Prediction of early acute readmission after colorectal cancer surgery using only clinical preoperative variables

Johan Stub Rønø Clausen, Andreas Weinberger Rosen, Karoline Bendix Bräuner, Mikail Gögenur, Viviane Annabelle Lin, Eldar Allakhverdiiev, Julie Sparholt Walbech, Ismail Gögenur.

Background

According to the WHO, colorectal cancer (CRC) caused 935.000 deaths in 2020 worldwide (1). Surgical removal of malignant tissue is the cornerstone in the treatment of the majority of the patients today. The surgical procedure itself, however, induces a risk of surgery-related postoperative morbidity. Retrospective studies have reported 30-day readmission rates ranging between 9-25% after colorectal surgery (2). Reported risk factors for 30-day readmission are inconsistent and constitute sociodemographic, clinical and perioperative factors, and reasons for readmissions are most commonly surgical-site infection (SSI), gastrointestinal obstruction, and medical complications such as pneumonia or sepsis (2-5). Acute readmissions may delay recovery and onset of adjuvant chemotherapy, are costly and may constitute a significant burden on healthcare systems with limited resources (6). The latter may be of particular importance considering the ongoing COVID-19 pandemic, where demands on critical healthcare may exceed available resources.

The patients' treatment trajectories are often planned at a multidisciplinary team conference (MDT), where surgeons consult with radiologists, oncologists and pathologists and decide if and how the surgery should be performed. Identifying patients with high risk of postoperative morbidity is crucial at the MDT, and a decision support tool visualizing personalized readmission risk may prove to be of high value for identifying high-risk patients and deciding the treatment plan accordingly. Interventions for high-risk patients may include intentional delay of surgery due to pre-operative physical training (pre-habilitation), choosing a less invasive surgical procedure or increasing postoperative monitoring compared to standard.

The majority of currently available prediction models based on CRC patients have been developed for predicting short term mortality or complications (e.g. anastomotic leakage) (7). One study describes a logistic regression model predicting the risk for multiple readmissions (>1) the first year after colon cancer surgery (8). Other models have been developed for predicting early readmissions, although not specifically intended for the CRC population (9). The quality and scale of the nationwide Danish clinical databases creates a unique opportunity to develop patient-level prediction models based on modern artificial intelligence (AI) algorithms.

Methods

An OMOP CDM was built using data from the nationwide Danish Colorectal Cancer Database (DCCG), which was established in 2001 and contains prospectively collected clinical data with very high granularity on patients diagnosed with colorectal cancer I Denmark. Completeness has been reported to 95% between 2001-2010 and 99% from 2010 (10). At this time, the database includes roughly 77.000 patients (11). The CDM was enriched with variables from the Danish National Patient Registry (DNPR) containing information on hospital admission types and dates. DNPR captures administrative data on hospital admission, diagnoses and procedures on all persons in the Danish public healthcare system (12).

OHDSI's ATLAS tool and R were used for creating the prediction models. A data-driven approach was taken. The target cohort was defined as patients with a colorectal cancer diagnosis undergoing any colorectal cancer surgery. Furthermore, patients must be eligible for readmission, meaning that the patient must appear in both registries and must be discharged within 180 days of index surgery. The outcome cohort was defined as patients having an emergency readmission. Time-at-risk was defined as 0-30 days from primary surgery. Data was included in the age, gender, conditions, measurement values, procedures and observation domains. Custom covariates were created for specific clinical scales (e.g. WHO Performance score, body mass index). Only preoperative covariates were included in the model, and data was included if available any time prior to index surgery. A Lasso-regression was chosen for modelling. Data was split by person with 25% used for testing.

Results

96 out of 267 variables were included in the final model. Between 2001 to 2019, 62.824 Patients underwent colorectal cancer surgery and were eligible for readmission. The incidence of unplanned 30-day readmission was 10.423 (16,6%).

The area under the ROC curve (AUC) was 0.60 (95%CI 0.59:0.61), and the area under the precision recall curve (AUPRC) was 0.22 with a Brier score of 0.14. Test calibration is visualized in figure 1. Calibration was considered acceptable with the predicted risk ranging between 0.05-0.25.

Figure 1. Test calibration plot.

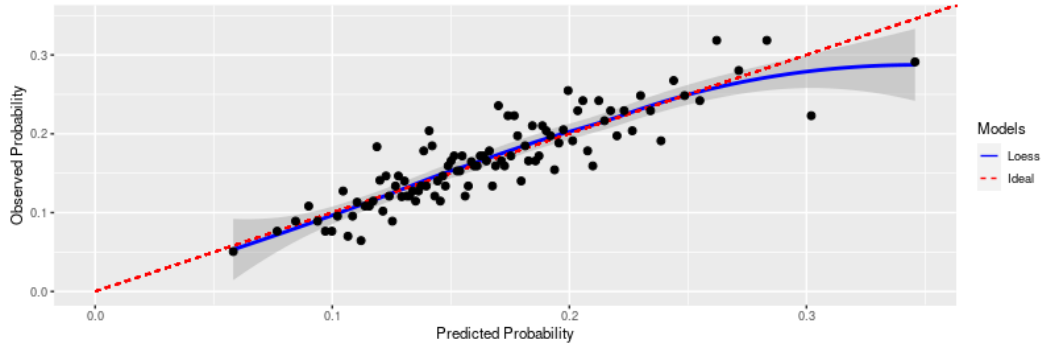
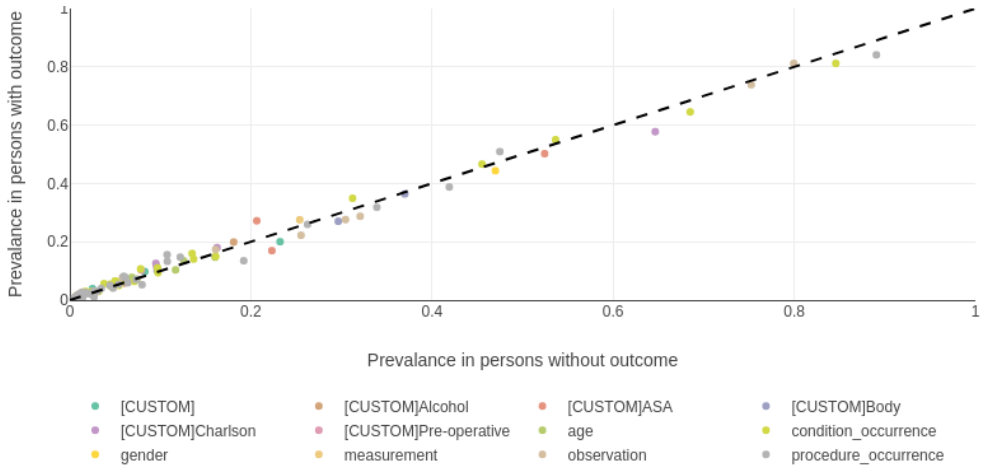


Figure 2. Prevalence of variables in patients with- and without 30-day readmission.



Covariates related to endoscopic and local tumor resection, cancer diagnosed by routine screening, elective surgery, M0 category and low comorbidity score were associated with a decreased risk of readmission. Likewise, permanent stent insertion, temporary colostomy, high comorbidity scores and neoadjuvant chemotherapy were associated with an increased risk of readmission.

Conclusion

The prediction model can not be used as a stand-alone tool for deciding a personalized treatment trajectory, but a combination of multiple postoperative outcome predictions may be supportive in the complex decision-making process during the MDT and ultimately reduce postoperative morbidity. Hence, it is not possible to select a threshold for high/low risk, as the risk of readmission should be seen as a continuum in combination with the patients wish, possible treatment strategies and other predicted clinical outcomes. The current model's performance may be improved with further enrichment from other Danish nationwide databases capturing high-granular phenomics.

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