Postoperative Outcomes in Patients with Do-not-resuscitate (DNR) Orders undergoing Elective Surgery

ABSTRACT

Background: Do-Not-Resuscitate (DNR) is a medical order against the use of cardiopulmonary resuscitation. While it does not preclude surgery, DNR status has been shown to be independently associated with worse surgical outcomes for a variety of procedures. Our prior study found that in the immediate postoperative period, DNR status was associated with increased mortality but not morbidity. This study further investigates the outcomes of DNR patients specifically in elective surgery. Understanding this relationship is crucial for informing DNR patients in goals of care discussions prior to pursuing elective surgery.

Methods: Using the 2007-2015 American College of Surgeons National Surgical Quality Improvement Program database, we performed a retrospective analysis of elective surgery cases comparing DNR and non-DNR cohorts. Differences between cohorts were assessed using the Pearson *chi*-square test for categorical variables and Student's *t* test for continuous ones. For all preoperative and operative characteristics, we applied univariate logistic regression to assess the association of each variable with DNR status. We then applied a 1:1 greedy nearest neighbor propensity score matching algorithm to reduce confounding by significant baseline characteristics and match by procedure. Lastly, we applied univariate logistic regression for all 30-day postoperative complications including mortality to assess the association of each adverse outcome with DNR status. All analyses were conducted in R Project for Statistical Computing (v3.4.0).

Results: DNR patients were more likely than non-DNR patients to be older in age and have poorer preoperative state of health in terms of functional status and medical comorbidities. The most common elective surgical procedures performed in DNR patients by surgical specialty were general surgery (39%), orthopedics (20%), vascular (19%), and urology (11%); these included lower extremity amputations, Roux-en-Y gastric bypass, femur fracture repairs, carotid endarterectomy, colectomy, and cystostomy, among others. In the propensity matched cohort adjusted for preoperative and operative factors, DNR patients were found to have increased 30-day postoperative mortality (OR 2.50 [1.55-4.05], $p < 0.001$) and length of stay (HR 2.08 [1.31-3.30], $p = 0.002$). Notably, DNR patients were not found to have increased incidence of any other postoperative complications.

Conclusion: DNR status is associated with higher mortality but not morbidity for elective surgeries in the 30-day postoperative period, independent of patients' baseline health. The lack of increased postoperative complications suggests that the isolated rise in postoperative mortality may be related to inherent differences in the management of postoperative complications in patients with DNR orders. This may be a consequence of withholding resuscitative measures, failure to rescue, or transition to comfort care. Therefore, DNR patients who are considering elective surgery should thoroughly assess the risks and benefits of the procedure, along with their increased risk of mortality due to DNR status, in light of their goals of care as part of the patient-centered shared decision making process in determining the appropriateness of the elective surgery.

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GLOSSARY

Acute MI	Acute myocardial infarction
ASA class	American Society of Anesthesiologists' Physical Status classification
BMI	Body mass index
CAD	Coronary artery disease
CHF	Congestive heart failure
COPD	Chronic obstructive pulmonary disorder
CPR	Cardiopulmonary resuscitation
CVA	Cerebrovascular accident
DM	Diabetes mellitus
DNR	Do-not-resuscitate
HIPAA	Health and Insurance Portability and Accountability Act
HTN	Hypertension
IV	Intravenous
MAC	Monitored anesthesia care
NSQIP	American College of Surgeons National Surgical Quality Improvement Program
Portal HTN	Portal hypertension
PS	Propensity matching
PVD	Peripheral vascular disease
Return to OR	Return to operating room
SD	Standard deviation
VTE	Venous thromboembolism
Work RVU	Work relative value unit

INTRODUCTION

Background on do-not-resuscitate orders

Do-not-resuscitate (DNR) is a medical order against the use of cardiopulmonary resuscitation (CPR) in the event of cardiopulmonary arrest.[1,2] The decision to implement such an order usually suggests advanced age[3,4] or end-stage disease,[5–7] and may be a marker of shorter life expectancy.[5,6,8,9]

Surgery in do-not-resuscitate patients

Notably, DNR status does not preclude surgery. However, it has also been shown to be an independent risk factor for postoperative mortality in a variety of surgical procedures, including trauma, emergent bowel obstruction, vascular, and cardiothoracic surgery.[10–19] Despite this, 15 percent of DNR patients do undergo surgery,[20,21] and over 80 percent would agree to palliative procedures or procedures unrelated to their primary diagnosis.[22]

Our previous study found that the most common procedures in the DNR population were emergent in nature (e.g. extremity amputation), and those that were elective were mainly palliative (e.g. lysis of adhesions to relieve small bowel obstruction) as opposed to life-extending (e.g. dialysis catheter placement).[18] Additionally, Kazaure found that both emergent and non-emergent procedures have increased mortality in DNR patients compared to non-DNR patients, with higher mortality in emergent than non-emergent procedures (3-fold vs. 2-fold increased risk, respectively).[23] In contrast, Beverly found no significant difference in mortality between emergent and non-emergent hip surgeries in DNR patients.[19]

However, none of these studies investigate both morbidity and mortality outcomes of DNR patients specifically in elective surgery. For DNR patients undergoing surgery, the informed consent process is arguably most relevant in the setting of scheduling an elective procedure. It is important to consider the risk of complications, length of hospital stay, and the possibility of failure to rescue, in addition to mortality, when assessing the risks and benefits of an elective procedure. The findings of this study will help inform physicians and patients with DNR orders in goals of care discussions prior to pursuing elective surgery.

Failure to rescue

Patients with DNR orders should receive the standard of care in all circumstances except in those requiring CPR. Failure to rescue in this particular context refers to a disparity in medical care toward certain patients due to their DNR status. It is important to consider the possibility of failure to rescue as a contributor to the higher mortality seen in surgical DNR patients.

Perioperative code status

Another controversial topic related to DNR orders is perioperative code status. The American Society of Anesthesiologists and the American College of Surgeons both recommend "required reconsideration" of perioperative code status in do-not resuscitate and do-not-intubate patients undergoing surgery.[24–26] Anesthesia management during surgery often require interventions commonly used in resuscitative measures, such as intubation, mechanical ventilation, and vasopressor support. Intraoperative CPR also has a higher survival rate than out-of-hospital CPR.[27] Patients should be informed of the option to suspend their DNR orders intraoperatively to the effect of any of these three directives: full attempt at resuscitation, limited attempt at resuscitation defined with regard to specific procedures, or limited attempted at resuscitation defined with regard to the patient's goals and values.

Patient-centered shared decision making

Patient-centered shared decision making is critical to ensuring that treatment plans are aligned with the patient's goals of care. This applies to DNR patients in both their decision to pursue elective surgery and their reconsideration of perioperative code status.[28] The patient or health care proxy and his or her health care providers should work together to thoroughly weigh the risks and benefits of a given intervention with the patient's desired outcomes. It is important therefore that patients are provided the relevant evidence in literature so that they may make an informed decision.

Specific aims

This study aims to analyze the perioperative characteristics and patterns of care in DNR patients who underwent surgery that was specifically elective in nature. The results of this study may better inform both physicians and patients with DNR orders in the patient-centered shared decision making process regarding the appropriateness of pursuing elective surgery or changing their perioperative code status.

METHODS

Overview

The objective of this study is to determine the postoperative outcomes of DNR patients who underwent elective surgery. This is a retrospective cohort study using a nationally validated risk-adjusted surgical database comparing outcomes of elective surgery in DNR and non-DNR patients. The primary outcome is 30-day postoperative mortality rate, and the secondary outcomes include 30-day postoperative complication rates and length of stay. We employ propensity score matching to generate a matched cohort and logistic regression for the outcomes analysis.

Data source

The American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database[29] includes 4,456,809 surgical cases from 2007 to 2015 from over 600 hospitals in the United States. The NSQIP database is de-identified and meets the criteria of the Health and Insurance Portability and Accountability Act (HIPAA) for protection of personal information. Certified surgical clinical reviewers prospectively collect 30-day postoperative data on 273 HIPAA-compliant variables for randomly assigned patients at each site. Data exclusion criteria include data from sites where 30-day follow-up rate is <80% or inter-rater reliability disagreement rate >5%; patients below age 18; minor cases; trauma and transplant cases; and cases where the patient is ASA class VI (e.g. brain dead). Institutional Review Board (Brigham and Women's Hospital, Boston, MA) approval was obtained for analysis of the data and was exempted from the consent requirement due to the de-identified nature of the data.

Study sample

Figure 1 is a flow diagram of our patient selection process and study design. Our sample population is taken from the NSQIP database and comprises of elective surgery patients with either positive or negative DNR status. NSQIP defines the do-not-resuscitate variable as follows:

> *If the patient has had a Do-Not-Resuscitate (DNR) order written in the physician's order sheet of the patient's chart and it has been signed or co-signed by an attending physician. There must be active DNR order at the time the patient*

is going to the OR. However, if the DNR order, as defined above, was rescinded immediately prior to surgery, in order to operate on the patient, enter "YES".

NSQIP introduced the elective surgery variable in 2011 to identify patients who are well enough to come from their home or normal living situation on the day of their scheduled surgery.

We first isolate our initial cohort of 2,595,959 patients who underwent elective surgery ("electsurg" = "Yes"). Next, we grouped the patients by their DNR status ("dnr" = "Yes" or "No"). Of note, since NSQIP retired the DNR variable in 2012, our study sample is limited to the years 2011 and 2012. The resulting cohort consists of 566 patients with positive DNR status and 316,431 patients with negative DNR status who underwent elective surgery.

For our covariate exclusion criteria, we exclude any underreported characteristic (preoperative, operative, or postoperative) wherein the exclusion of its missing data would reduce the exposure group size by 20 percent or more. Our rationale for excluding covariates based on missing data is to maximize the data available for complete case analysis. Variables exempt from exclusion include death, which is the primary outcome of the analysis and the censor for Cox hazards ratios, as well as the *a priori* variables predetermined to be included in our matching model. The preoperative laboratory values albumin and International Normalized Ratio (INR) were excluded based on the covariate exclusion criteria. Our cohort after exclusion of covariates and missing data consists of 459 DNR and 137,901 non-DNR patients who underwent elective surgery.

Variables

Baseline characteristics include demographic, preoperative comorbidity, and operative data. Demographic data include age and age group (<65, 65 to 80, >=80), sex, race, body mass index (BMI) and BMI group (<18.5, 18.5 to 25, 25 to 30, >=30), functional status, baseline dyspnea, and the American Society of Anesthesiologist's Physical Status classification (ASA class).

Preoperative comorbidity data include history of smoking in the past year, alcohol use of >2 drinks per day in the past 2 weeks, diabetes (insulin or non-insulin dependent), chronic obstructive pulmonary disorder, congestive heart failure, coronary artery disease (composite of angina, myocardial infarction, and percutaneous coronary intervention), peripheral vascular disease (including rest pain and gangrene), kidney disease (composite of acute preoperative renal failure and dialysis), portal hypertension (including ascites), cerebrovascular accident (with or without residual neurologic deficit), chronic steroid use, recent weight loss of >10% in the past 6 months, chemotherapy in the past 30 days, radiotherapy in the past 90 days, preoperative wound infection, bleeding disorder, preoperative sepsis (including septic shock), recent prior operation in the past 30 days, and preoperative laboratory tests (creatinine, hematocrit, and platelets).

Operative data include the Current Procedural Terminology (CPT) code, surgical subspecialty, physician work relative value unit (work RVU), and principal anesthesia technique.

Outcomes include 30-day postoperative mortality, complications, and other adverse events. Mortality is derived from the days from operation to death variable (negative if "dopertod" is -99 and positive otherwise). Complications include surgical site infections (composite of superficial, deep, and organ space infections), wound dehiscence, pneumonia, unplanned reintubation, failure to wean from ventilator after 48 hours, progressive renal insufficiency, acute renal failure, urinary tract infection, stroke, cardiac arrest requiring CPR, myocardial infarction, transfusion requirement, venous thromboembolism (composite of deep venous thrombosis requiring therapy and pulmonary embolism), sepsis (including septic shock); and reoperation. Total length of hospital stay and number of postoperative complications are also included in the outcomes.

Statistical methods

R Project for Statistical Computing[30] (version 3.4.0) is used to perform all statistical analyses. The NSQIP Data Analysis web application built with the Shiny package was specifically developed in our group to automate outcomes analyses using the NSQIP database.[31] In this retrospective analysis, we compare the outcomes in the exposure group (DNR patients) and the control group (non-DNR patients) within our cohort of elective surgery patients.

Differences between cohorts are assessed using the Student's *t* test for continuous variables and the Pearson *chi*-square test for categorical variables. Continuous variables include age, BMI, creatinine, hematocrit, platelets, work RVU, total length of hospital stay, and number of postoperative complications. Age and BMI are also represented as categorical variables. All other baseline characteristics and outcomes are categorical variables.

Of note, each categorical variable has a reference value against which statistical tests are to be performed. For binary categorical variables, the reference is the negative value. For multi-category variables, see Tables 1, 2, and 5 for the reference, which is listed as the first value. Additionally, within multi-category variables, categories without DNR patients are either excluded if the variable is nominal, or combined with the subsequent category if the variable is ordinal. For example, ASA classes 1 and 2 are combined as a single category.

In our analysis, we first perform univariate logistic regression of the baseline characteristics with respect to the exposure variable (DNR status) in the unmatched cohort. Variables that are significantly associated with DNR status are potential confounders of the outcomes in our analysis.

Given the heterogeneity in baseline characteristics between the exposure and control groups as well as the smaller exposure group size (0.3% of total sample size), we choose to perform propensity score matching to generate a matched cohort that improves covariate balance and therefore reduces the effect of confounding in the outcomes analysis.[31] We use the MatchIt package[32] to implement a 1:1 greedy nearest neighbor matching algorithm. We include as covariates in the model all the potential confounders from above, in addition to the following *a priori* variables: age group, sex, race, BMI group, ASA class, CPT code, surgical subspecialty, and work RVU. The CPT code, surgical subspecialty, and work RVU, an indicator of surgical complexity, act together to match the groups by procedure type. Our matched cohort consists of 459 DNR patients matched to 459 non-DNR patients.

Covariate balance after matching is assessed by repeating univariate logistic regression of all baseline characteristics with respect to DNR status, this time in the matched cohort. We consider covariates to be well balanced if no significant association remains between them and DNR status. Good covariate balance implies that associations found between DNR status and outcomes using the matched cohort are unlikely to be confounded by other variables.

Finally, we perform logistic regression analysis of the outcomes with respect to DNR status in the matched cohort to assess for significant differences in 30-day postoperative mortality, complication rates, total length of stay, and number of complications.

Logistic regressions are modeled using the binomial distribution for all variables except for the number of postoperative complications which is modeled using the Poisson distribution. Cox proportional hazards model is used for total length of hospital stay with death as the competing event. From the logistic regression, we calculate the odds ratio (OR) and associated

95% confidence intervals (CI). ORs not including 1.00 in the 95% CI are considered statistically significant. The significance level for each hypothesis is $p < 0.05$.

Sensitivity analysis

Sensitivity analysis of our study using G*Power[33] (version 3.1) calculated 90% power for detecting an effect size of 4.3% in mortality. Post-hoc analysis showed that a power of 98.7% was achieved.

RESULTS

The results of this study include detailed comparisons of the baseline characteristics, matching process, and postoperative outcomes in DNR and non-DNR patients who underwent elective surgery.

Baseline characteristics of the unmatched cohort

Table 1 is a comparison of the baseline characteristics of the 566 DNR and 316,431 non-DNR patients in the initial unmatched cohort. Both univariate logistic regression and the Pearson *chi*-square or Student's *t* tests were performed. On average, DNR patients were significantly older in age (mean of 76.0 vs. 56.2 years, with 52.1% vs. 6.8% in the >=80 year-old group); less commonly of black or Asian race (4.6% vs. 9.1% and 1.6% vs. 2.2% respectively); and lower in BMI (mean of 28.5 vs. 30.1 kg/m^2, with 40.7% vs. 26.6% in the <25 kg/m^2 groups). The ASA class distribution leaned heavily toward classes III and IV (89.0% vs. 41.4%), which reflected their globally increased comorbidity burden, with higher incidences of dependent functional status, dyspnea, smoking, drinking, hypertension, diabetes, chronic obstructive pulmonary disorder, congestive heart failure, coronary artery disease, peripheral vascular disease, kidney disease, cerebrovascular accident, chronic steroid use, recent weight loss, preoperative wound infection, bleeding disorder, preoperative sepsis, and recent prior operation. In terms of surgery specific factors, DNR patients were more likely to undergo subspecialty surgery in orthopedics (20.3% vs. 15.1%), vascular (18.6% vs. 8.1%), cardiac (1.8% vs. 1.0%), and urology (10.6% vs. 6.5%), as well as undergo spinal anesthesia (9.2% vs. 3.7%).

Baseline characteristics of the matched cohort

Table 2 is a comparison of the baseline characteristics of the 459 DNR and 459 non-DNR patients in the matched cohort. DNR and non-DNR patients are matched by both procedure and baseline health status. We see that elective surgeries performed in the DNR population represent 209 different CPT codes. Table 3 is a list of the most common elective procedures performed in DNR patients by CPT code, which include lower extremity amputation, Roux-en-Y gastric bypass, femur fracture repairs, carotid endarterectomy, colectomy, and cystostomy, among others. Table 4 is a list of the most common elective procedures performed in DNR patients by surgical specialty, which include general surgery (39%), orthopedics (20%), vascular (19%), and urology (11%).

The absence of significant preoperative and operative characteristics indicate that covariate balance was successfully achieved in the matching process. Additionally, Figures 2 and 3 are qualitative plots of the propensity scores from the match. We can appreciate that the distributions of the exposure and control groups are substantially more similar in the matched cohort compared to the unmatched cohort. Both the quantitative and qualitative measures are consistent with good covariate balance.

Outcomes analysis

Table 5 is a comparison of risk-adjusted 30-day postoperative outcomes in 459 DNR and 459 non-DNR patients in the matched cohort. Figure 4 is a plot of the odds ratios and 95% confidence intervals of our primary and secondary outcomes. The only significant outcomes in DNR patients within the 30-day postoperative period after elective surgery were an increased risk of death (OR 2.51 [1.55-4.05] $p < 0.001$, with absolute mortality rate of 13.1% vs. 5.1%) and an increased average length of hospital stay (7.65 ± 9.55 vs. 6.87 ± 9.21 days, $p = 0.002$) compared to non-DNR patients.

Notably, outside of postoperative mortality, there was no significant difference in the incidence of any other postoperative complications, including resuscitative measures such as cardiac arrest requiring CPR, unplanned reintubation, and reoperation. The most common elective surgery complications in both DNR and non-DNR patients were bleeding requiring transfusion, urinary tract infection, reoperation, and sepsis.

The total length of hospital stay was analyzed using Cox proportional hazards model, with death as the competing event. Technically, total length of hospital stay is the sum of days from hospital admission to operation and days from operation until discharge. Among patients of the matched cohort who died within the 30-day postoperative period, the average number of days from operation until death was 11.97 ± 7.80 days, with 62.5 percent of deaths occurring during hospitalization and 37.5 percent after discharge. There were no significant differences between DNR and non-DNR patients who died with respect to the average number of days from operation until death (11.72 ± 8.22 vs. 12.50 ± 6.95 days, $p = 0.559$) or whether the death occurred before or after discharge (60% vs. 68% before discharge, $p = 0.478$).

DISCUSSION

Summary of elective surgery outcomes in DNR patients

Our outcomes regression analysis showed that DNR patients who underwent elective surgery have a higher 30-day postoperative mortality rate (13.1% vs. 5.1%) compared to non-DNR patients who underwent the same procedure, independent of their poorer baseline health. These findings are consistent with prior studies of DNR patients in a variety of other surgical contexts, with reported mortality rates ranging from 21 to 37.5 percent.[10,12,14,19,23] Notably, despite the increased mortality, DNR patients did not have a higher 30-day postoperative complication rate after elective surgery. There were no significant differences in the incidence of resuscitative measures such as cardiac arrest requiring CPR, unplanned reintubation, or reoperation in the 30-day postoperative period. DNR patients also had an increased average length of hospital stay (7.65 ± 9.55 vs 6.87 ± 9.21 days).

Possible causes of increased mortality but not morbidity

We explore the possible causes of this higher mortality rate in the absence of change in complication rate in DNR patients who underwent elective surgery. Of note, NSQIP does not record the causes and circumstances of death, which make it difficult to definitively attribute causation.

Deaths from withholding cardiopulmonary resuscitation

First and foremost, the increased mortality may be attributed to the deaths in the subset of DNR patients who experienced cardiac arrest and did not receive CPR, as per their DNR orders. In this case, the increased mortality would be a direct consequence of adhering to their goals of care. However, it is not clear how NSQIP records cases of cardiac arrest where CPR is withheld, since the variable for cardiac arrest only accounts for cases where CPR is given. Distinguishing these two scenarios would be helpful in elucidating which patients did or did not receive CPR, for example, when comparing DNR and non-DNR patients and their outcomes.

Deaths from less aggressive treatment of complications

Alternatively, the increased mortality may be attributed to less aggressive treatment received by DNR patients once complications arose. This may be due to the presence of failure to rescue, as Siracuse suggested,[10] or because DNR patients were more likely to convert to comfort care in the event of rapid deterioration. The prior would be in opposition to the patient's goals of care, and the latter in accordance. Walsh's study, in which the majority of DNR patients underwent non-elective surgeries, found a lower incidence of resuscitative measures performed on DNR patients postoperatively, and suggested this as more consistent with transition to comfort measures.[18] Since our study, which looked only at elective surgeries, did not elicit any significant differences in postoperative resuscitative measures, we cannot infer that there was greater transition to comfort care, nor that patients with complications requiring resuscitation failed to receive them.

Insufficient characterization of comorbidities and outcomes

It is also possible that the variables used in our analysis failed to capture the severity of certain comorbidities and outcomes due to insufficient detail. All categorical outcomes and the majority of baseline characteristics are binary in nature. For example, the NSQIP variable for congestive heart failure is limited to only Yes or No values. However, a more detailed characterization of this variable that distinguishes between New York Heart Association classes 1 through 4 may identify nuances in the cohort distributions that significantly affect the matching process and consequently the outcomes regression.

Evaluating the purpose of surgery

It is also important to consider the purpose of the elective surgery and its possible effects on the rate of mortality and complications. For example, the risks and benefits of a given procedure (e.g. gastrostomy tube) may differ greatly depending on whether it is palliative in nature (e.g. for relief of malignant bowel obstruction) or life-extending (e.g. for nutrition). The purpose of the surgery is thus an important point of consideration in the patient-centered shared decision making process. NSQIP does not currently record the purpose of the surgery, which makes it difficult to assess these differences. However, the NSQIP Geriatric Surgery Pilot Project,[34] implemented 2014 to 2016, identified a number of geriatric-specific risk factors and outcome measures to include in future NSQIP models, including admission from palliative care or hospice and new DNR order during hospitalization. These additions would allow us to better examine if there are significant differences in outcomes in palliative and non-palliative elective surgeries.

Patient-centered shared decision making

The results of this study are highly relevant to DNR patients considering elective surgery in the patient-centered shared decision making process. Specifically, DNR patients considering elective surgery should be informed that they are at increased risk of postoperative mortality due to their DNR status, in addition to their increased risk of mortality due to poor baseline health. Therefore, DNR patients must weigh their reasons for undergoing surgery (e.g. palliative vs. life-extending) against the risk of dying sooner in deciding whether a particular elective procedure would be worthwhile to pursue. It is crucial that patients and their physicians discuss, as part of the patient-centered shared decision making process, the expected outcomes of the elective surgery in light of the patient's goals of care, in order to determine the appropriateness of the intervention.

Limitations

The NSQIP database presents several limitations to this study. First, data is collected from participating hospitals and is not statistically representative of the national population. At the same time, the data collected is audited by trained Surgical Certified Reviewers and has been shown to be of high quality.[35,36] Second, there is a high percentage of missing values (e.g. preoperative laboratory tests), which need to be handled for logistic regression analysis. Third, the de-identified nature of the data limits our assessment of hospital characteristics, such as geographic region, volume of surgery, type (e.g. community or academic), and available on-site resources (e.g. intensive and palliative care), which may influence the surgical outcomes. Fourth, variables are deliberately generic so as to be applicable to all types of procedures. However, this limits in-depth exploration of risk factors and outcomes targeted in certain specializations. Specifically, with regards to our study on DNR status in elective surgery, NSQIP does not record, for example, the preoperative diagnosis, the purpose of the surgery (e.g. palliative), the causes and circumstances of death, whether CPR was performed or withheld, whether changes to perioperative code status were made (e.g. suspended), or whether transition to comfort measures only was made. These parameters provide insight into the care of DNR patients in the perioperative period. Fifth, as mentioned previously, since the DNR variable was retired in 2012 and the elective surgery variable was introduced in 2011, our study sample was limited to two years of data.

In terms of the statistical methods, propensity score matching is preferred in outcomes analysis of cohorts with few exposures and many potentially confounding covariates as a means of reducing the bias in estimated treatment effects. However, there is a tradeoff between bias and variance depending on the covariates included in the model and the algorithm used. Additionally, there may be insufficient power to detect an effect in some of the secondary outcomes due to their lower incidences.

Conclusions

In conclusion, DNR status is associated with higher mortality but not morbidity for elective surgeries in the 30-day postoperative period, independent of patients' baseline health. Furthermore, the lack of increased postoperative complications suggests that the isolated rise in postoperative mortality may be related to inherent differences in the management of postoperative complications in patients with DNR orders. This may be a consequence of withholding resuscitative measures, failure to rescue, or transition to comfort care. Therefore, DNR patients who are considering elective surgery should thoroughly assess the risks and benefits of the procedure, along with their increased risk of mortality due to DNR status, in light of their goals of care as part of the patient-centered shared decision making process in determining the appropriateness of the elective surgery.

Suggestions for future work

Further research is needed to determine the exact cause of the isolated increase in mortality in DNR patients undergoing elective procedures, as well as distinguish between transition to comfort care and the presence of failure to rescue. This will likely entail an in-depth analysis of specialized variables targeted to surgical DNR patients, such as those found in the NSQIP Geriatric Surgery Pilot Project. More nuanced discussion of surgery-specific risks for DNR patients and perioperative code status will also be possible and should be included in the patient-centered shared decision-making process pending these investigations.

SUMMARY

In summary, patients with do-not-resuscitate orders who are considering elective surgery should be aware that they are at increased risk of dying after the procedure compared to others of the same baseline health who do not have do-not-resuscitate orders. They are also more likely to stay in the hospital for a longer period of time after the surgery. However, their do-not-resuscitate status does not put them at increased risk of suffering from other surgical complications. Patients with do-not-resuscitate orders should therefore carefully evaluate the expected outcomes of the elective surgery in light of these findings, and through patient-centered discussions with their physician, decide whether the intervention is consistent with their goals of care.

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TABLES

Table 1 Baseline characteristics of the unmatched cohort

	DNR		Non-DNR			
Unmatched	**Num/Denom (Mean)**	**% (SD)**	**Num/Denom (Mean)**	**% (SD)**	**p value**	**Univariate logistic regression**
Age						
	76.02	13.46	52.02	16.01	<0.001	1.115(1.106-1.124); <0.001
<65	114 / 566	20.141	212098 / 316431	67.028	<0.001	NA
65-79	157 / 566	27.739	82761 / 316431	26.155	NA	3.529(2.773-4.493); <0.001
>=80	295 / 566	52.12	21572 / 316431	6.817	NA	25.443(20.488-31.596) <0.001
Sex						
Male	253 / 565	44.779	132451 / 316295	41.876	0.162	NA
Female	312 / 565	55.221	183844 / 316295	58.124	NA	0.888(0.753-1.049);0.163
Demographics						
White	410 / 562	72.954	222959 / 315309	70.711	0.001	NA
Black	26 / 562	4.626	28548 / 315309	9.054	NA	0.495(0.333-0.736); 0.001
Asian	6 / 562	1.068	6884 / 315309	2.183	NA	0.474(0.212-1.061); 0.07
Other	7 / 562	1.246	3851 / 315309	1.221	NA	0.988(0.468-2.088); 0.976
Not Reported	113 / 562	20.107	53067 / 315309	16.83	NA	1.158(0.94-1.426); 0.168
BMI						
	28.47	8.99	30.1	8.03	<0.001	0.970(0.958-0.983); <0.001
18.5-25	184 / 522	35.249	78361 / 311476	25.158	<0.001	NA
<18.5	29 / 522	5.556	4807 / 311476	1.543	NA	2.036(1.777-2.332);<0.001
25-30	141 / 522	27.011	99050 / 311476	31.8	NA	0.677(0.618-0.742);<0.001
>=30	168 / 522	32.184	129258 / 311476	41.499	NA	0.505(0.458-0.558);<0.001
Functional Status						
No Dyspnea	451 / 566	79.682	292165 / 316431	92.331	<0.001	NA
Dyspnea with moderate exertion	92 / 566	16.254	22740 / 316431	7.186	NA	2.621(2.094-3.281);<0.001
Dyspnea at rest	23 / 566	4.064	1526 / 316431	0.482	NA	9.764(6.403-14.89);<0.001
Independent	373 / 559	66.726	309354 / 315712	97.986	<0.001	NA
Partially Dependent	138 / 559	24.687	5491 / 315712	1.739	NA	20.844(17.115-25.385);<0.001
Totally Dependent	48 / 559	8.587	867 / 315712	0.275	NA	45.917(33.75-62.47);<0.001

Table 1 (cont'd)

ASA Class						
3-Severe Disturb	342 / 566	60.424	118287 / 315292	37.517	<0.001	NA
1/2 -No Disturb/ Mild Disturb	60 / 566	10.601	184358 / 315292	58.472	NA	0.113(0.086-0.148);<0.001
4-Life Threat	162 / 566	28.622	12573 / 315292	3.988	NA	4.456(3.693-5.377);<0.001
5-Moribund	2 / 566	0.353	74 / 315292	0.023	NA	9.348(2.286-38.232);0.002
Comorbidities						
Smoking	68 / 566	12.014	55972 / 316430	17.689	<0.001	0.635(0.493-0.819);<0.001
Drinking	21 / 566	3.71	7641 / 316430	2.427	0.047	1.549(1.001-2.397);<0.001
Hypertension	419 / 566	74.028	142183 / 316430	44.933	<0.001	3.493(2.895-4.216);<0.001
Diabetes	162 / 566	28.622	45640 / 316430	14.423	<0.001	2.379(1.982-2.856);<0.001
COPD	97 / 566	17.138	12917 / 316430	4.082	<0.001	4.86(3.903-6.052);<0.001
CHF	37 / 566	6.537	1216 / 316430	0.384	<0.001	18.131(12.931-25.423);<0.001
CAD	81 / 566	14.311	17026 / 316430	5.381	<0.001	2.937(2.32-3.718);<0.001
PVD	85 / 566	15.018	9576 / 316430	3.026	<0.001	5.663(4.492-7.138);<0.001
CKD	45 / 566	7.951	4010 / 316430	1.267	<0.001	6.729(4.955-9.139);<0.001
CVA	102 / 566	18.021	9517 / 316430	3.008	<0.001	7.089(5.716-8.792);<0.001
Steroid use	49 / 566	8.657	9303 / 316430	2.94	<0.001	3.129(2.333-4.197);<0.001
Weight loss	23 / 566	4.064	3433 / 316430	1.085	<0.001	3.862(2.541-5.869);<0.001
Wound infection	99 / 566	17.491	7722 / 316430	2.44	<0.001	8.475(6.815-10.54);<0.001
Bleeding disorder	65 / 566	11.484	10773 / 316430	3.405	<0.001	3.681(2.841-4.77);<0.001
Sepsis	60 / 566	10.601	2668 / 316430	0.843	<0.001	13.945(10.642-18.273);<0.001
Recent surgery	32 / 566	5.654	3731 / 316430	1.189	<0.001	4.982(3.482-7.128);<0.001
Labs						
Creatinine	1.36	1.11	1	0.85	<0.001	1.23(1.176-1.287);<0.001
Hematocrit	2.39	3.7	1.48	5.33	<0.001	1.039(1.019-1.058);<0.001
Platelets	2.14	1.32	1.8	1.53	<0.001	1.166(1.1-1.236);<0.001
Surgical Specialty						
General Surgery	222 / 566	39.223	157964 / 316431	49.921	<0.001	NA
Orthopedics	115 / 566	20.318	47689 / 316431	15.071	NA	1.716(1.37-2.15);<0.001
Vascular	105 / 566	18.551	25634 / 316431	8.101	NA	2.915(2.31-3.678);<0.001
Gynecology	13 / 566	2.297	23264 / 316431	7.352	NA	0.398(0.227-0.696);0.001
Urology	60 / 566	10.601	20550 / 316431	6.494	NA	2.078(1.561-2.764);<0.001
Neurosurgery	15 / 566	2.65	12000 / 316431	3.792	NA	0.889(0.527-1.501);0.661
Otolaryngology (ENT)	8 / 566	1.413	11753 / 316431	3.714	NA	0.484(0.239-0.981);0.044
Plastics	8 / 566	1.413	10297 / 316431	3.254	NA	0.553(0.273-1.12);0.100

Table 1 (cont'd)

Thoracic	10 / 566	1.767	4145 / 316431	1.31	NA	1.717(0.91-3.237);0.095
Cardiac Surgery	10 / 566	1.767	3135 / 316431	0.991	NA	2.27(1.203-4.281);0.011
Surgical Complexity						
Work RVU	18.11	9.28	16.47	9.56	<0.001	1.016(1.008-1.024);<0.001
Anesthesia						
General	470 / 566	83.039	283308 / 316329	89.561	<0.001	NA
MAC/IV Sedation	35 / 566	6.184	15640 / 316329	4.944	NA	1.349(0.957-1.902);0.088
Spinal	52 / 566	9.187	11779 / 316329	3.724	NA	2.661(1.997-3.546);<0.001
Regional	5 / 566	0.883	3125 / 316329	0.988	NA	0.964(0.399-2.33);0.936
Other	2 / 566	0.353	1773 / 316329	0.56	NA	0.68(0.169-2.729);0.586
Epidural	2 / 566	0.353	704 / 316329	0.223	NA	1.712(0.426-6.881);0.448

Note: hematocrit was decreased by one order of magnitude and platelet count was decreased by two orders of magnitude so that changes of similar magnitude in laboratory values are reflective of comparable significance.

Table 2 Baseline characteristics of the matched cohort

	DNR		Non-DNR			
Matched	Num/Denom (Mean)	% (SD)	Num/Denom (Mean)	% (SD)	p value	Univariate logistic regression
Age						
	76.62	13.2	75.11	13.47	0.088	1.009(0.999-1.018);0.088
<65	84 / 459	18.301	81 / 459	17.647	0.901	NA
65-79	130 / 459	28.322	136 / 459	29.63	NA	0.922(0.625-1.359);0.681
>=80	245 / 459	53.377	242 / 459	52.723	NA	0.976(0.686-1.39);0.894
Sex						
Male	208 / 459	45.316	221 / 459	48.148	0.39	NA
Female	251 / 459	54.684	238 / 459	51.852	NA	1.121(0.864-1.452);0.39
Demographics						
White	348 / 459	75.817	341 / 459	74.292	0.928	NA
Black	22 / 459	4.793	20 / 459	4.357	NA	1.078(0.578-2.011);0.814
Asian	6 / 459	1.307	5 / 459	1.089	NA	1.176(0.356-3.889);0.791
Other	7 / 459	1.525	7 / 459	1.525	NA	0.98(0.34-2.823);0.97
Not Reported	76 / 459	16.558	86 / 459	18.736	NA	0.866(0.615-1.22);0.411
BMI						
	27.76	7.95	27.38	7.44	0.452	1.006(0.99-1.024);0.451
18.5-25	165 / 459	35.948	182 / 459	39.651	0.717	NA
<18.5	27 / 459	5.882	26 / 459	5.664	NA	1.145(0.642-2.042);0.645
25-30	129 / 459	28.105	122 / 459	26.58	NA	1.166(0.843-1.614);0.354
>=30	138 / 459	30.065	129 / 459	28.105	NA	1.18(0.857-1.624);0.31
Functional Status						
No Dyspnea	354 / 459	77.124	362 / 459	78.867	0.793	NA
Dyspnea with moderate exertion	83 / 459	18.083	78 / 459	16.993	NA	1.088(0.773-1.532);0.628
Dyspnea at rest	22 / 459	4.793	19 / 459	4.139	NA	1.184(0.63-2.226);0.6
Independent	313 / 459	68.192	303 / 459	66.013	0.761	NA
Partially Dependent	113 / 459	24.619	119 / 459	25.926	NA	0.919(0.68-1.243);0.585
Totally Dependent	33 / 459	7.19	37 / 459	8.061	NA	0.863(0.526-1.417);0.561
ASA Class						
3-Severe Disturb	282 / 459	61.438	258 / 459	56.209	0.366	NA
1/2 - No Disturb/ Mild Disturb	49 / 459	10.675	59 / 459	12.854	NA	0.76(0.502-1.15);0.194
4-Life Threat	126 / 459	27.451	141 / 459	30.719	NA	0.818(0.61-1.097);0.179
5-Moribund	2 / 459	0.436	1 / 459	0.218	NA	1.83(0.165-20.279);0.622

Table 2 (cont'd)

Comorbidities						
Smoking	52 / 459	11.329	57 / 459	12.418	0.61	0.901(0.604-1.345);0.61
Drinking*	17 / 459	3.704	18 / 459	3.922	0.863	0.942(0.479-1.852);0.863
Hypertension	348 / 459	75.817	330 / 459	71.895	0.176	1.226(0.912-1.646);0.177
Diabetes	130 / 459	28.322	123 / 459	26.797	0.605	1.079(0.808-1.442);0.605
COPD	76 / 459	16.558	80 / 459	17.429	0.725	0.94(0.666-1.327);0.725
CHF	31 / 459	6.754	32 / 459	6.972	0.896	0.966(0.579-1.612);0.896
CAD	68 / 459	14.815	66 / 459	14.379	0.852	1.036(0.718-1.494);0.852
PVD	75 / 459	16.34	71 / 459	15.468	0.718	1.067(0.749-1.521);0.718
CKD	39 / 459	8.497	48 / 459	10.458	0.311	0.795(0.51-1.239);0.311
CVA	84 / 459	18.301	79 / 459	17.211	0.666	1.077(0.768-1.512);0.666
Steroid use	41 / 459	8.932	41 / 459	8.932	1	1(0.635-1.574);1
Weight loss**	16 / 459	3.486	22 / 459	4.793	0.32	0.717(0.372-1.384);0.322
Wound infection	76 / 459	16.558	73 / 459	15.904	0.788	1.049(0.739-1.49);0.788
Bleeding disorder	57 / 459	12.418	49 / 459	10.675	0.409	1.186(0.791-1.78);0.409
Sepsis	51 / 459	11.111	44 / 459	9.586	0.448	1.179(0.77-1.805);0.449
Recent surgery	29 / 459	6.318	27 / 459	5.882	0.783	1.079(0.628-1.853);0.783
Labs						
Creatinine	1.37	1.14	1.42	1.48	0.544	0.97(0.879-1.07);0.544
Hematocrit	3.25	1.84	3.11	2.62	0.351	1.028(0.97-1.089);0.353
Platelets	2.36	1.1	2.34	1.2	0.77	1.017(0.908-1.139);0.769
Surgical Specialty						
General Surgery	173 / 459	37.691	170 / 459	37.037	0.956	NA
Orthopedics	92 / 459	20.044	90 / 459	19.608	NA	1.004(0.701-1.439);0.98
Vascular	93 / 459	20.261	93 / 459	20.261	NA	0.983(0.688-1.404);0.923
Gynecology	9 / 459	1.961	5 / 459	1.089	NA	1.769(0.581-5.386);0.315
Urology	45 / 459	9.804	51 / 459	11.111	NA	0.867(0.551-1.364);0.537
Neurosurgery	15 / 459	3.268	17 / 459	3.704	NA	0.867(0.42-1.792);0.7
Otolaryngology (ENT)	7 / 459	1.525	4 / 459	0.871	NA	1.72(0.494-5.982);0.394
Plastics	5 / 459	1.089	4 / 459	0.871	NA	1.228(0.324-4.652);0.762
Thoracic	10 / 459	2.179	13 / 459	2.832	NA	0.756(0.323-1.771);0.519
Cardiac Surgery	10 / 459	2.179	12 / 459	2.614	NA	0.819(0.345-1.946);0.651

Table 2 (cont'd)

Surgical complexity						
Work RVU	18.19	9.43	18.01	9.33	0.768	1.002(0.988-1.016);0.768
Anesthesia						
General	385 / 459	83.878	391 / 459	85.185	0.942	NA
MAC/IV Sedation	26 / 459	5.664	23 / 459	5.011	NA	1.148(0.644-2.047);0.64
Spinal	41 / 459	8.932	41 / 459	8.932	NA	1.016(0.644-1.601);0.947
Regional	4 / 459	0.871	2 / 459	0.436	NA	2.031(0.37-11.155);0.415
Other	1 / 459	0.218	1 / 459	0.218	NA	1.016(0.063-16.296);0.991
Epidural	2 / 459	0.436	1 / 459	0.218	NA	2.031(0.183-22.494);0.564

Note: hematocrit was decreased by one order of magnitude and platelet count was decreased by two orders of magnitude so that changes of similar magnitude in laboratory values are reflective of comparable significance.

Table 3 Common elective surgeries performed in DNR patients by CPT code (count >=10)

Frequency	CPT code	Procedure Name
29	27590	Amputation of thigh
22	43644	Roux-en-Y gastric bypass (laparoscopic)
21	27236	ORIF of femoral neck fracture
16	35301	Thromboendarterectomy of neck artery
13	27880	Amputation of leg
13	27125	Partial hip hemiarthroplasty
12	44140	Partial colectomy with anastomosis
11	27245	ORIF of trochanteric femoral fracture
10	51040	Cystostomy

Table 4 Distribution of surgical specialties in elective surgeries performed in DNR patients

Surgical specialty	Frequency	%
General Surgery	222	39.22261484
Orthopedics	115	20.3180212
Vascular	105	18.55123675
Urology	60	10.60070671
Neurosurgery	15	2.650176678
Gynecology	13	2.296819788
Cardiac Surgery	10	1.766784452
Thoracic	10	1.766784452
Otolaryngology (ENT)	8	1.413427562
Plastics	8	1.413427562
Other	0	0
Unknown	0	0
Interventional Radiologist	0	0

Table 5 Risk-adjusted 30-day postoperative outcomes

	DNR		Non-DNR			
Outcomes	**Num/Denom (Mean)**	**% (SD)**	**Num/Denom (Mean)**	**% (SD)**	**p value**	**Univariate logistic regression**
Death	60 / 459	13.072	26 / 459	5.664	<0.001	2.504(1.55-4.047);<0.001
Return to OR	19 / 459	4.139	26 / 459	5.664	0.285	0.719(0.392-1.319);0.286
Failure to wean	8 / 459	1.743	17 / 459	3.704	0.068	0.461(0.197-1.08);0.074
Reintubation	6 / 459	1.307	5 / 459	1.089	0.762	1.203(0.364-3.969);0.762
Surgical site infection	13 / 459	2.832	14 / 459	3.05	0.845	0.926(0.431-1.994);0.845
Dehiscence	5 / 459	1.089	5 / 459	1.089	1	1(0.288-3.478);1
Pneumonia	15 / 459	3.268	23 / 459	5.011	0.185	0.64(0.33-1.244);0.188
Renal insufficiency	2 / 459	0.436	0 / 459	0	0.157	1.044(0.587-1.857);0.883
Renal failure	6 / 459	1.307	8 / 459	1.743	0.59	0.747(0.257-2.169);0.591
Stroke	1 / 459	0.218	3 / 459	0.654	0.316	0.332(0.034-3.201);0.34
Cardiac arrest requiring CPR	4 / 459	0.871	1 / 459	0.218	0.179	4.026(0.449-36.142);0.214
Acute MI	11 / 459	2.397	6 / 459	1.307	0.221	1.854(0.68-5.056);0.228
Transfusion	84 / 459	18.301	85 / 459	18.519	0.932	0.986(0.706-1.376);0.932
VTE	4 / 459	0.871	2 / 459	0.436	0.413	2.009(0.366-11.022);0.422
UTI	29 / 459	6.318	22 / 459	4.793	0.313	1.34(0.758-2.369);0.315
Sepsis	20 / 459	4.357	19 / 459	4.139	0.87	1.055(0.555-2.004);0.87
Mean length of stay	7.65	9.55	6.87	9.21	0.208	2.079(1.311-3.295);0.002

FIGURES

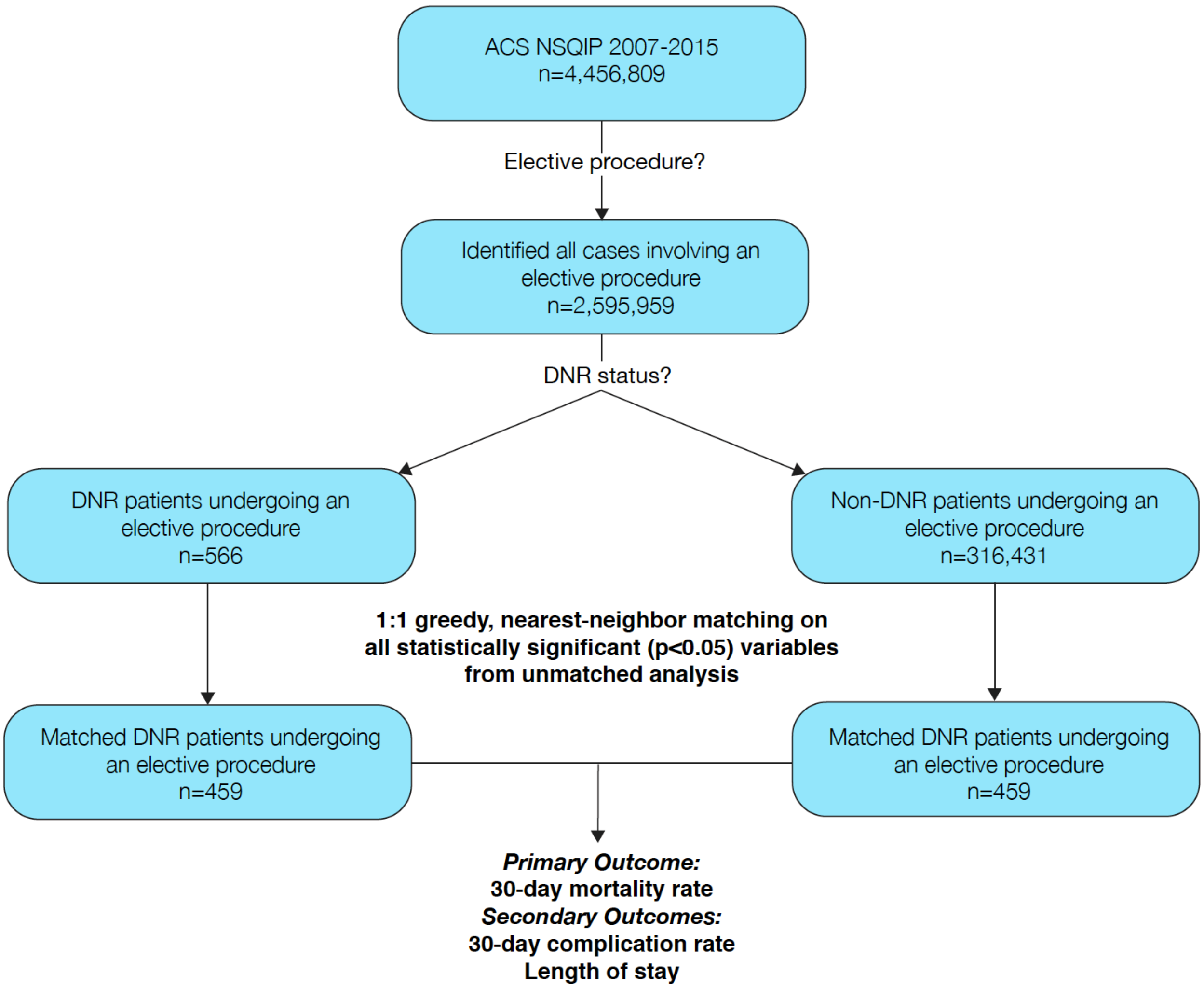

Figure 1 Patient selection process and study design

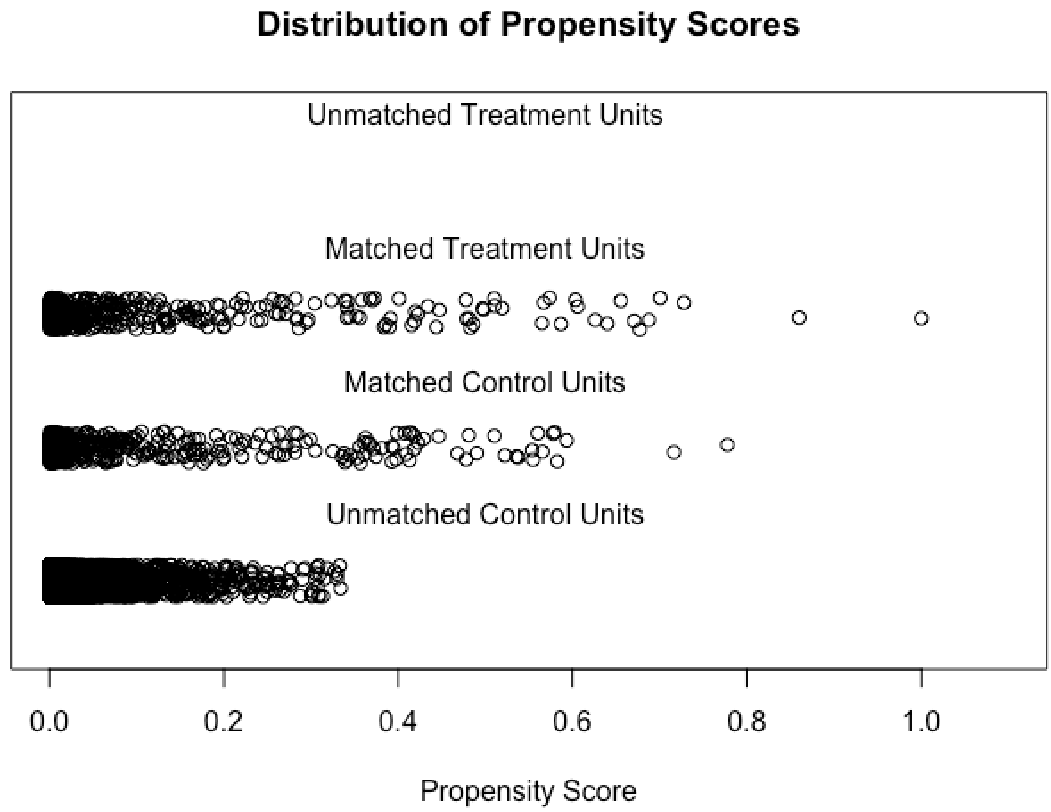

Figure 2 Jitter plot of distribution of propensity scores

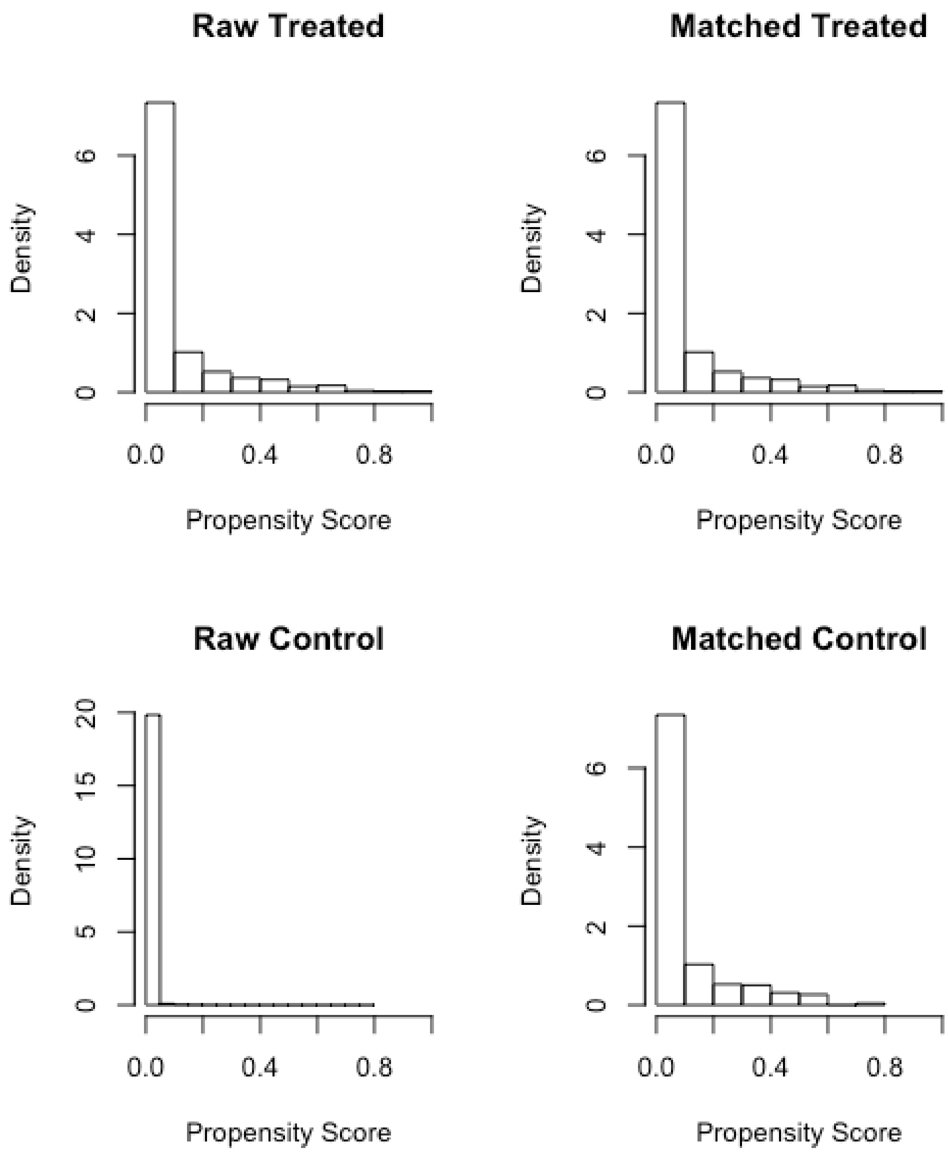

Figure 3 Histogram of distribution of propensity scores

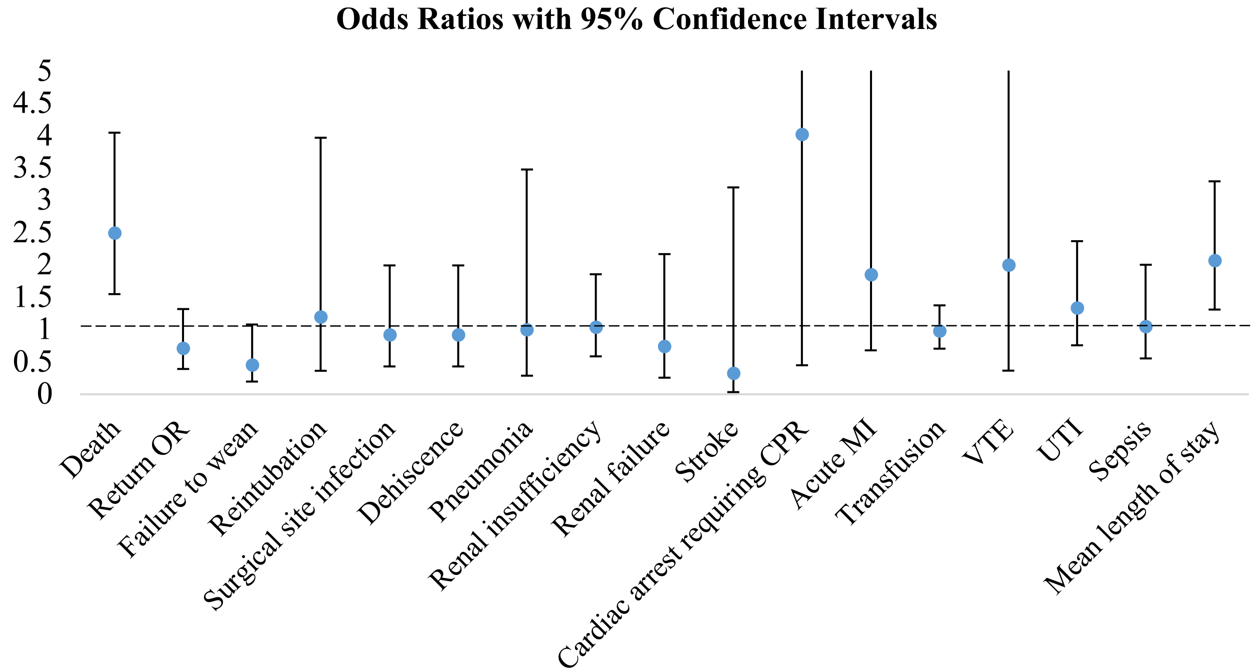

Figure 4 Plot of odds ratios and 95% confidence intervals of the 30-day postoperative outcomes