# Supporting Information



**(a)** Logistic Regression  **(b)** ElasticNet
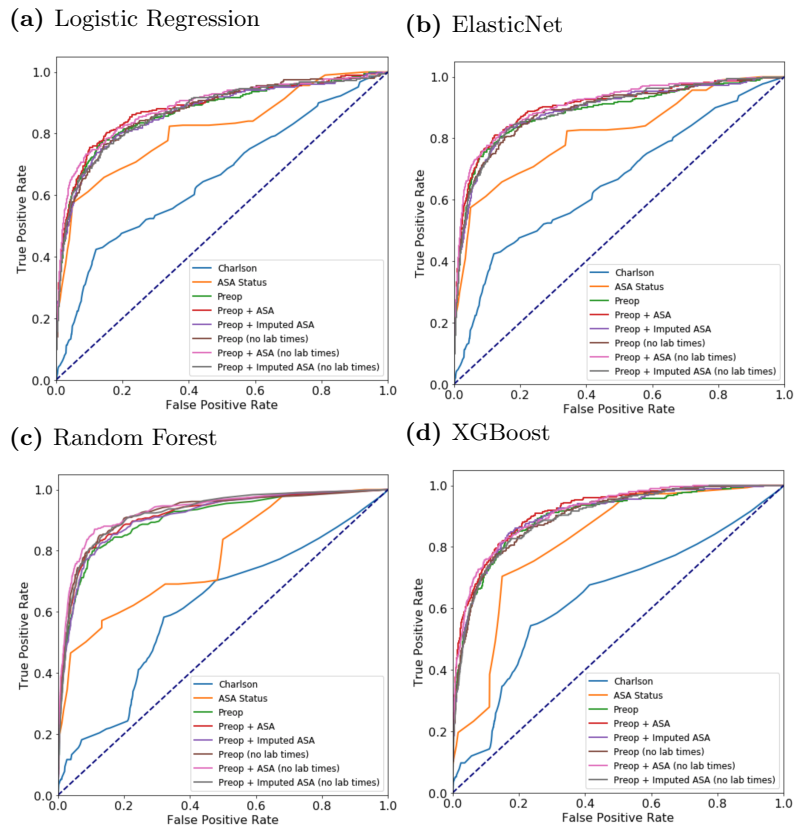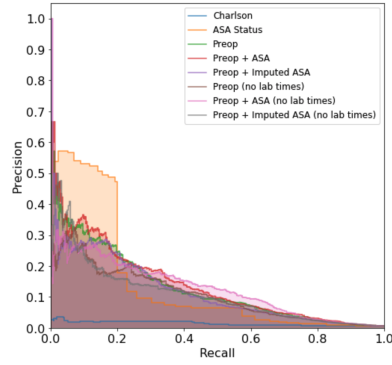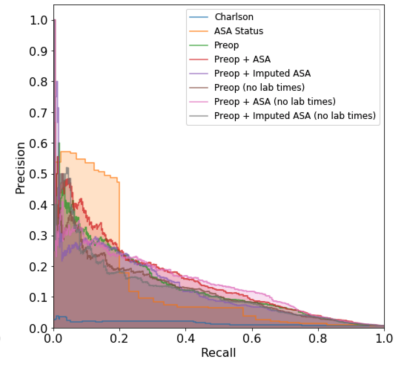
**(c)** Random Forest  **(d)** XGBoost

**Fig S1. Receiver Operating Characteristic (ROC) curves** ROC curves show the false positive rate on the x-axis and the true positive rate on the y-axis. The optimal point is the upper-left corner. Plots were generated using cross-validated predictions on entire dataset. Models that use preoperative features consistently outperform models that only use Charlson score or ASA status. Logistic Regression (a) and ElasticNet (b) (linear models) outperform Random Forest (c) and XGBoost (d) (non-linear models) when using a single input feature. However, non-linear models (c, d) outperform linear models (a, b) when using multiple features.

**(a)** Logistic Regression



**(b)** ElasticNet



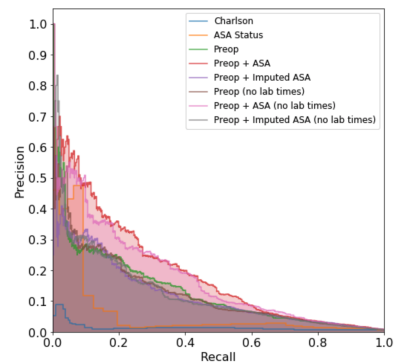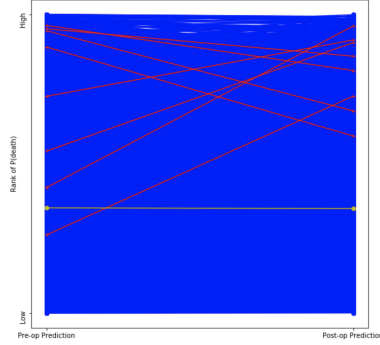**(c)** Random Forest
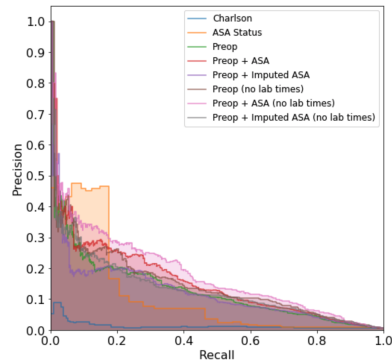


**(d)** XGBoost



**Fig S2. Precision-recall (PR) curves** PR curves show the recall on the x-axis and precision on the y-axis. The optimal point is in the upper-right corner. Figs (a) and (b) show that the linear models have very similar PR curves. The gradient boosted trees model (d) has better precision-recall compared to the random forest (c).

**(a)** ASA Status $= 2$
$(\rho = 0.127, p = 1.313e^{-71})$

**(b)** ASA Status $= 3$
$(\rho = 0.393, p = 0.0)$
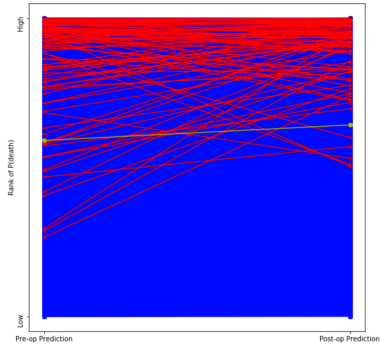
**(c)** ASA Status $= 4$
$(\rho = 0.523, p = 1.823e^{-194})$
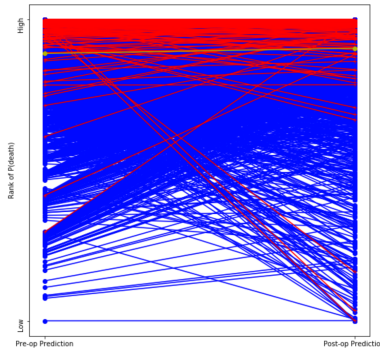
**(d)** ASA Status $= 5$
$(\rho = 0.521, p = 3.306e^{-10})$
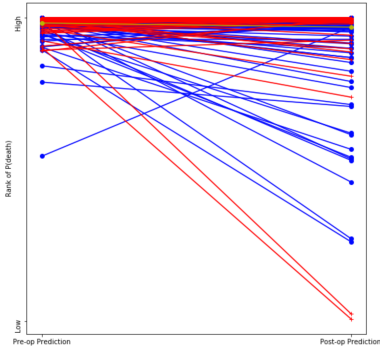
**Fig S3. Change in preoperative and postoperative mortality prediction rank** Points on the left of the plot are preoperative predictions of mortality, and points on the right are postoperative predictions of mortality. The preoperative probability predictions were ranked from highest to lowest, and for each patient a line from the preoperative prediction is then connected to the rank in list of sorted postoperative predictions. If a point does not change its rank in the list of risk scores, then the line will be straight across. Otherwise if the rank increased, it will have positive slope, or negative slope if it decreased. Blue lines are patients that survived surgery, and red lines are in-hospital mortalities. The median survivor points are displayed by the yellow line. Spearman rank-order correlation coefficient and p-value are shown above each plot.

3
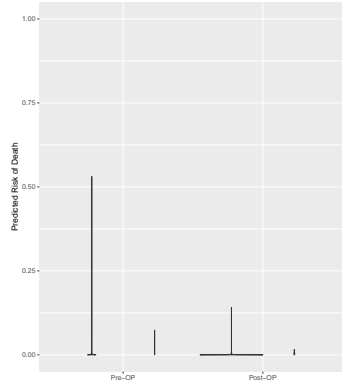
**(a)** ASA Status = 2

**(b)** ASA Status = 3
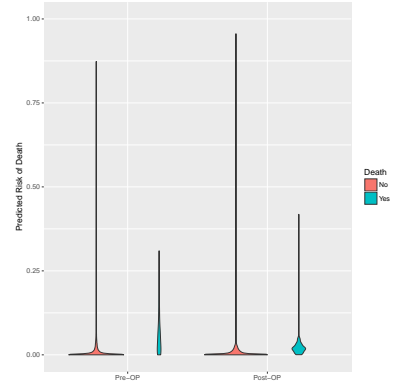
**(c)** ASA Status = 4
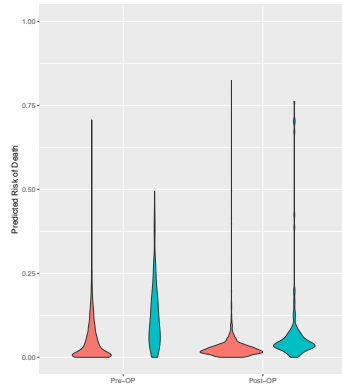
**(d)** ASA Status = 5
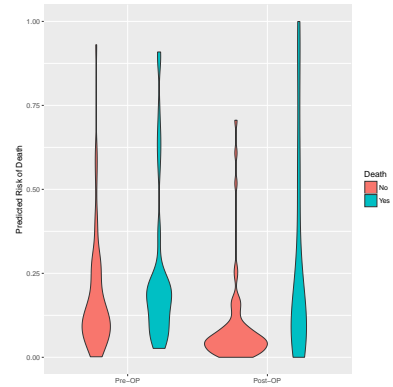
**Fig S4. Comparison of preoperative and postoperative mortality prediction using risk scores** Violin plots showing the distributions of mortality risk, stratified by ASA status. Preoperative risk (2 left violins of each plot) and postoperative risk (right 2 violins of each plot) are shown in each plot. Red violins are patients that died during surgery, and blue violins are survivors.
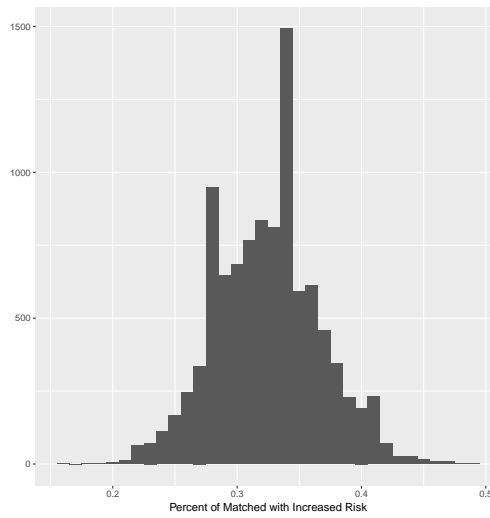
**Fig S5. Null distribution of increasing risk for matched individuals based on similar pre-operative scores** For each individual who died, we found a matched individual who falls within one percentile of the pre-operative risk percentile of the individual that died. We then calculated the number of individuals in this matched set who had increased chance of death for their post-operative score. We repeated this process 10,000 times. This histogram represents the percent of matched individuals that have a higher post-operative score than pre-operative score. We restrict our analysis to individuals who fall in less than the ninety-fifth percentile.

**Table S1. Feature List**

| Feature | Fraction of Values Missing |
|---|---|
| HCUP CODE | 0.043 |
| AGE | 0.0 |
| HRS ADMSN TO SURGERY | 0.009 |
| BICARBONATE | 0.939 |
| CHLORIDE | 0.136 |
| CREATININE | 0.259 |
| GLUCOSE | 0.228 |
| HEMOGLOBIN | 0.123 |
| INR | 0.282 |
| PLATELET COUNT | 0.255 |
| PROTHROMBIN TIME | 0.293 |
| POTASSIUM | 0.132 |
| SODIUM | 0.134 |
| UREA NITROGEN | 0.148 |
| WHITE BLOOD CELL COUNT | 0.259 |
| ALBUMIN | 0.361 |
| ALKALINE PHOSPHATASE | 0.362 |
| ALT | 0.334 |
| AST | 0.329 |
| BNP | 0.923 |
| BILIRUBIN TOTAL | 0.373 |
| SYS BLOOD PRESSURE | 0.005 |
| DIAS BLOOD PRESSURE | 0.005 |
| SYS PAP | 0.986 |
| DIAS PAP | 0.986 |
| PULSE | 0.007 |
| SPO2 | 0.012 |
| ECHO EF | 0.793 |
| HEIGHT IN | 0.015 |
| WEIGHT KG | 0.009 |
| BMI | 0.014 |
| ASA STATUS | 0.0 |
| GENDER | 0.0 |
| PAT CLASS | 0.0 |
| PRE SURG LOCATION | 0.004 |

Preoperative features used in the model. All features are readily available via the EHR system prior to surgery. HCUP codes are included as features, but not shown in this table. Refer to Table S2 for a full list of HCUP codes.

## Table S2. Comparison of HCUP codes between overall surgeries and surgeries with death

| HCUP | Count | Percent | $P(D|HCUP)$ | Rank Overall | Rank Death | Rank $P(D|HCUP)$ |
|---|---|---|---|---|---|---|
| INCISION AND EXCISION OF CNS | 1600 (43) | 3.2 (14.3) | 0.027 | 2 | 1 | 18 |
| OTHER OR PROCEDURES ON VESSELS OTHER THAN HEAD AND NECK | 739 (16) | 1.5 (5.3) | 0.022 | 24 | 2 | 22 |
| COLORECTAL RESECTION | 1053 (14) | 2.1 (4.7) | 0.013 | 15 | 3 | 33 |
| SMALL BOWEL RESECTION | 335 (12) | 0.7 (4) | 0.036 | 46 | 4 | 14 |
| TREATMENT, FRACTURE OR DISLOCATION OF HIP AND FEMUR | 1081 (10) | 2.2 (3.3) | 0.009 | 13 | 5 | 46 |
| DIAGNOSTIC BRONCHOSCOPY AND BIOPSY OF BRONCHUS | 242 (10) | 0.5 (3.3) | 0.041 | 57 | 6 | 9 |
| INSERTION, REPLACEMENT, OR REMOVAL OF EXTRACRANIAL VENTRICULAR SHUNT | 464 (9) | 0.9 (3) | 0.019 | 37 | 7 | 26 |
| HEART VALVE PROCEDURES | 890 (8) | 1.8 (2.7) | 0.009 | 20 | 8 | 46 |
| UPPER GASTROINTESTINAL ENDOSCOPY, BIOPSY | 418 (8) | 0.8 (2.7) | 0.019 | 40 | 9 | 26 |
| OTHER OR THERAPEUTIC PROCEDURES ON RESPIRATORY SYSTEM | 956 (8) | 1.9 (2.7) | 0.008 | 19 | 10 | 48 |
| AMPUTATION OF LOWER EXTREMITY | 243 (7) | 0.5 (2.3) | 0.029 | 56 | 11 | 16 |
| OTHER ORGAN TRANSPLANTATION | 315 (7) | 0.6 (2.3) | 0.022 | 47 | 12 | 22 |
| OTHER OR GASTROINTESTINAL THERAPEUTIC PROCEDURES | 844 (7) | 1.7 (2.3) | 0.008 | 23 | 13 | 48 |
| EXPLORATORY LAPAROTOMY | 96 (7) | 0.2 (2.3) | 0.073 | 83 | 14 | 5 |
| DIAGNOSTIC ULTRASOUND OF HEART (ECHOCARDIOGRAM) | 146 (6) | 0.3 (2) | 0.041 | 67 | 15 | 9 |
| SPINAL FUSION | 1297 (6) | 2.6 (2) | 0.005 | 6 | 16 | 53 |
| ILEOSTOMY AND OTHER ENTEROSTOMY | 463 (5) | 0.9 (1.7) | 0.011 | 38 | 17 | 38 |
| OTHER DIAGNOSTIC PROCEDURES (INTERVIEW, EVALUATION, CONSULTATION) | 138 (4) | 0.3 (1.3) | 0.029 | 70 | 18 | 16 |
| DEBRIDEMENT OF WOUND, INFECTION OR BURN | 382 (4) | 0.8 (1.3) | 0.01 | 44 | 19 | 42 |
| OTHER OR UPPER GI THERAPEUTIC PROCEDURES | 284 (4) | 0.6 (1.3) | 0.014 | 51 | 20 | 31 |
| INCISION AND DRAINAGE, SKIN AND SUBCUTANEOUS TISSUE | 172 (4) | 0.3 (1.3) | 0.023 | 63 | 21 | 20 |
| CORONARY ARTERY BYPASS GRAFT (CABG) | 401 (4) | 0.8 (1.3) | 0.01 | 42 | 22 | 42 |
| OTHER OR HEART PROCEDURES | 310 (4) | 0.6 (1.3) | 0.013 | 49 | 23 | 33 |
| AORTIC RESECTION, REPLACEMENT OR ANASTOMOSIS | 217 (4) | 0.4 (1.3) | 0.018 | 58 | 24 | 28 |
| OTHER HERNIA REPAIR | 1053 (4) | 2.1 (1.3) | 0.004 | 14 | 25 | 57 |
| ENDOSCOPIC RETROGRADE CANNULATION OF PANCREAS (ERCP) | 254 (4) | 0.5 (1.3) | 0.016 | 54 | 26 | 29 |
| EXTRACORPOREAL CIRCULATION AUXILIARY TO OPEN HEART PROCEDURES | 5 (3) | 0 (1) | 0.6 | 149 | 27 | 2 |
| OTHER OR LOWER GI THERAPEUTIC PROCEDURES | 702 (3) | 1.4 (1) | 0.004 | 25 | 28 | 57 |
| OTHER THERAPEUTIC PROCEDURES, HEMIC AND LYMPHATIC SYSTEM | 1612 (3) | 3.3 (1) | 0.002 | 1 | 29 | 64 |
| INCISION OF PLEURA, THORACENTESIS, CHEST DRAINAGE | 21 (3) | 0 (1) | 0.143 | 122 | 30 | 3 |
| GASTROSTOMY, TEMPORARY AND PERMANENT | 38 (2) | 0.1 (0.7) | 0.053 | 110 | 31 | 7 |
| OTHER OR THERAPEUTIC PROCEDURES OF URINARY TRACT | 411 (2) | 0.8 (0.7) | 0.005 | 41 | 32 | 53 |
| COLONOSCOPY AND BIOPSY | 51 (2) | 0.1 (0.7) | 0.039 | 101 | 33 | 12 |
| OTHER VASCULAR BYPASS AND SHUNT, NOT HEART | 49 (2) | 0.1 (0.7) | 0.041 | 103 | 34 | 9 |
| OPEN PROSTATECTOMY | 1040 (2) | 2.1 (0.7) | 0.002 | 16 | 35 | 64 |
| TRACHEOSCOPY AND LARYNGOSCOPY WITH BIOPSY | 495 (2) | 1 (0.7) | 0.004 | 35 | 36 | 57 |
| CHOLECYSTECTOMY AND COMMON DUCT EXPLORATION | 1189 (2) | 2.4 (0.7) | 0.002 | 8 | 37 | 64 |
| EXCISION, LYSIS PERITONEAL ADHESIONS | 75 (2) | 0.2 (0.7) | 0.027 | 90 | 38 | 18 |
| PROCEDURES ON SPLEEN | 51 (2) | 0.1 (0.7) | 0.039 | 100 | 39 | 12 |
| CREATION, REVISION AND REMOVAL OF ARTERIOVENOUS FISTULA OR VESSEL-TO-VESSEL CANNULA FOR DIALYSIS | 200 (2) | 0.4 (0.7) | 0.01 | 60 | 40 | 42 |
| PROCTOSCOPY AND ANORECTAL BIOPSY | 87 (2) | 0.2 (0.7) | 0.023 | 87 | 41 | 20 |
| HYSTERECTOMY, ABDOMINAL AND VAGINAL | 1102 (2) | 2.2 (0.7) | 0.002 | 12 | 42 | 64 |
| LOBECTOMY OR PNEUMONECTOMY | 571 (2) | 1.2 (0.7) | 0.004 | 30 | 43 | 57 |
| GASTRECTOMY, PARTIAL AND TOTAL | 47 (1) | 0.1 (0.3) | 0.021 | 104 | 44 | 24 |
| TRACHEOSTOMY, TEMPORARY AND PERMANENT | 105 (1) | 0.2 (0.3) | 0.01 | 79 | 45 | 42 |
| PARTIAL EXCISION BONE | 509 (1) | 1 (0.3) | 0.002 | 33 | 46 | 64 |
| KIDNEY TRANSPLANT | 1287 (1) | 2.6 (0.3) | 0.001 | 7 | 47 | 70 |
| BIOPSY OF LIVER | 16 (1) | 0 (0.3) | 0.062 | 128 | 48 | 6 |
| SUTURE OF SKIN AND SUBCUTANEOUS TISSUE | 367 (1) | 0.7 (0.3) | 0.003 | 45 | 49 | 60 |
| OTHER DIAGNOSTIC PROCEDURES, FEMALE ORGANS | 37 (1) | 0.1 (0.3) | 0.027 | 111 | 50 | 18 |
| DIAGNOSTIC DILATATION AND CURETTAGE (D and C) | 13 (1) | 0 (0.3) | 0.077 | 134 | 51 | 4 |
| DECOMPRESSION PERIPHERAL NERVE | 102 (1) | 0.2 (0.3) | 0.01 | 80 | 52 | 42 |
| OTHER DIAGNOSTIC PROCEDURES ON LUNG AND BRONCHUS | 56 (1) | 0.1 (0.3) | 0.018 | 96 | 53 | 28 |
| LAPAROSCOPY | 439 (1) | 0.9 (0.3) | 0.002 | 39 | 54 | 64 |
| ENDOSCOPY AND ENDOSCOPIC BIOPSY OF THE URINARY TRACT | 77 (1) | 0.2 (0.3) | 0.013 | 89 | 55 | 33 |
| INGUINAL AND FEMORAL HERNIA REPAIR | 252 (1) | 0.5 (0.3) | 0.004 | 55 | 56 | 57 |
| PLASTIC PROCEDURES ON NOSE | 166 (1) | 0.3 (0.3) | 0.006 | 64 | 57 | 51 |
| HIP REPLACEMENT, TOTAL AND PARTIAL | 1435 (1) | 2.9 (0.3) | 0.001 | 5 | 58 | 70 |
| MASTOIDECTOMY | 87 (1) | 0.2 (0.3) | 0.011 | 86 | 59 | 38 |
| PERIPHERAL VASCULAR BYPASS | 65 (1) | 0.1 (0.3) | 0.015 | 94 | 60 | 30 |
| OTHER DIAGNOSTIC PROCEDURES ON MUSCULOSKELETAL SYSTEM | 84 (1) | 0.2 (0.3) | 0.012 | 88 | 61 | 35 |
| OTHER OR THERAPEUTIC PROCEDURES ON NOSE, MOUTH AND PHARYNX | 886 (1) | 1.8 (0.3) | 0.001 | 21 | 62 | 70 |
| EMBOLECTOMY AND ENDARTERECTOMY OF LOWER LIMBS | 95 (1) | 0.2 (0.3) | 0.011 | 84 | 63 | 38 |
| OTHER VASCULAR CATHETERIZATION, NOT HEART | 89 (1) | 0.2 (0.3) | 0.011 | 85 | 64 | 38 |
| OTHER THERAPEUTIC PROCEDURES ON MUSCLES AND TENDONS | 576 (1) | 1.2 (0.3) | 0.002 | 29 | 65 | 64 |
| OTHER OR THERAPEUTIC NERVOUS SYSTEM PROCEDURES | 1140 (1) | 2.3 (0.3) | 0.001 | 11 | 66 | 70 |
| REPAIR OF CYSTOCELE AND RECTOCELE, OBLITERATION OF VAGINAL VAULT | 141 (1) | 0.3 (0.3) | 0.007 | 69 | 67 | 50 |
| OTHER THERAPEUTIC PROCEDURES ON EYELIDS, CONJUNCTIVA, CORNEA | 113 (1) | 0.2 (0.3) | 0.009 | 75 | 68 | 46 |
| OTHER OR PROCEDURES ON VESSELS OF HEAD AND NECK | 189 (1) | 0.4 (0.3) | 0.005 | 61 | 69 | 53 |
| OTHER THERAPEUTIC ENDOCRINE PROCEDURES | 1436 (1) | 2.9 (0.3) | 0.001 | 4 | 70 | 70 |
| MYRINGOTOMY | 1 (1) | 0 (0.3) | 1 | 171 | 71 | 1 |
| ARTHROSCOPY | 26 (1) | 0.1 (0.3) | 0.038 | 119 | 72 | 13 |

The numbers in parentheses () in the Count and Percent columns represent the count and percentage of individuals who died in-hospital undergoing surgery who were classified under the given HCUP description.

## Table S3. Predicting Mortality using Preoperative Features

| Model | Logistic Regression | ElasticNet Classifier | Random Forest | XGBoost Classifier |
|---|---|---|---|---|
| **Accuracy** | 0.967 (0.964-0.970) | 0.962 (0.959-0.965) | 0.994 (0.993-0.994) | 0.993 (0.993-0.994) |
| **F1 Score** | 0.158 (0.140-0.175) | 0.154 (0.139-0.169) | 0.053 (0.007-0.099) | 0.086 (0.023-0.149) |
| **Precision** | 0.094 (0.083-0.106) | 0.090 (0.081-0.098) | 0.292 (0.035-0.548) | 0.361 (0.119-0.604) |
| **Recall** | 0.489 (0.431-0.546) | 0.550 (0.491-0.609) | 0.029 (0.004-0.054) | 0.052 (0.011-0.093) |
| **Specificity** | 0.970 (0.967-0.973) | 0.965 (0.962-0.968) | 1.000 (1.000-1.000) | 0.999 (0.999-1.000) |

Model performance metrics for predicting mortality using preoperative features and 10-fold cross-validation.
True positives: TP, False positives: FP, True negatives: TN, False negatives: FN.
Accuracy = (TP+TN)/(TP+TN+FP+FN). Precision = TP/(TP+FP).
Recall = TP/(TP+FN).
Specificity = TN/(TN+FP). F1 Score = 2/((1/Recall)+(1/Precision)).

## Table S4. Predicting Mortality using Preoperative Features + ASA Status

| Model | Logistic Regression | ElasticNet Classifier | Random Forest | XGBoost Classifier |
|---|---|---|---|---|
| **Accuracy** | 0.971 (0.969 - 0.972) | 0.966 (0.964 - 0.967) | 0.994 (0.994 - 0.994) | 0.994 (0.993 - 0.994) |
| **F1 Score** | 0.167 (0.147 - 0.188) | 0.172 (0.157 - 0.187) | 0.053 (0.007 - 0.098) | 0.178 (0.122 - 0.234) |
| **Precision** | 0.101 (0.089 - 0.114) | 0.101 (0.092 - 0.110) | 0.255 (0.051 - 0.459) | 0.436 (0.316 - 0.557) |
| **Recall** | 0.485 (0.425 - 0.545) | 0.585 (0.526 - 0.644) | 0.030 (0.004 - 0.056) | 0.113 (0.076 - 0.150) |
| **Specificity** | 0.974 (0.972 - 0.975) | 0.968 (0.967 - 0.970) | 1.000 (1.000 - 1.000) | 0.999 (0.999 - 0.999) |

Model performance metrics for predicting mortality using both preoperative features and ASA status as input features, and 10-fold cross-validation. For an explanation of the metrics see the description of Table S3

## Table S5. Predicting Mortality using ASA Status

| Model | Logistic Regression | ElasticNet Classifier | Random Forest | XGBoost Classifier |
|---|---|---|---|---|
| **Accuracy** | 0.948 (0.936 - 0.959) | 0.948 (0.936 - 0.959) | 0.865 (0.737 - 0.994) | 0.885 (0.749 - 1.022) |
| **F1 Score** | 0.132 (0.093 - 0.171) | 0.132 (0.093 - 0.171) | 0.111 (0.056 - 0.165) | 0.059 (-0.005 - 0.123) |
| **Precision** | 0.104 (0.013 - 0.194) | 0.104 (0.013 - 0.0194) | 0.092 (-0.003 - 0.187) | 0.063 (-0.038 - 0.165) |
| **Recall** | 0.574 ((0.468 - 0.681) | 0.574 (0.468 - 0.681) | 0.548 (0.425 - 0.670) | 0.280 (0.085 - 0.475) |
| **Specificity** | 0.950 (0.937 - 0.962) | 0.950 (0.937 - 0.962) | 0.867 (0.738 - 0.996) | 0.889 (0.751 - 1.027) |

Model performance metrics for predicting mortality using only the ASA status as an input feature, and 10-fold cross-validation. For an explanation of the metrics see the description of Table S3

## Table S6. Predicting Mortality using Charlson Comorbidity

| Model | Logistic Regression | ElasticNet Classifier | Random Forest | XGBoost Classifier |
|---|---|---|---|---|
| Accuracy | 0.871 (0.813-0.929) | 0.871 (0.813-0.929) | 0.915 (0.847-0.983) | 0.929 (0.861-0.997) |
| F1 Score | 0.039 (0.030-0.048) | 0.039 (0.030-0.048) | 0.046 (0.017-0.074) | 0.042 (0.012-0.072) |
| Precision | 0.021 (0.016-0.026) | 0.021 (0.016-0.026) | 0.029 (0.007-0.052) | 0.029 (0.007-0.052) |
| Recall | 0.412 (0.265-0.560) | 0.412 (0.265-0.560) | 0.180 (0.081-0.279) | 0.136 (0.053-0.220) |
| Specificity | 0.874 (0.815-0.933) | 0.874 (0.815-0.933) | 0.920 (0.851-0.989) | 0.934 (0.865-1.000) |

Model performance metrics for predicting mortality using only the Charlson comorbidity as an input feature, and 10-fold cross-validation. For an explanation of the metrics see the description of Table S3

## Table S7. Predicting Mortality using Preoperative Features + imputed-ASA Score

| Model | Logistic Regression | ElasticNet Classifier | Random Forest | XGBoost Classifier |
|---|---|---|---|---|
| Accuracy | 0.968 (0.966-0.970) | 0.963 (0.960-0.965) | 0.994 (0.994-0.994) | 0.994 (0.993-0.994) |
| F1 Score | 0.148 (0.132-0.165) | 0.144 (0.129-0.160) | 0.052 (0.007-0.096) | 0.093 (0.048-0.138) |
| Precision | 0.089 (0.079-0.099) | 0.084 (0.075-0.093) | 0.223 (0.051-0.396) | 0.361 (0.161-0.561) |
| Recall | 0.459 (0.400-0.517) | 0.521 (0.451-0.591) | 0.030 (0.004-0.056) | 0.056 (0.027-0.085) |
| Specificity | 0.9671 (0.969-0.973) | 0.965 (0.963-0.968) | 1.000 (0.999-1.000) | 0.999 (0.999-1.000) |

Model performance metrics for predicting mortality using both preoperative features and the imputed-ASA score as input features, and 10-fold cross-validation. For an explanation of the metrics see the description of Table S3

## Table S8. Predicting Mortality using Preoperative Features + ASA status, Without Lab Times

| Model | Logistic Regression | ElasticNet Classifier | Random Forest | XGBoost Classifier |
|---|---|---|---|---|
| Accuracy | 0.977 (0.975-0.978) | 0.972 (0.970-0.974) | 0.994 (0.994-0.994) | 0.994 (0.993-0.994) |
| F1 Score | 0.205 (0.183-0.227) | 0.198 (0.178-0.219) | 0.048 (0.015-0.080) | 0.175 (0.127-0.224) |
| Precision | 0.130 (0.116-0.143) | 0.120 (0.108-0.133) | 0.307 (0.075-0.538) | 0.474 (0.328-0.620) |
| Recall | 0.492 (0.428-0.556) | 0.568 (0.501-0.636) | 0.026 (0.008-0.045) | 0.109 (0.078-0.141) |
| Specificity | 0.980 (0.978-0.981) | 0.975 (0.973-0.976) | 1.000 (1.000-1.000) | 0.999 (0.999-1.000) |

Model performance metrics for predicting mortality using both preoperative features and the ASA score but without lab times as input features, and 10-fold cross-validation. For an explanation of the metrics see the description of Table S3

**Table S9. Predicting Mortality using Preoperative Features + imputed-ASA status, Without Lab Times**

| Model | Logistic Regression | ElasticNet Classifier | Random Forest | XGBoost Classifier |
|---|---|---|---|---|
| Accuracy | 0.974 (0.972-0.975) | 0.969 (0.967-0.970) | 0.994 (0.994-0.994) | 0.994 (0.993-0.994) |
| F1 Score | 0.169 (0.146-0.191) | 0.162 (0.146-0.177) | 0.035 (0.000-0.070) | 0.083 (0.038-0.129) |
| Precision | 0.104 (0.091-0.118) | 0.097 (0.088-0.106) | 0.183 (0.011-0.356) | 0.305 (0.104-0.507) |
| Recall | 0.442 (0.373-0.511) | 0.502 (0.445-0.559) | 0.020 (0.000-0.040) | 0.050 (0.022-0.077) |
| Specificity | 0.977 (0.975-0.978) | 0.971 (0.970-0.973) | 1.000 (1.000-1.000) | 0.999 (0.999-1.000) |

Model performance metrics for predicting mortality using both preoperative features and the imputed-ASA score but without lab times as input features, and 10-fold cross-validation. For an explanation of the metrics see the description of Table S3

**Table S10. Model Feature Importance: With ASA and Without Lab Time Features**

| Feature | Random Forest | Linear Regression | Elastic Net | XGBoost |
|---|---|---|---|---|
| ALBUMIN | 0.04* | -0.79 | -1.08* | 0.03* |
| ASA STATUS | 0.08* | 2.62* | 2.17* | 0.03* |
| INR | 0.04* | 0.76 | 0.3 | 0.01 |
| PAT CLASS INPATIENT | 0.05* | -0.61 | -0.09 | 0.02 |
| PAT CLASS SAME DAY ADMIT | 0.04* | -1.89* | -0.47 | 0 |
| PRE SURG LOCATION PRE-ADMISSION | 0.05* | 1.26 | -0.29 | 0 |
| AGE LT 89 | 0.01 | 1.24 | 0.93* | 0.04* |
| BILIRUBIN.TOTAL | 0.02 | 0.09 | 0.85* | 0.03* |
| PRE SURG LOCATION RR ED | 0.02 | 1.36 | 0.84* | 0.01 |
| ALKALINE.PHOSPHATASE | 0.01 | 0.08 | 0.26 | 0.03* |
| ALT | 0.01 | -0.06 | -0.25 | 0.03* |
| AST | 0.02 | 0.12 | 0.06 | 0.03* |
| BICARBONATE | 0.03 | 0.77 | -0.25 | 0.03* |
| BMI | 0.01 | 0.11 | 0.21 | 0.03* |
| BNP | 0.03 | 0.11 | 0.79 | 0.03* |
| CREATININE | 0.02 | -0.03 | 0 | 0.03* |
| DIAS.BLOOD.PRESSURE | 0.03 | -0.93 | -0.53 | 0.03* |
| ECHO.EF | 0.01 | -0.3 | 0 | 0.03* |
| GLUCOSE | 0.03 | 0.55 | 0.76 | 0.03* |
| HEIGHT IN | 0.01 | -1.25 | -0.43 | 0.03* |
| HEMOGLOBIN | 0.03 | -0.26 | -0.36 | 0.03* |
| HRS ADMSN TO SURGERY | 0.02 | -0.13 | 0.26 | 0.04* |
| PLATELET.COUNT | 0.03 | 0.5 | -0.39 | 0.04* |
| PULSE | 0.01 | 0.74 | 0.18 | 0.03* |
| SPO2 | 0.02 | -0.97 | -0.56 | 0.03* |
| SYS.BLOOD.PRESSURE | 0.02 | 0.33 | -0.73 | 0.04* |
| UREA.NITROGEN | 0.02 | 0.28 | 0.34 | 0.03* |
| WEIGHT KG | 0.01 | 0.48 | 0 | 0.03* |
| WHITE.BLOOD.CELL.COUNT | 0.02 | 0.48 | 0.62 | 0.03* |
| PAP.HRS 2 SURGERY | NA | -2.17* | NA | NA |
| PULSE.HRS 2 SURGERY | NA | -1.93* | NA | NA |
| SODIUM | 0.01 | -2.28* | 0 | 0.02 |

The bold values with the * indicates that the value was one of the top five strongest predictors for the given model. In the Logistic Regression and ElasticNet columns the model weights are shown, where negative values indicate the feature lowers the probability of mortality. The non-linear model features are ranked according to the mean decrease in Gini impurity.

**Table S11. Model Feature Importance: Without ASA and With Lab Time Features**

| Feature | Random Forest | Linear Regression | Elastic Net | XGBoost |
|---------|---------------|-------------------|-------------|---------|
| CREATININE.HRS 2 SURGERY | **0.03*** | 0.42 | 0 | 0.01 |
| INR | **0.03*** | 1.47 | **1.03*** | 0.02 |
| PAT CLASS INPATIENT | **0.04*** | -0.83 | -0.35 | 0.01 |
| PAT CLASS SAME DAY ADMIT | **0.03*** | **-1.78*** | -0.77 | 0 |
| PLATELET.COUNT.HRS 2 SURGERY | **0.03*** | -1.5 | -0.22 | 0.01 |
| PRE SURG LOCATION PRE-ADMISSION | **0.04*** | 0.2 | -0.51 | 0 |
| UREA.NITROGEN.HRS 2 SURGERY | **0.03*** | -0.27 | -0.03 | 0.01 |
| HEIGHT IN | 0.01 | -1.39 | **-1.04*** | **0.03*** |
| PRE SURG LOCATION RR 6ICU | 0.01 | 1.1 | **0.89*** | 0.01 |
| SPO2 | 0.01 | -1.1 | **-0.79*** | 0.02 |
| SYS.BLOOD.PRESSURE | 0.01 | -1.11 | **-0.84*** | 0.02 |
| AGE LT 89 | 0.01 | 1.03 | 0.64 | **0.03*** |
| BMI | 0 | 0.22 | 0.1 | **0.03*** |
| GENDER M | 0.01 | 0.03 | 0 | **0.03*** |
| HRS ADMSN TO SURGERY | 0.02 | 0.02 | 0 | **0.03*** |
| PLATELET.COUNT | 0.01 | 0.16 | 0 | **0.03*** |
| UREA.NITROGEN | 0.01 | 0.19 | 0.29 | **0.03*** |
| WHITE.BLOOD.CELL.COUNT | 0.01 | 0.48 | 0.47 | **0.03*** |
| CASE SRV NAME Otolaryngology | 0 | **-2.14*** | -0.46 | 0 |
| CASE SRV NAME Surgery, Surgery | 0.01 | **-1.68*** | -0.24 | 0 |
| HCUP CODE 105.0 | 0 | **-1.66*** | -0.67 | 0 |
| PAT CLASS OVERNIGHT RECOVERY | 0 | **-2.18*** | -0.63 | 0 |

The bold values with the * indicates that the value was one of the top five strongest predictors for the given model. In the Logistic Regression and ElasticNet columns the model weights are shown, where negative values indicate the feature lowers the probability of mortality. The non-linear model features are ranked according to the mean decrease in Gini impurity.

**Table S12. Model Feature Importance: With ASA and Time Features**

| Feature | Random Forest | Linear Regression | Elastic Net | XGBoost |
|---|---|---|---|---|
| ASA STATUS | **0.07*** | **2.62*** | **2.31*** | **0.04*** |
| CHLORIDE.HRS 2 SURGERY | **0.03*** | -0.68 | -0.46 | 0.01 |
| CREATININE.HRS 2 SURGERY | **0.03*** | -1.27 | -0.38 | 0.01 |
| HEMOGLOBIN.HRS 2 SURGERY | **0.03*** | 0.39 | -0.09 | 0.01 |
| PAT CLASS INPATIENT | **0.04*** | -0.61 | 0 | 0.01 |
| PLATELET.COUNT.HRS 2 SURGERY | **0.03*** | -0.68 | -0.06 | 0.01 |
| POTASSIUM.HRS 2 SURGERY | **0.03*** | -0.27 | -0.43 | 0.01 |
| PRE SURG LOCATION PRE-ADMISSION | **0.04*** | 1.26 | **-0.98*** | 0 |
| UREA.NITROGEN.HRS 2 SURGERY | **0.03*** | -0.08 | -0.41 | 0.01 |
| AGE LT 89 | 0.01 | 1.24 | **0.89*** | **0.03*** |
| CASE SRV NAME Neurological Surgery | 0 | 1.72 | **0.91*** | 0.01 |
| HCUP CODE 114.0 | 0 | 1.27 | **1.06*** | 0 |
| BMI | 0.01 | 0.11 | 0.09 | **0.03*** |
| GLUCOSE | 0.01 | 0.55 | 0.42 | **0.03*** |
| HEIGHT IN | 0.01 | -1.25 | -0.69 | **0.03*** |
| PLATELET.COUNT | 0.01 | 0.5 | 0.34 | **0.03*** |
| PULSE | 0.01 | 0.74 | 0.39 | **0.03*** |
| SYS.BLOOD.PRESSURE | 0.01 | 0.33 | 0 | **0.03*** |
| UREA.NITROGEN | 0.01 | 0.28 | 0.17 | **0.03*** |
| PAP.HRS 2 SURGERY | 0.01 | **-2.17*** | -0.34 | 0.01 |
| PAT CLASS SAME DAY ADMIT | 0.02 | **-1.89*** | -0.8 | 0 |
| PULSE.HRS 2 SURGERY | 0.02 | **-1.93*** | 0 | 0.01 |
| SODIUM | 0.01 | **-2.28*** | -0.39 | 0.02 |

The bold values with the * indicates that the value was one of the top five strongest predictors for the given model. In the Logistic Regression and ElasticNet columns the model weights are shown, where negative values indicate the feature lowers the probability of mortality. The non-linear model features are ranked according to the mean decrease in Gini impurity.

**Table S13. Change in Pre- to Post-operative Risk using ASA-like risk bins**

|  | Post 1 | Post 2 | Post 3 | Post 4 | Post 5 | Sum |
|---|---|---|---|---|---|---|
| **Pre 1** | 1376 | 2104 | 0 | 0 | 0 | 3480 |
| **Pre 2** | 704 | 10581 | 8149 | 155 | 4 | 19593 |
| **Pre 3** | 1354 | 6742 | 13856 | 1558 | 30 | 23540 |
| **Pre 4** | 41 | 153 | 1487 | 1017 | 75 | 2773 |
| **Pre 5** | 5 | 13 | 48 | 43 | 18 | 127 |
| **Sum** | 3480 | 19593 | 23540 | 2773 | 127 | 49513 |

This tables shows how risk changes for groups defined by the number of patients with each ASA score, from 1 to 5. Patient risk scores were sorted from highest-risk to lowest risk, and then patients were binned into 5 categories, where the number of patients in each category corresponds to the number of patients in each ASA status group. For example, 127 patients had an ASA status of 5, therefore, bins Pre 5 and Post 5 each have 127 patients.

**Table S14. Change in Pre- to Post-operative Risk using ASA-like risk bins for In-hospital Mortalities**

|  | Post 1 | Post 2 | Post 3 | Post 4 | Post 5 | Sum |
|---|---|---|---|---|---|---|
| **Pre 1** | 0 | 0 | 0 | 0 | 0 | 0 |
| **Pre 2** | 0 | 0 | 8 | 1 | 1 | 10 |
| **Pre 3** | 1 | 0 | 52 | 36 | 5 | 94 |
| **Pre 4** | 2 | 0 | 38 | 107 | 28 | 175 |
| **Pre 5** | 1 | 0 | 0 | 11 | 12 | 24 |
| **Sum** | 4 | 0 | 98 | 155 | 46 | 303 |

This tables shows how risk changes for groups defined by the number of patients with each ASA score, from 1 to 5. Patient risk scores were sorted from highest-risk to lowest risk, and then patients were binned into 5 categories, where the number of patients in each category corresponds to the number of patients in each ASA status group. In this table we only show in-hospital mortalities. The number of patients in group 5 increases between the preoperative and postoperative periods, showing that the postoperative model is capturing the increased risk derived from intraoperative data.