Effect of anaesthesia type on postoperative mortality and morbidities: a matched analysis of the NSQIP database

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Abstract

Background. The anaesthetic technique may influence clinical outcomes, but inherent confounding and small effect sizes makes this challenging to study. We hypothesized that regional anaesthesia (RA) is associated with higher survival and fewer postoperative organ dysfunctions when compared with general anaesthesia (GA).

Methods. We matched surgical procedures and type of anaesthesia using the US National Surgical Quality Improvement database, in which 264,421 received GA and 64,119 received RA. Procedures were matched according to Current Procedural Terminology (CPT) and ASA physical status classification. Our primary outcome was 30-day postoperative mortality and secondary outcomes were hospital length of stay, and postoperative organ system dysfunction. After matching, multiple regression analysis was used to examine associations between anaesthetic type and outcomes, adjusting for covariates.

Results. After matching and adjusting for covariates, type of anaesthesia did not significantly impact 30-day mortality. RA was significantly associated with increased likelihood of early discharge (HR 1.09; P < 0.001), 47% lower odds of intraoperative complications, and 24% lower odds of respiratory complications. RA was also associated with 16% lower odds of developing deep vein thrombosis and 15% lower odds of developing any one postoperative complication (OR 0.85; P < 0.001). There was no evidence of an effect of anaesthesia technique on postoperative MI, stroke, renal complications, pulmonary embolism or peripheral nerve injury.

Conclusions. After adjusting for clinical and patient characteristic confounders, RA was associated with significantly lower odds of several postoperative complications, decreased hospital length of stay, but not mortality when compared with GA.

Key words: general anaesthesia; patient outcome; regional anaesthesia; registry
Editor’s Key Points

- Regional anaesthesia offers several benefits and can avoid risks of general anaesthesia
- Nonrandomized comparisons of such groups must account for selection bias and confounding, and this requires very large datasets
- This study identified some benefits, including reduced respiratory complications and hospital stay
- Regional anaesthesia was not associated with reduced 30-day mortality

overall mortality and morbidity after GA, yet complications do occur and may be related to the anaesthetic technique utilized. Moreover, the impact of anaesthesia management could have longer term effects on overall outcome than what we currently attribute to it.

The effect of anaesthesia type on overall patient outcome has been the interest of numerous studies. The majority of these studies have focused on specific surgical procedures and/or groups of patients (e.g. vascular or orthopaedic surgery) and have yielded inconsistent results. There is uncertainty as to whether RA has favourable outcomes compared with GA in a broad range of surgical patients. The remarkably low number of anaesthesia-related deaths in the USA, estimated at only 8.2/million hospital surgical discharges, limits our ability to compare the outcomes of these two techniques in randomized trials. The dearth of large representative samples, confounding, and the small effects have made this a challenging question to answer. We utilized the American College of Surgeons National Surgical Quality Improvement (ACS-NSQIP) database to test our hypothesis that RA may be associated with higher survival and fewer postoperative organ dysfunctions when compared with GA, after adjustment for clinical and patient characteristic confounders.

Methods

Data source

The Institutional Review Board at Vanderbilt University Medical Centre approved this study. We accessed unidentified pooled data from the ACS-NSQIP (2005-2011) database, which collects over 250 patient variables for surgeries from over 300 participating community and academic medical centres across the USA. Data are collected and entered by trained professionals to ensure accuracy and reliability. The ACP-NSQIP database includes patient characteristics, major perioperative risk factors, comorbidities, procedure type and duration, anaesthesia type, postoperative complications including organ dysfunctions and 30-day mortality, and hospital length of stay. As we used unidentified retrospective patient data, consent was deemed unnecessary and was not obtained.

Study population

Anaesthesia types reported in the ACP-NSQIP database as epidural, spinal, or peripheral nerve block anaesthesia were all considered as part of the RA group. Anaesthetics in which a regional technique may have been used in combination with a general anaesthesia, were classified as a general anaesthetic (primary anaesthetic) for the purpose of this study. Patients who received a regional anaesthetic were matched to those who received a general anaesthetic according to Current Procedural Terminology (CPT) code and ASA physical status. This had the effect of excluding those CPT codes and ASA physical status combinations for which there were no regional anaesthetic matches; thus our cohort comprised of matched patients undergoing procedures where both types of anaesthetic options were considered appropriate. In addition, patients in the RA group who could not be matched were excluded from analysis.

Outcomes of interest

The primary outcome was 30-day postoperative mortality. Secondary outcomes were hospital length of stay (LOS) and the occurrence of the following postoperative organ dysfunctions: respiratory complications (pneumonia, reintubation or respiratory failure requiring mechanical ventilation for more than 48 h), myocardial infarction (MI), renal complications (progressive renal insufficiency as defined by an increase in serum creatinine by $>2.0 \text{ mg}\text{d}^{-1}$ above baseline value, or new onset renal failure requiring renal replacement therapy), deep venous thrombosis (DVT), pulmonary embolism, stroke, peripheral nerve injury (PNI) and major intraoperative complications (death and/or cardiac arrest).

Statistical analysis

As mechanically ventilated patients and procedures lasting more than 4 h are more likely to receive GA, those procedures were excluded before matching. Figure 1. To reduce selection bias caused by procedure type and the overall severity of comorbid illness, patients in the RA group were matched to patients in the GA group in a ratio of 1:10 with replacement (i.e. patients in the GA group were eligible to match with multiple patients in the RA group). Patients were matched exactly with respect to CPT code and ASA status grouping (1 or 2, 3, and 4 or 5). After matching, weighted multiple regression analysis was used to examine the covariate-adjusted associations between type of anaesthetic (RA vs GA) and each outcome. Logistic regression was used for binary categorical outcomes, and Cox proportional hazards regression was used for the time-to-event outcome. Weighting was used to account for the 1:10 matching ratio (each match received 1/10 weight). We adjusted for age, gender, race, BMI, ASA status, functional status before surgery, smoking, alcohol use, weight loss, surgical specialty, emergency status of procedure, operative time, and for presence of major preoperative comorbidities, including hypertension, diabetes mellitus, and history of the following: severe chronic obstructive pulmonary disease, coronary artery disease (angina, MI and/or prior coronary intervention), renal dysfunction ($\text{Cr} > 3 \text{ mg}\text{d}^{-1}$), stroke (with or without deficit), and history of disseminated cancer. A natural cubic spline function with three knots was used for continuous variables (age, BMI and surgical time) to allow for nonlinear covariate associations. Wald-type confidence intervals and tests were used for simple inferences. A likelihood ratio test was used to evaluate simultaneous hypotheses. The effects of anaesthetic type are presented as odds ratios (OR) or hazard ratio (HR) for the time-to-event outcomes with corresponding 95% confidence interval. This approach was selected in favour of a marginal approach (e.g. propensity score matching) in order to more fully describe the effect of anaesthetic type on postoperative mortality and morbidity. All analyses were implemented using R 3.1.2 (R Foundation for Statistical Computing, Vienna, Austria). A significance level of 0.05 was used for statistical inference.

Results

Of the 1.7 million procedures in the NSQIP database 328,540 surgical procedures were matched after exclusions, which included...
264,421 in the GA group and 64,119 in the RA group. Nevertheless, only 161 RA procedures failed to match with GA counterpart (Fig. 1). Table 1 summarizes patient characteristics, surgical specialty groups, ASA status, operative times and major co-morbidities before and after matching. Patients in our study population had a median age of 64.5 yr, 48.8% females, 17.9% had general surgery, 21% vascular surgery, 50.8% orthopaedic surgery and 9.9% genitourinary surgery. ASA Class I and II patients accounted for 46.2% of the cohort and 46.4% were ASA III. Intraoperative and postoperative outcomes are summarized in Table 2.

After matching and adjusting for preoperative comorbidities (see Fig. 2, Table 2), anaesthesia type had no significant effect on 30-day mortality (OR 1.07; 95 CI: 0.56, 2.05; P = 0.81), but RA was associated with increased likelihood of early discharge (HR 1.04; 95% CI: 1.03, 1.05; P < 0.001; increased hazard of early discharge, i.e. shorter length of stay). RA was associated with 47% lower odds of intraoperative complications and 24% lower odds of respiratory complications. It was also associated with 16% lower odds of developing DVT and 15% lower odds of developing one or more postoperative complication (OR 0.85; 95% CI: 0.80, 0.91; P < 0.001) (Fig. 2, Table 2). There was no evidence of an effect of anaesthesia technique on postoperative MI, stroke, renal complications.

All outcome measures were further analysed by considering the interaction of anaesthetic technique and ASA subgroups: (I/II), III, (IV/V). There was significant evidence of an interaction for Hospital LOS, respiratory complications, and any one postoperative complication. The odds ratios associated with anaesthesia technique, stratified by ASA subgroup are listed in Table 3 and Appendix 2.

### Discussion

In this analysis of ACS-NSQIP database, which represents a large and diverse patient population from across the USA, we found no evidence of a beneficial effect on 30-day postoperative mortality. We did however find evidence of association between anaesthesia technique and development of some postoperative organ dysfunctions and hospital LOS, after matching and adjusting for all relevant confounding variables in the database.

A number of studies, often restricted to a specific procedure/patient population, have shown mortality and morbidity benefits with RA over GA, though many others did not. A meta-analysis of 28 randomized controlled studies of total knee arthroplasty patients, showed that anaesthetic technique had no effect on mortality or respiratory complications. However, Ruppert and colleagues was able to demonstrate reduction in mortality in patients undergoing endovascular surgery using RA. In the ACS-NSQIP database of over 26,000 patients undergoing carotid endarterectomy, there was no effect of anaesthesia type on mortality or postoperative morbidities. Interestingly, Eck and colleagues analysed the same patient population and while they confirmed the lack of mortality difference, they found an increased risk of MI in the GA group, a result similar to that reported by Kfoury and colleagues. RA, however, has been associated with a reduction in respiratory complications in patients undergoing endovascular aortic surgery

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infrainguinal revascularization for peripheral vascular disease in lower extremity amputation and hip surgery patients.
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In our cohort, consisting of a large and diverse patient population undergoing a variety of surgical procedures, we found that RA was associated with lower odds of many postoperative organs dysfunction and shorter hospital lengths of stay. Our data adds to the literature because of the generalizability of our findings across patient populations and more importantly the lower odds of postoperative organ dysfunction associated with RA, may explain the overall reduction in hospital LOS. We hypothesize that the smaller incidence of respiratory complications associated with RA, is related to fewer perturbations in respiratory mechanics and ventilation-perfusion imbalances. GA is associated with decreased muscle tone, atelectasis, shunt and hypoxia, all of which may lead directly or indirectly to respiratory failure.

In this analysis, RA was significantly associated with lower odds for DVT risk. However, there was no significant difference between groups in regard to thromboembolism. Ramanan and colleagues, in an unadjusted analysis on vascular patients (ACS-NSQIP 2007-2009), showed increased risk of DVT in central vascular procedures, but found reduced risk of overall thromboembolism when RA was used. There was no evidence of association between anaesthesia type and postoperative renal dysfunction, after matching and adjustment for confounders. Other studies showed that RA was associated with fewer renal complications in patients undergoing endovascular aortic
aneurysm repair\textsuperscript{7} and Neuman and colleagues\textsuperscript{12} were also able to demonstrate the same effect in hip fracture surgery. In contrast, many others researchers in agreement with our results, have found that there was no effect of anaesthesia type on postoperative renal function in patients undergoing intra-abdominal surgery,\textsuperscript{22} carotid endarterectomy\textsuperscript{10} and endovascular procedures.\textsuperscript{7}\textsuperscript{17} It is likely that anaesthesia type may impact renal function in high-risk patients and we believe it is of interest to study its effect retrospectively and prospectively in future work.

While anaesthesia type had no significant effect on some postoperative complications, there was 15% reduction of any one or more of those complications when analysed combined ($P < 0.001$). Combining all postoperative complication allowed us to show the small but statistically significant effect of RA, on reduction of individual postoperative complications, otherwise missed by the analysis of each one separately. The overall reduction in postoperative complications is, perhaps, the explanation of the decreased hospital LOS. Hospital LOS and resource utilization is an integral part of delivering effective and efficient patient care. We found significant reduction in hospital LOS associated with RA use. Based on our findings, RA may be a component of a cost reduction strategy by avoiding postoperative morbidities and decreasing hospital LOS. Helwani and colleagues\textsuperscript{19} were able to show significant reduction in hospital LOS in patients undergoing hip Arthroplasty which is similar to our findings. In addition, we found no difference in the incidence of PNI between groups, which is sometimes considered a barrier to performing regional anaesthesia.

Our study design has several limitations. We evaluated a large surgical database and assessed the impact of anaesthetic type on patient outcomes. To reduce the effect of selection bias,
we matched patients by CPT code and ASA status before adjusting for all relevant confounding patient characteristic and clinical variables (Appendix 2). Although we have taken special care to address the possibility for confounding among all observed variables, there may be confounding with unobserved variables (i.e., variable not recorded in the ACS-NSQIP database). Another limitation inherent to database analysis is the uncertain quality of data collected from diverse locations. The quality of data...
collection in the ACS-NSQIP database has been evaluated previously\(^{23}\) and was found to have inter-rater disagreement of only 1.5% in 2008, adding confidence to the findings in this study. Third, while there is evidence that RA is associated with superior clinical outcomes, this does not imply causality. Lastly, we were unable to isolate those patients who had a regional anesthetic technique supplemented to the general anesthesia, from those who had a pure general anesthetic. However, by grouping these techniques, our findings are likely biased towards the null and thus more conservative. Despite these limitations, this is one of the largest analyses of the ACS-NSQIP database showing an independent association between anesthesia type, some patient outcomes and hospital LOS.

### Conclusions

In this analysis, after matching and adjusting for clinical and patient characteristic confounders, RA was not associated with reduced mortality but was associated with fewer intraoperative and postoperative complications and decreased hospital LOS, relative to GA in a wide range of procedures and diverse patient population. While these findings do not imply causation, they are supportive of the safety and efficacy of RA. Therefore, anaesthetists may consider the preferential use of RA techniques in patients undergoing procedures in which RA is an option.

### Authors’ contributions

Study design/planning: N.N.S., P.P.P.
Study conduct: N.N.S., M.A.H., P.P.P.
Data analysis: N.N.S., M.A.H., Y.S., M.S.S., P.P.P.
Writing paper: N.N.S., L.M.W., M.S.S., P.P.P.

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### Declaration of interest

None declared.

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### Table 3 Summary of significant results in ASA subgroups. Incidence and adjusted odds of postoperative outcomes; hospital length of stay, respiratory complication, intraoperative complications and any one complication in both study groups. The hazard ratio (HR) was calculated for hospital length of stay using Cox proportional hazards regression. Increased hazard of discharge corresponds to shorter length of stay. The odds ratio (OR) was computed for all other outcomes using logistic regression. LOS = Length of stay

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<th>Outcome</th>
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<th>P-value</th>
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<td>(1.04, 1.13)</td>
<td>&lt;0.001</td>
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<tr>
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of national surgical quality improvement program database. Vascular 2015; 23: 113–9


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