for any complication and 0.760 (95% CI: 0.62–0.90) for serious complications. Performance was also satisfactory for cardiac complications (AUC 0.755), surgical site infection (AUC 0.696), and mortality (AUC 0.747), while it was limited for renal failure (AUC 0.351) and sepsis (AUC 0.272).

The complementary calibration analysis, shown in Tables 2 and 3 showed adequate correspondence between observed and estimated probabilities for most outcomes in the overall cohort, with low *d* values and overlap percentages generally above 90%.

ACS-NSQIP performance by complication and type of surgery (Tables 2 and 3)

When stratified by type of procedure, the model showed different behavior. In elective surgery, discrimination was acceptable for overall complications (AUC 0.689) and serious complications (AUC 0.661), with good calibration and very close observed and predicted rates for both morbidity and mortality. D values were close to 0, and Spiegelhalter's Z was non-significant, indicating no systematic under- or

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overestimation.

In urgent surgery, discrimination was high (AUC 0.870 for any complication and 0.780 for serious complications), but calibration was poor, with a clear underestimation of the actual risk. Thus, the observed complication rate was 60% compared to the predicted 17%, and mortality was 15% compared to 3.3%. This pattern was also observed in sepsis (15% vs. 1.4%). Correspondingly, d values exceeded clinically relevant thresholds (>0.2), and Spiegelhalter's Z indicated significant miscalibration. The percentage overlap between predicted and observed distributions was also markedly reduced. Figure 2 graphically illustrates these standardized differences, showing that in urgent procedures the deviation between the observed and estimated values was systematic and more pronounced than in elective procedures.

DISCUSSION

Our findings reveal that ACS-NSQIP has adequate discriminatory power to predict postoperative complications in the entire cohort of elderly patients, with an AUC of 0.741 for any complication and 0.760 for serious complications. This performance was particularly satisfactory for predicting cardiac complications, surgical site infection, and mortality.

Calibration in the overall cohort was also adequate, with good agreement between observed and estimated probabilities for most outcomes. These results are consistent with previous studies, such as that by D'Acapito et al. (which also found very high discrimination of the ACS-NSQIP model for mortality (c-statistic: 0.957) and serious complications (c-statistic: 0.755) in octogenarian patients undergoing cholecystectomy. However, when stratified by the nature of the intervention (elective vs. urgent), we observed critical differences in the model's performance (16). In elective surgery, discrimination was acceptable (AUC 0.689 for overall complications and 0.661 for serious complications) and, crucially, showed good calibration, with observed and predicted rates very close for both morbidity and mortality. This suggests that, in elderly patients who are carefully selected for elective surgery, the tool is valuable for risk assessment. A similar finding in D'Acapito et al. showed that the observed mortality in elective cholecystectomies in octogenarians was zero and fell within the 95% confidence interval of the ACS-NSQIP model, with a predicted mortality of 1.5%. Although D'Acapito et al. reported a worsening of the discriminatory ability for elective surgery, they attributed this to a "floor effect" due to the low event rate in this low-risk group (16).

In contrast, in urgent surgery, although discrimination was high (AUC 0.870 for any complication and 0.780 for serious complications), calibration was notably poor in our study, showing a clear underestimation of the actual risk. For example, the observed complication rate was 60% versus 17% predicted, and the observed mortality was 15% versus 3.3% predicted. Figure 1 graphically illustrates these standardized deviations, which were systematic and more pronounced in urgent procedures compared to elective ones. This is a finding of great clinical relevance, as a model that underestimates risk can lead to suboptimal decisions and inadequate preparation for complications. It is important to note an apparent divergence in the calibration results for urgent surgery with respect to D'Acapito et al (16). In their study, for emergency cholecystectomy in octogenarians, the ACS-NSQIP model showed very high discriminatory power (c-statistic: 0.933 for mortality) and, notably, excellent calibration. The differences between our findings (clear underestimation) and those of D'Acapito et al. (excellent calibration with slight overestimation for mortality/serious complications) could be due to specific characteristics of the study cohorts (our cohort is even older than that of D'Acapito et al.), specific definitions of complications, or the origin of the data (single-center study vs. multi-institutional program). What both studies do agree on is the complexity of risk assessment in emergency settings for elderly patients, where accurate prediction is critical.

The presence of frailty and comorbidities is a determining factor in the results. In our cohort, comorbidities were frequent, with hypertension (68.2%) and diabetes mellitus (30.6%) being the most common. The Charlson index was ≥5 in almost half of the patients, with a higher proportion in those undergoing emergency surgery (60.0% vs. 41.5%). The ASA classification also reflected greater severity in this group. A study using NSQIP data conducted by Lee et al. ((17)in octogenarians (≥80 years) also

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confirmed that being an octogenarian is an independent risk factor for increased mortality (OR 3.29) and serious complications (OR 1.54) after cholecystectomy. This study highlighted that complete functional dependence was the factor associated with the highest probability of serious complications (OR 3.77) and mortality (OR 4.81). Functional dependence is an easy part of the medical history to obtain and can provide a quick insight into significantly increased surgical risk. In addition, the choice of surgical technique is a modifiable risk factor. Lee et al. found that octogenarians were more likely to undergo open cholecystectomies (7.2% vs. 2.8% in non-octogenarians). However, minimally invasive surgery was significantly protective against serious complications (OR 0.30) and mortality (OR 0.29) in octogenarians. This underscores the importance of optimizing elderly patients to maximize the likelihood of success with laparoscopic approaches and considering alternative rescue procedures before converting to open surgery. However, it is important to emphasize that, despite age, the surgical approach to gallstone disease is associated with fewer long-term complications. Asmar et al.(18)found that nonoperative management (NOM) of acute cholecystitis in frail geriatric patients was associated with significant morbidity and mortality. In their study, the NOP failure rate at 6 months was 18.9%, with higher mortality in the NOP group (5.2% vs. 3.2% in the operated group). Both antibiotic treatment alone and percutaneous drainage were associated with an independent increase in mortality. The CHOCOLATE study (19) also supported high recurrence rates of gallstone-related diseases in the percutaneous drainage group, with poor long-term disease resolution. Giraud et al. (20) also emphasized that nonoperative management in the elderly is risky, with a high failure rate of delayed elective cholecystectomy (44% in patients ≥75 years vs. 18% in <75 years), mainly due to the decision to refrain from surgery because of physical deterioration or excessive comorbidities, or because of the patient's refusal to undergo surgery. All these data suggest that surgical treatment is the best option even in elderly patients. However, the possible higher morbidity of urgent surgery, combined with poorer calibration of the scales in these scenarios, probably translates into the need to identify specific tools in this population group that are adapted to surgical scenarios.

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Our study has several limitations. Firstly, it is retrospective and single-centre, and secondly, the sample size is small, particularly for urgent surgery. Furthermore, the sample size was small, and the number of postoperative events was too low to develop a reliable risk model. While this was not the study's primary objective, such a model would have been useful, particularly given the limited effectiveness of existing tools in this subgroup. Regarding the results of emergency surgery, the observed underestimation is clinically consistent with the greater baseline frailty and frequent acute physiological deterioration seen in very elderly patients undergoing unplanned procedures. However, this finding should be interpreted with caution, as the small sample size limits the accuracy of the estimates. While we consider this to be a clinically relevant result, the miscalibration observed in this group should be treated as exploratory and hypothesis-generating rather than definitive. In addition to all of the above, a further limitation is the absence of geriatric-specific variables, such as frailty and functional dependency. These parameters are not routinely collected in our institution and are only recorded when patients are referred to the geriatric department, which is neither systematic nor possible in urgent surgery cases. While our dataset was complete for all routinely collected variables, the absence of these geriatric factors may have affected the performance of the model, particularly in urgent cases. Despite these limitations, this study provides valuable insights into the application of a standardised tool in a population of very elderly patients, a group that is traditionally underrepresented in the literature.

CONCLUSION

In patients ≥85 years undergoing elective cholecystectomy, ACS-NSQIP proved to be a useful tool with good discriminatory power and adequate calibration for predicting postoperative complications. In emergency surgery, however, the model showed a tendency to underestimate the actual risk. Although this finding is clinically relevant, it should be interpreted with caution due to the small sample size and considered exploratory rather than definitive. Comprehensive preoperative assessment, as well as cooperation between geriatricians and surgeons, is essential to adapt management goals and improve outcomes in this vulnerable population.

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Conflict of Interest/Disclosure

The authors have no conflicts of interest to declare.

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Table 1. Basal characteristics and surgical results				
Results	Overall N=85	Elective N=65	Urgent n=20	P value
Age (years)	87.84 ± 2.23	87.62 ± 2.17	88.57 ± 2.34	0.095
Male sex (%)	43.5 (37)	46.2 (30)	35 (7)	0.379
Hypertension	85.9 (73)	81.5 (53)	100 (20)	0.038
Diabetes Mellitus	21.2 (18)	23.1 (15)	15 (3)	0.544
Ischemic heart disease	11.8 (10)	9.2 (6)	20 (4)	0.236
Heart failure	10.6 (9)	9.2 (6)	15 (3)	0.434
Peripheral vascular disease	8.2 (7)	7.7 (5)	10 (2)	0.665
Stroke/TIA	12.9 (11)	10.8 (7)	20 (4)	0.278
COPD	10.6 (9)	9.2 (6)	15 (3)	0.434
Liver disease	9.4 (8)	10.8 (7)	5 (1)	0.674
Chronic kidney disease	10.6 (9)	9.2 (6)	15 (3)	0.434
Active malignancy	2.4 (2)	3.1 (2)	-	1.000
Metastasis	1.2 (1)	1.5 (1)	-	1.000
Immunosuppression	4.7 (4)	3.1 (2)	10 (2)	0.234
ASA				0.008
- **II**	41 (48.2)	55.4 (36)	25 (5)	
- **III**	40 (47.1)	43.1 (28)	60 (12)	
- **IV**	4 (4.7)	2.5 (1)	15 (3)	
Charlson	5.12 ± 1.4	5.12 ± 1.4	5 ± 1.16	0.949
Dependency				0.087
- **Partial dependency**	16.5 (14)	13.8 (9)	25 (5)	
- **Total dependency**	1.2 (1)	-	5 (1)	
Cognitive impairment	7.1 (6)	4.6 (3)	15 (3)	0.139
Surgical indication				0.448
- **Cholecystitis**	51	55.4 (36)	100 (20)	
- **ERCP**	11	13.8 (9)	-	
- **Pancreatitis**	13	16.9 (11)	-	
- **Biliary colic**	10	13.8 (9)	-	
Previous cholecystostomy	17.6 (15)	20 (13)	10 (2)	0.504
Laparoscopic approach				0.031

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Table 2. Discriminative performance of ACS-NSQIP for postoperative outcomes in the overall, elective and urgent cohorts

	Overall	Elective			Urgent		
	AUC (IC 95%)	**c-statistic (IC 95%)**	Spiegelhalter z	**Brier score**	**c-statistic (IC 95%)**	Spiegelhalter z	**Brier score**
Any Complication	0.741 (0.63-0.85)	0.689 (0.48-0.89)	3.37	0.079	0.870 (0.69-1.00)	5.119	0.373
Serious Complication	0.760 (0.62-0.90)	0.661 (0.52-0.80)	0.46	0.206	0.780 (0.58-0.99)	2.062	0.204
Cardiac Complication	0.755 (0.56-0.95)	0.746 (0.51-0.97)	2.18	0.058	0.734 (0.27-1.00)	4.557	0.174
SSI	0.696 (0.54-0.85)	0.720 (0.57-.87)	2.38	0.101	0.868 (0.71-1.00)	0.365	0.044
UTI	0.827 (0.74-0.91)	-	-	-	0.632 (0.41-0.85)	1.212	0.048
Renal Failure	0.351 (0.07-0.63)	0.505 (0.14-0.86)	2.16	0.045	0.125 (0.00-0.29)	5.443	0.099
Readmission	0.591 (0.45-0.73)	0.591 (0.43-0.74)	0.88	0.045	0.639 (0.41-0.86)	0.061	0.088
Return to OR	0.810 (0.72-0.89)	0.844 (.75-0.93)	0.13	0.015	-	-0.686	0.0008
Discharge to Nursing or Rehab Facility	0.738 (0.58-0.89)	0.726 (0.61-0.83)	-2.00	0.052	0.737 (0.53-0.93)	-2.194	0.118
Sepsis	0.272 (0.00-0.57)	0.352 (0.21-0.49)	0.13	0.015	0.225 (0.00-0.56)	5.177	0.148
Death	0.747 (0.499-0.99)	0.438 (0.31-0.56)	-0.29	0.016	0.804 (0.53-1.00)	2.929	0.097

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Table 3. Calibration of ACS-NSQIP in elective and urgent surgery: observed vs predicted risk and agreement metrics

	Elective				Urgent			
	Observed probability	**Predicted probability**	**d**	**Overlap (%)**	**Observed probability**	**Predicted probability**	**d**	**Overlap (%)**
Any Complication	0.246	0.086	0.44	84%	0.60	0.17	0.985	57
Serious Complication	0.092	0.073	0.06	98.1%	0.30	0.14	0.393	84
Cardiac Complication	0.062	0.010	0.28	94.8%	0.20	0.029	0.557	
SSI	0.108	0.022	0.31	91.4%	0.05	0.035	0.074	98,5
UTI	-	0.010	-	-	0.05	0.016	0.191	96.6
Renal Failure	0.046	0.004	0.27	95.8%	0.10	0.006	0.429	90.6
Readmission	0.123	0.081	0.13	95.8%	0.10	0.096	0.013	99.6
Return to OR	0.015	0.012	0.025	99.7%	0.00	0.023	-0.21	97.7
Discharge to Nursing or Rehab Facility	0.031	0.123	-0.35	90.8%	0.05	0.267	-0.62	78.3
Sepsis	0.015	0.012	0.025	99.7%	0.15	0.014	0.511	86.4
Death	0.015	0.019	-0.03	99.6%	0.15	0.033	0.414	88.3

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Figure 1. ROC curves of the ACS-NSQIP score for predicting postoperative outcomes

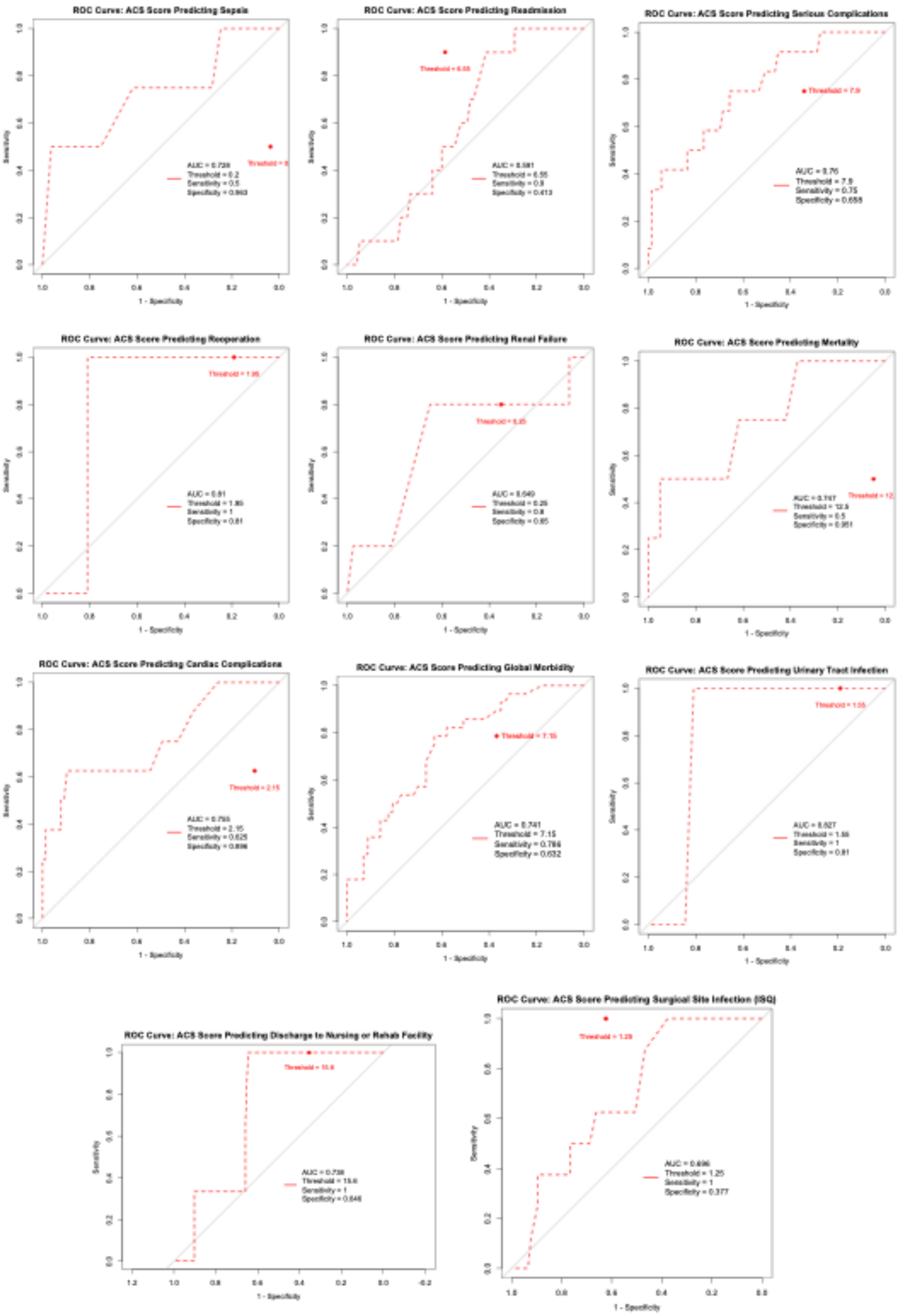

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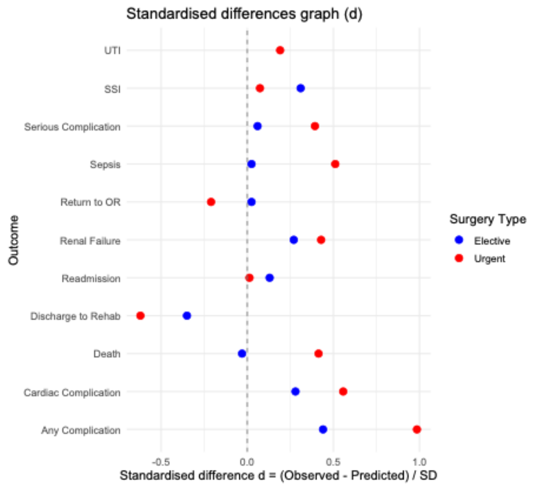
Figure 2. Standardised differences (d-values) between observed and predicted outcomes for elective and urgent surgery



Bars represent the standardised difference between observed and predicted probabilities for each postoperative outcome (d = (observed – predicted)/SD). Values close to zero indicate good calibration. Positive values indicate underestimation of risk by the ACS-NSQIP model, whereas negative values reflect overestimation. A systematic underestimation is observed in urgent procedures compared with elective surgery.

Supplementary figure 1. STROBE flow chart.