

Developing a multivariable prediction model for preadmission prediction of postoperative delirium, malnutrition and wound infection in older gastrointestinal surgery patients

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SAMENVATTING

Rationale: Screening en voorbereiding van patiënten om postoperatieve complicaties te voorkomen, ontbreken voor oudere gastro-enterologische chirurgiepatiënten. Gesuggereerd wordt dat meer gedaan kan worden, wanneer patiënten voorbereid en in optimale conditie zijn voor een ziekenhuisopname. De combinatie van risico identificatie en voorspelling van postoperatieve complicaties met behulp van preoperatieve patiëntkarakteristieken in deze populatie is nog niet gemaakt.

Doel: Het ontwikkelen van prognostische modellen, met behulp van preoperatieve patiëntkarakteristieken, om postoperatieve delirium, ondervoeding en wondinfectie te kunnen voorspellen in de preopname periode bij gastro-enterologische chirurgiepatiënten met de leeftijd van 65 jaar en ouder.

Methode: Een prognostisch voorspellend onderzoek, met retrospectief dossieronderzoek. De uitkomstmaten waren delirium, ondervoeding en wondinfectie. De studie is uitgevoerd en gerapporteerd met behulp van de *Transparent reporting of a multivariable prediction model for individual prognosis or diagnosis* (TRIPOD)-statement.

Statistische analyse: Met *backward selection* in een logistische regressie analyse werden modellen ontworpen. De prestaties van de modellen werd getest met de discriminatie (*Receiver operating characteristic curves*) en de kalibratie (*Hosmer-Lemeshow goodness of fit test*).

Resultaten: Een ASA fysieke status classificatie 3, gebruik van hulpmiddelen, gebruik van benzodiazepines en slechthorenden zonder hoortoestel worden geassocieerd met postoperatieve delirium. Voor ondervoeding werden de volgende voorspellers gevonden: re-operatie ≤ 2 jaar, afhankelijk van mantelzorg, ≥ 2 chronische ziekten, onbedoeld gewichtsverlies, verlies van eetlust en onvoldoende orale intake. Andere gastro-enterologische procedures, diabetes mellitus, preoperatieve depressie en het weigeren van informatie over chirurgie en anesthesie werden geassocieerd met postoperatieve wondinfectie.

Conclusie: Op basis van deze prognostische modellen kunnen patiënten met een verhoogd risico op postoperatieve delirium, ondervoeding of wondinfectie geïdentificeerd worden voordat zij opgenomen worden. Een optimalisatie van de conditie in de periode voor ziekenhuisopname is hierbij belangrijk.

Aanbevelingen: Verder onderzoek is nodig om deze modellen in nieuwe datasets te valideren, voordat gebruik in de klinische praktijk geadviseerd wordt.

Trefwoorden: Predictie, Gastro-enterologische oudere patiënt, Delirium, Ondervoeding, Wondinfectie

ABSTRACT

Rationale: Screening and preparing patients before admission to prevent postoperative complications is lacking for older gastrointestinal patients. It is suggested that more can be done when patients are prepared and optimized before admission. No combination of risk factor identification and prediction of postoperative complications with preadmission patient characteristics is made for this population.

Aim: To develop prognostic models, with the use of preadmission patient characteristics, to predict postoperative delirium, malnutrition and wound infection in gastrointestinal surgery patients of 65 years and older in the preadmission period.

Method: A prognostic study, with retrospective patients' files search. Main study outcomes were postoperative delirium, malnutrition and wound infection. This study was conducted and reported considering the *Transparent reporting of a multivariable prediction model for individual prognosis or diagnosis* (TRIPOD)-statement.

Statistical analysis: Through backward elimination in logistic regression analyses models were set up. Performance of the models was tested by the discrimination (Receiver Operating Characteristic curves) and calibration (Hosmer-Lemeshow goodness of fit) test.

Results: An ASA physical status classification 3, the use of resources, the use of benzodiazepines and impaired hearing without a hearing aid are associated with postoperative delirium. For malnutrition the predictors re-operation ≤ 2 years, relying on informal care, ≥ 2 chronic diseases, unintended weight loss, loss of appetite and insufficient oral intake are associated. The predictors diabetes mellitus, other GI procedures, preoperative depression and refusing information about surgery and anesthesia have a predictive value for postoperative wound infection.

Conclusion: Based on these prediction models, patients can be identified before surgery for being at risk for postoperative delirium, malnutrition and wound infection and their condition can be optimized.

Implications of key findings: Further research is needed to validate these models in new datasets, before the models could be used in clinical practice.

Keywords: Prediction, Gastrointestinal older patients, Delirium, Malnutrition, Surgical Site Infection.

INTRODUCTION

In the Netherlands, the share of older people (65+) increased from 12.8% in 1990 to 17.8% in 2016 and is expected to grow to 23.8% in 2030 (1,2). During hospitalization, older patients have a higher risk of being frail (3). Being frail is defined as chronic reduction in physical or mental condition (4,5). Furthermore, surgery and anesthesiological techniques are improving and now also allow older people to have (gastrointestinal (GI)) surgery. Frail older people have the highest risk of care related complications and mortality after GI surgery (6,7).

This study focusses on high frequency postoperative complications and will be aimed at establishing risk factors for malnutrition, delirium and wound infection, because they are most likely to occur after surgery in GI patients during hospitalization. GI patients frequently suffer from postoperative delirium (incidence 14.0% to 47.0%) (8-12), malnutrition (25.0% to 40.0%) (13,14) and wound infection (17.9% to 26.3%) (15-17). These complications are associated with functional and cognitive decline, delayed recovery to the preoperative functional status and a decreased quality of life after being discharged (18,19). This often leads to a prolonged hospital stay, which increases the risk on acquiring care related complications.

Delirium is characterized by an attention or awareness disorder, an acute onset (in hours to days), a fluctuating severity of symptoms, and changes in cognition or perception (20,21). Malnutrition is defined as a subacute or chronic state of nutrition in which a combination of varying degrees of over- or undernutrition and inflammatory activity has led to a change in body composition and diminished function (22). Wound infection, a surgical site infection, is an infection that occurs within 30 days after surgery in the part of the body where the surgery took place (23).

Much more can be done when patients are prepared and optimized before admission (19). In cardiac surgery, it is proven that postoperative complications can be reduced by preparation of vulnerable patients before admission and surgery (24,25). The Prevention of Decline in Older Cardiac Surgery Patients Programme (PREDOCS Programme) was developed, and includes screening for increased risks of several postoperative complications based on preoperative patient characteristics (25,26). The PREDOCS Programme is based on multivariable prognostic models. Such models are suitable for specific patient categories and can therefore not be used for GI patients.

Research is done aiming at risk factors for postoperative complications for GI surgery (8,13-15,17,27). However, no combination of risk factor identification, prediction of postoperative complications and interventions to prepare for surgery have been made for older GI surgery patients. Such risk factor identification and predictions are important, because of the large impact that post-operative complications have on the recovery of elderly surgery patients (19).

Developing such an intervention is a complex process, which starts with developing multivariable prognostic models. Based on preadmission patient characteristics, these models have the ability to predict postoperative delirium, malnutrition or wound infection. As such, patients can be screened for having a higher risk for postoperative malnutrition, delirium or wound infection before admission. Also, this risk assessment allow preparing GI patients at risk for postoperative delirium, malnutrition and wound infection before surgery. This could lead to less functional and cognitive decline, less delay in recovery and a greater quality of life after being discharged.

OBJECTIVE

To develop prognostic models, with the use of preadmission patient characteristics collected one to six weeks before the surgery period, to predict postoperative delirium, malnutrition and wound infection after gastrointestinal surgery in patients of 65 years and older.

METHOD

Design and data source

The design of this study was a prognostic research. A retrospective patients' file search was conducted in two Dutch hospitals, a peripheral hospital and a top clinical hospital. Data was collected as a part of continuous data registry from the hospitals. The study outcomes and predictors were collected from individual patients' files, including nursing records and medical files.

To improve the objective judgement and reproducibility of the presented prognostic model, the new Transparent Reporting of a multivariable Prediction model for Individual Prognosis Or Diagnosis (TRIPOD) guideline was used (28).

Participants

This study focused on patients of 65 years and older, who were elected to GI surgery between January 2015 and March 2016. In order to be eligible to participate in this study, a subject had to meet all of the following criteria: 1. The age of 65 years and older; 2. Underwent elected GI surgery between January 1, 2015 and March 30, 2016; 3. Patients' total admission period is reported in the medical and nursing file. Potential subjects were excluded from this study if: 1. Suffered from preoperative delirium or wound infection;

Outcomes

All three outcomes were collected from the postoperative part of the hospital admission. In this study a delirium is screened by the Delirium Observation Screening Scale (DOSS) by nurses

(29,30). In every shift, a nurse fulfills the DOSS, which leads to three scores (0-13) and a 24h-score (0-39) as the sum of the shift scores. The 24h-score of the DOSS must be divided by 3, when this outcome is ≥ 3 a delirium is most likely to be present (29). In this study a DOSS score ≥ 3 was therefore used as cutoff point for delirium. The DOSS has a sensitivity of 90% and a specificity of 91% for delirium in older (65+) hospitalized patients (31).

A wound infection is diagnosed by a surgeon by physical examination during or after hospitalization, within a maximum of 30 days after surgery. A surgical site infect was diagnosed based on criteria from the 'Procedure-associated Module SSI' written by the Centers of Disease Control and Prevention (CDC) by a surgeon (23).

Malnutrition is screened at least once a week during hospitalization with the Malnutrition Universal Screening Tool (MUST) by nurses (32). The MUST score is calculated based on the body mass index, weight loss within three to six months and expected food intake in the next five days (32). (Preventive) treatment of malnutrition starts when patients have a high risk of malnutrition (score ≥ 2 /red) and not particularly when a patient is diagnosed with malnutrition (32). In this study a MUST score ≥ 2 was therefore used as cutoff point for malnutrition. The MUST has a sensitivity of 85% and a specificity of 93% in surgery patients (33).

Both the MUST and DOSS screening scores were collected from the nurses records. The occurrence of wound infection was collected from the medical files. All outcomes were presented as binary data for the occurrence of the complication.

Predictors

The literature was reviewed to identify potential predictors and risk factors associated with aspects of preadmission functioning of the patients with postoperative delirium (8-10,34), malnutrition (13,35) and wound infection (15-17). Based on these studies and clinical knowledge, a list of 46 potential predictors was formed (appendix A). These predictors were collected as binary, continuous and nominal data. The potential predictors were divided into six categories: general, comorbidity, resources, social status, frailty, medication and condition.

The potential predictors were collected from both nurses records and medical files, including anesthesiological records. All potential predictors were presented or transformed in binary data, with the use of dummy variables.

Sample Size

The sample size was based on incidence numbers of the postoperative complications and the number of elected patients in the inclusion period. Based on the number of positive cases (incidence) of the outcomes, the full models were build. The power-rule of 10 positive cases

per included predictor in the full model was used, because this is the minimum for reliable modelling (36).

Statistical analysis method

All data were collected in Microsoft Excel and analysed in IBM SPSS (SPSS) version 23. Both the outcomes and predictors were collected by the main researcher (SK). A minimum of 10% of the collected data were also collected by nursing students. A Cohen's kappa was calculated to assess the similarity in the data collection, to measure the interrater reliability. Missing data were handled with predictive mean matching in Statistical Package R (RE) as a way of multiple imputation in outcomes and predictors that were partly missing (37). Variables that were not available as part of the continuous preadmission data registry of the hospitals, could not be collected and were therefore excluded from data collection.

Prediction selection

Before analyses, the potential predictors were grouped into six categories: general, comorbidity, resources, social Status, frailty and medication. A seventh category for malnutrition was applicable: condition. A different set of potential predictors was used for each of the outcomes. Also, clinical relevant interaction between predictors were calculated with correlation coefficients and, where needed based on clinical relevance and a >0.70 correlation coefficient, two predictors were combined and transformed into one predictor.

Given the large number of potential predictors, the power rule of 10 positive cases was not applicable for the prediction selection. Therefore, twostep statistical analyses for the prediction selection and full model analyses was used. Firstly, a regression analysis was used to reduce the number of predictors. Within each category a multivariable logistic regression was fitted for each of the outcomes, selecting important predictors per category with stepwise backward selection. The stopping rule for this first selection ($p < 0.157$) is based on the Akaike Information Criterion (AIC). The AIC was chosen because of the comparison of the models based on their fit to the data and penalizing for the complexity of the model (36).

Secondly, the important predictors from the categories were combined into a full multivariable logistic regression model, for each outcome separately, using stepwise backward selection, and $p < 0,05$ as stopping rule to arrive at small (final) models.

Model performance

The discrimination and calibration of the models were used to express the performance of the models. The discrimination shows the ability of the prognostic models to distinguish patients with high risks of the complication and patients with low risks. The discrimination was estimated by Receiver Operating Characteristic (ROC) curves and the accompanying C-statistics (area under the curve) with a 95% confidence interval.

The Hosmer-Lemeshow test is a measurement for calibration. The calibration of a model shows how close an observed outcome is to the predicted outcome (36). The goodness-of-fit is calculated with a Hosmer-Lemeshow test and rates to the ability of a model to fit in a given set (36).

Ethical issues

The study was conducted according to the principles of the Declaration of Helsinki. Because of the retrospective patients' file search, the Medical Research Involving Human Subjects was not applicable. The study was conducted according to the Medical Treatment Contracts Act from the Civil Law, the Personal Data Protection Act and Good Clinical Practice (GCP). Both hospitals' local ethical review boards gave permission to conduct patients' file research. All data was anonymized during data collection.

RESULTS

Participants

A total of 667 individual patient files was available for data collection (SK and nursing students). Table 1 shows the baseline characteristics of the participants. In total, 36.8% suffered from one or more of the three postoperative complications. Wound infection occurred in 15.3% of the participants, delirium in 13.0% and malnutrition in 8.5%. The Cohen's kappa of the outcome measures were moderate to almost perfect (Table 2).

An amount of 46% of the data was imputed by the supervising researcher (RE). Missing data occurred in both the outcomes and predictors (appendix A). Within the outcome measurements, a DOSS score was missing in 82.8%, the MUST score in 86.1% and a wound infection in 69.8%. Missing data percentages in the predictors had a range from 0 through 70%. After imputation, a total of 667 complete cases were available for analyses.

– TABLE 1, TABLE 2 –

Model development

A total of 12 predictors were excluded from data collection and analyses (table 3, 4 and 5). Ten predictors from the category condition were not collected through the continuous data registry for the nursing records or medical files. One predictor from the category resources was depended from another predictor and could therefore not be included in regression analyses. Additionally, one predictor from the category medication did not occur in the population and was also excluded from analyses.

Delirium

For delirium, 28 predictors were associated, based on literature review and clinical knowledge. After analyses within the categories, nine predictors were associated with postoperative delirium. Table 3 shows the predictor selection process within the six categories and the full model for delirium.

For the full model analyses, six predictors could be included based on the number of positive delirium cases (n=57). The predictors age, American Society of Anesthesiologists Physical Status Classification (ASA classification) 2 and living alone were dropped based on low coefficients, high p-values and low expected clinical relevance. Additionally, two predictors were strongly interacting with each other and had a clinical relevant association with delirium. 'Impaired hearing' and 'hearing aid' were transformed in 'having an impaired hearing without a hearing aid' for the full model of delirium. The predictor 'actively supported' was excluded in the full model analyses based on a high p-value. This resulted in four predictors in the final model for delirium: ASA classification 3, use of resources, use of benzodiazepines and impaired hearing – no hearing aid.

– TABLE 3 –

Malnutrition

Table 4 shows the prediction selection process within the seven categories and for the full model for malnutrition. For malnutrition, 43 predictors were found to be associated, based on literature review and clinical knowledge. After analyses within the categories, ten predictors were found to be associated with postoperative malnutrition.

Based on the incidence of malnutrition (n=87) nine predictors could be included in full model analyses. The predictors 'hearing aid' and the 'use of resources' were dropped for full model analysis, based on a combination of coefficients, p-values and expected clinical relevance. The predictors 'wheelchair' and 'living alone' were dropped during analyses, based on high p-values (>0.05). Resulting in the final model for malnutrition with six predictors: re-operation within two years, ≥ 2 chronic diseases, relying on informal care, unintended weight loss, loss of appetite and insufficient oral intake.

– TABLE 4 –

Wound infection

For wound infection, 30 predictors were found to be associated based on literature review and clinical practice. After analyses within the six categories, a total of ten predictors were found

to be associated with wound infection. For the full model, a total of ten predictors could be included based on incidence numbers (n=102). Table 5 shows both the process for prediction selection within the six categories and the full model.

Because of the low coefficient for 'days between preoperative screening and surgery', this predictor was dropped during the full model analyses. During backward analyses, the predictors wheelchair, walker or walking stick, relying on informal care, physical disability and the use of benzodiazepines were dropped based on high p-values. Resulting in a final model for wound infection with four predictors: other GI procedures, diabetes mellitus, preoperative depression and refusing information on surgery and anesthesia.

– TABLE 5 –

Model performance

Table 6 shows the performance measurements. The ROC curves are shown in figure 1, 2 and 3. The highest discrimination was found for delirium. The C-statistic for delirium was 0.81 (95% CI: 0.74 – 0.88), for malnutrition 0.70 (95% CI: 0.64 – 0.76) and for wound infection 0.68 (95% CI: 0.62 – 0.73). The Hosmer-Lemeshow test was not significant in all of the models which means that the models fitted the study sample.

–TABLE 6 –

– FIGURE 1, FIGURE 2, FIGURE 3 –

DISCUSSION

In this study, preadmission patient characteristics were identified and associated with postoperative malnutrition, delirium and wound infection in older gastro intestinal surgery patients. With these patient characteristics and the postoperative complications, three prediction models were developed. These models could provide a better preadmission identification of patients at risk for postoperative wound infection, malnutrition and delirium and allow for optimizing the condition of these patients in waiting time for the hospital admission.

Risk assessment in the preadmission period for specific postoperative complications is not very common in prediction studies with older GI patients. Most studies focus on the hospital period itself or outcomes such as (medical) postoperative complications in general or mortality (4,15,16). Also, studies show differences in risk factors for the occurrence of postoperative complications. Comparing the results of this study to other studies, shows similarities and differences.

In our study, an ASA classification was included in the final model for delirium. In a study about risk factors of postoperative delirium in patients with major abdominal surgery, ASA classification 3 and 4 were identified as preoperative risk factors (8). Frailty was also assessed and found to be associated with postoperative complications in different studies to predict surgical complications in elderly colorectal surgery patients. Frailty is assessed differently in these studies, but includes weight loss, physical exhaustion, physical activity level, grip strength and walking speed (5). In our study, weight loss and being physically disabled are included in the final model for malnutrition. Unintended weight loss was the most important predictor in a study to predict malnutrition in surgical cancer patients (13). This predictor was also found in our model for malnutrition. In the model for wound infection, diabetes mellitus is included. This corresponds to one of the findings of a study regarding risk factors of a surgical site infect after abdominal surgery (17).

In the final model for malnutrition, re-operation within two years, two or more chronic diseases, and loss of appetite have a negative coefficient. This means that they have a protective value in the combination of predictors in the final model. These predictors could be protective, because of the interventions that are provided in the period before the preoperative screening and in the waiting time for admission by nurses and surgeons. For example, a patient who lost his appetite before the preoperative screening due to his surgical indication, could provide extra information about high nourished food and the need of not losing weight before and after surgery.

To fully appreciate the presented results, some additional points must be considered. Firstly, a total of 369 patients files and medical files of the 667 available cases were screened. This means 298 (44%) of the cases were imputed to create a dataset without missing values. The high percentages of missing values are therefore not reflecting daily practice. The missing data was imputed, to fit the sample size and power rule of model development.

The outcomes have higher percentages of missing values than the predictors. The MUST was missing, mostly in patients with a short stay. Wound infection was missing, because of the unclear reports of the surgeon or if the surgery was less than six weeks ago. In the Intensive care unit, 60-70% of the delirium patients are not diagnosed when patients are not screened as standard care (38). This is also a concern in nursing wards with the DOSS score. These missing values in the outcomes could lead to under fitted models. The best available methods were used to deal with these missing data and to minimize bias, by using multiple mean imputation (37). Predictors that were not measured at all, were excluded from data collection. These predictors could be important, but are missing in the final model. It is a

strength, however, that only frequently used predictors are used to maximize the clinical applications of the models.

Secondly, in this study the outcomes malnutrition and delirium were screened with screening instruments and wound infection was diagnosed. In clinical practice it is difficult to diagnose malnutrition and delirium in these patients and diagnosis requires more than one discipline. Furthermore, screening instruments are compendious, less time consuming, a low burden for patients and ask for little expertise for the nurses (39,40). For these, validated instruments were therefore chosen. It should, although, be considered that screening instead of diagnosing could lead to false-positive and false-negative outcomes.

Collecting data from two centers strengthen the generalizability of the findings of this study. The reliability of this study is strengthened by collecting a large amount of data by the main researcher (SK) and nursing students. The interrater reliability was substantial with moderate to almost perfect Cohen's Kappa's. Also, peer review from the supervising investigator (RE) has enlarged the reliability and validation of this study due to his vast experience with prediction research. The identification of the potential predictors based on both literature review and clinical knowledge strengthen the validation of this study.

As mentioned before and shown in the comparison with other studies, risk assessment with preadmission patient characteristics for specific postoperative complications is not common. This means that this study provides a first step in risk assessment for malnutrition, delirium and wound infection in a large group of surgical patients. With these models older gastrointestinal patients can be screened for being at risk with the patient characteristics that are already collected through continuous data registry. Patients at risk can be prepared in waiting time for their surgery for better postoperative outcomes and less postoperative complications. This is important because of the large impact that postoperative complications have on the recovery of older surgery patients (19).

Because of the performance measurements of the final models in the same dataset as the development, it is recommended to validate the models in a new dataset with a similar population. Before validation, additional data collection could reduce the number of missing values and increase the positive cases to reduce the imputation percentage. Also, some predictors that are associated with postoperative complications in general, such as handgrip strength, should be considered to be measured through continuous data registry. The consideration of the predictors that are not yet collected, should be made based on extra costs, time and effort for practice. These predictors that are not yet collected through continuous data registry could be strong predictors for the different postoperative complications. After adjusting the potential predictions in the continuous data registry and further development and validation of the model in a new dataset, the prediction models could be used in clinical practice.

CONCLUSION

This study shows different predictors for postoperative complications in older GI surgery patients. An ASA classification 3, the use of resources, the use of benzodiazepines and impaired hearing without a hearing aid have predictive values for postoperative delirium. For malnutrition the predictors re-operation within two years, ≥ 2 chronic diseases, relying on informal care, unintended weight loss, loss of appetite and insufficient oral intake are associated. The predictors other GI procedures, diabetes mellitus, preoperative depression and refusing information about surgery and anesthesia have a predictive value for postoperative wound infection. Based on these predictors, patients can be identified prior to surgery for being at risk for postoperative delirium, malnutrition and wound infection and their condition can be optimized. These predictive models should be validated in a new dataset with older GI surgery patients before it will be used in clinical practice.

SUPPLEMENTARY INFORMATION

Both the dataset and data syntaxes are available for further research and quality checks through the main researcher (SK) and the supervisor (RE).

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TABLES AND FIGURES

Table 1
Characteristics of the study population

N= 667	Frequencies	Percentages
<i>General</i>		
Age, median (1stQ – 3thQ)	71.15	(67.56 – 76.01)
Days between preoperative screening and surgery, median (1stQ – 3thQ)	20.00	(9.00 – 32.00)
Female gender	367	55.0
Previous GI ¹ procedures	294	44.1
Re-operation within two years	175	26.2
<i>Comorbidity</i>		
≥2 Chronic diseases	175	26.2
Diabetes Mellitus	110	16.5
ASA classification ² ≤ 1	82	12.2
2	452	67.8
3	131	19.6
≥4	2	0.3
<i>Resources</i>		
Glasses or contact lenses	475	71.2
Hearing aid	91	13.6
Use of resources	35	5.2
Wheelchair	8	1.2
Walking stick or walker	57	8.5
<i>Social Status</i>		
Actively supported ³	616	92.4
Relying on informal care	36	5.4
Living Alone	158	23.7
<i>Frailty</i>		
Impaired hearing	107	16
Preoperative depression	31	6.4
Want information on surgery and/or anesthesia	534	80.1
Physical disability ⁴	100	15.0
<i>Medication</i>		
Use of benzodiazepines	80	12.0
<i>Condition</i>		
Unintended weight loss	175	26.2
Chewing problems	1	0.1
Loss of appetite ⁵	40	6.0
Insufficient oral intake	48	7.2
10% weight loss within 6 months	72	10.8
<i>Postoperative complications</i>		
Delirium	57	8.5
Malnutrition	87	13.0
Wound infection	102	15.3
Total ⁶	246	36.9

¹ GI: gastrointestinal; ² ASA classification: ASA Physical Status Classification; ³ Actively Supported: At least weekly support from family, friend or other nearby people; ⁴ Physical disability: a limitation on a person's physical functioning, mobility, dexterity or stamina; ⁵ Loss of appetite due to social conditions, loneliness or a deteriorated physical situation; ⁶ Patients with one or more postoperative complication(s)

Table 2
Cohen's kappa for outcome measurements

Outcome	Cohen's Kappa N=155 (p<0.05)
Delirium	0.859*
Malnutrition	0.518*
Wound infection	0.448*

Table 3
Predictor selection for postoperative delirium

	Analyses within categories ¹	Analyses full model ²		
	Coefficient (p-value)	Coefficient (p-value)	OR	95%CI OR
General				
Age	0.085 (0.000)	Dropped		
Female gender	0.085 (0.733)	Not entered		
Days between preoperative screening and surgery	-0.003 (0.588)	Not entered		
Comorbidity				
ASA classification ³ 2	1.139 (0.123)	Dropped		
ASA classification ³ 3	2.167 (0.004)	0.747 (0.000)	2.069	1.066-4.013
ASA classification ³ 1	24.675 (1.000)	Not entered		
ASA classification ³ ≥4	-0.157 (1.000)	Not entered		
Diabetes Mellitus	-0.102 (0.784)	Not entered		
History of CVA/TIA ⁴	-0.168 (0.699)	Not entered		
Resources				
Hearing aid	0.623 (0.094)	Dropped		
Use of resources	2.977 (0.000)	2.976 (0.001)	19.603	8.637-44.492
What kind of resources ⁵	Not entered			
Glasses or contact lenses	0.143 (0.681)	Not entered		
Orthopedic shoes	-48.328 (1.000)	Not entered		
Wheelchair	0.207 (0.811)	Not entered		
Walker or walking stick	-0.465 (0.397)	Not entered		
Social Status				
Actively supported ⁶	0.938 (0.147)	Dropped		
Living alone	0.730 (0.021)	Dropped		
Relying on informal care	0.119 (0.834)	Not entered		
Living together	-48.324 (1.000)	Not entered		
Other residential state	-48.710 (1.000)	Not entered		
Frailty				
Impaired hearing	1.087 (0.000)	Dropped		
Impaired mobility ⁷	0.092 (0.862)	Not entered		
Anxious for surgery or anesthesia	0.001 (0.998)	Not entered		
Preoperative depression	0.086 (0.893)	Not entered		
Refuse information about surgery or anesthesia	0.168 (0.613)	Not entered		
Physical disability ⁸	0.422 (0.220)	Not entered		
Medication				
Use of benzodiazepines	1.789 (0.000)	1.685 (0.000)	5.394	2.685-10.838
Correlated predictors transformed in new predictor				
Impaired hearing – no hearing aid ⁹		1.685 (0.000)	6.327	2.118-18.898
Intercept final model		-3.439 (0.000)	0.032	

¹ Multivariable logistic regression analyses, backward selection, stopping-rule p>0.157; ² Multivariable logistic regression analyses, backward selection, stopping-rule p>0.05; ³ ASA classification: ASA Physical Status Classification; ⁴ CVA: Cerebrum Vascular Accident; TIA: Transient Ischemic Attack; ⁵ Excluded from analyses because of depended variable of 'use of resources'; ⁶ Actively supported: at least weekly support from family, friend or other nearby people; ⁷ Impaired mobility: a limitation in independent, purposeful physical movement of the body or of one or more extremities; ⁸ Physical disability: a limitation on a person's physical functioning, mobility, dexterity or stamina; ⁹ Replaced predictors 'hearing aid' and 'impaired hearing' in analyses

Table 4
Predictor selection for postoperative malnutrition

	Analyses within categories ¹	Analyses full model ²		
	Coefficient (p-value)	Coefficient (p-value)	OR	95%CI OR
General				
Re-operation within two years	-1.002 (0.003)	-1.056 (0.002)	0.348	0.176-0.686
Female gender	0.212 (0.390)	Not entered		
Days between preoperative screening and surgery	0.003 (0.341)	Not entered		
Age	0.023 (0.252)	Not entered		
Hemoglobin ♀ <7.4 mmol, ♂ <8.6 mmol	0.250 (0.345)	Not entered		
Comorbidity				
≥2 chronic diseases	-0.483 (0.099)	-0.864 (0.007)	0.422	0.225-0.792
Diabetes Mellitus	0.119 (0.724)	Not entered		
History of renal failure	-99.284 (1.000)	Not entered		
Resources				
Hearing aid	-0.630 (0.116)	Dropped		
Wheelchair	1.443 (0.053)	Dropped		
Use of resources	0.818 (0.057)	Dropped		
What kind of resources ³	Not entered			
Glasses or contact lenses	0.347 (0.200)	Not entered		
Orthopedic shoes	0.195 (0.876)	Not entered		
Walker or walking stick	-0.323 (0.475)	Not entered		
Social Status				
Relying on informal care	0.742 (0.071)	0.947 (0.033)	2.578	1.078-6.165
Living alone	0.428 (0.093)	Dropped		
Living together	0.325 (0.770)	Not entered		
Other residential state	0.771 (0.513)	Not entered		
Actively supported ⁴	0.087 (0.848)	Not entered		
Frailty				
Anxious for surgery or anesthesia	-0.554 (0.368)	Not entered		
Preoperative depression	0.532 (0.260)	Not entered		
Refuse information about surgery or anesthesia	-0.015 (0.960)	Not entered		
Physical disability ⁵	-0.478 (0.197)	Not entered		
Impaired hearing	-0.389 (0.274)	Not entered		
Medication				
Use of benzodiazepines	0.501 (0.109)	Not entered		
Poly pharmacy ⁶	0.031 (0.896)	Not entered		
Condition				
Unintended weight loss	0.765 (0.005)	0.768 (0.006)	2.155	1.078-6.165
Loss of appetite ⁷	-1.035 (0.057)	-1.128 (0.043)	0.324	0.108-0.966
Insufficient oral intake	1.357 (0.001)	1.449 (0.001)	4.259	1.870-9.703
Chewing problems	38.452 (1.000)	Not entered		
10% weight loss within 6 months	0.543 (0.165)	Not entered		
Fat percentage ⁸	Not entered			
5% weight loss within 1 month ⁸	Not entered			
Protein level ⁸	Not entered			
Serum Albumin level ⁸	Not entered			
Transferrin level ⁸	Not entered			
Leptin level ⁸	Not entered			
Insulin Like Growth Factor Binding ⁸	Not entered			
Mid upper Arm Circumference (MAC) ⁸	Not entered			
Hand Grip strength ⁸	Not entered			
Triceps Skin Fold Thickness * MAC ⁸	Not entered			
<i>Intercept final model</i>		-1.910 (0.000)	0.148	

¹ Multivariable logistic regression analyses, backward selection, stopping-rule p>0.157; ² Multivariable logistic regression analyses, backward selection, stopping-rule p>0.05; ³ Excluded from analyses because of depended variable of 'use of resources'; ⁴ At least weekly support from family, friend or other nearby people; ⁵ Physical disability: a limitation on a person's physical functioning, mobility, dexterity or stamina; ⁶ Poly Pharmacy ≥ 3 Medication Prescriptions; ⁷ Loss of appetite due to social conditions, loneliness or a deteriorated physical situation; ⁸ Excluded from data collection because no available data from continuous data registry.

Table 5*Predictor selection for postoperative wound infection*

	Analyses within categories ¹	Analyses full model ²		
	Coefficient (p-value)	Coefficient (p-value)	OR	95%CI OR
General				
Days between preoperative screening and surgery	-0.015 (0.028)	Dropped		
Other GI ³ procedures	0.590 (0.007)	0.541 (0.016)	1.718	1.106-2.667
Age	-0.020 (0.303)	Not entered		
Female gender	-0.052 (0.815)	Not entered		
Open cholecystectomy	-0.151 (0.764)	Not entered		
Comorbidity				
Diabetes Mellitus	0.864 (0.001)	0.921 (0.000)	2.511	1.509-4.178
ASA classification ⁴ 1	0.035 (0.924)	Not entered		
ASA classification ⁴ 2	28.429 (1.000)	Not entered		
ASA classification ⁴ 3	0.343 (0.178)	Not entered		
ASA classification ⁴ ≥4	1.976 (0.164)	Not entered		
Resources				
Wheelchair	1.663 (0.044)	Dropped		
Walker or walking stick	0.521 (0.153)	Dropped		
Orthopedic shoes	-50.083 (1.000)	Not entered		
Glasses or contact lenses	0.091 (0.714)	Not entered		
Hearing aid	0.365 (0.226)	Not entered		
Use of resources	-49.639 (1.000)	Not entered		
Sort of resource ⁵	Not entered			
Social Status				
Relying on informal care	0.812 (0.037)	Dropped		
Living together	-0.157 (0.890)	Not entered		
Other residential state	0.413 (0.716)	Not entered		
Living alone	-0.113 (0.700)	Not entered		
Actively supported ⁶	-0.204 (0.596)	Not entered		
Frailty				
Preoperative depression	1.104 (0.006)	1.074 (0.010)	2.928	1.298-6.604
Physical disability ⁷	0.443 (0.122)	Dropped		
Refuses information on surgery & anesthesia	0.888 (0.000)	0.965 (0.000)	2.626	1.624-4.247
Anxious for surgery or anesthesia	0.339 (0.424)	Not entered		
Impaired hearing	0.130 (0.649)	Not entered		
Medication				
Use of benzodiazepines	0.553 (0.059)	Dropped		
Use of diuretics	0.155 (0.705)	Not entered		
Treatment with immunosuppressive medication ⁶	Not entered			
<i>Intercept final model</i>		<i>-2.480 (0.000)</i>	<i>0.084</i>	

¹ Multivariable logistic regression analyses, backward selection, stopping-rule $p > 0.157$; ² Multivariable logistic regression analyses, backward selection, stopping-rule $p > 0.05$; ³ GI: gastrointestinal; ⁴ ASA classification: ASA Physical Status Classification; ⁵ Excluded from analyses because of depended variable of 'use of resources'; ⁶ No occurrence in current dataset, no predictive value in logistic regression analyses; ⁷ physical disability: a limitation on a person's physical functioning, mobility, dexterity or stamina.

Table 6

Performance statistics

	Delirium	Malnutrition	Wound infection
Calibration			
Hosmer-Lemeshow goodness of fit (p-value)	0.46	0.78	0.69
Discrimination			
C-statistic	0.81	0.70	0.68
95% CI	0.74-0.88	0.64-0.76	0.62-0.73

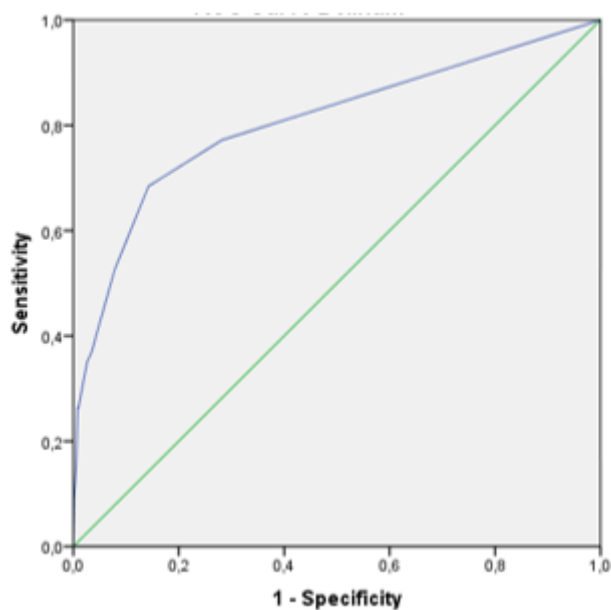


Figure 1; ROC Curve Delirium

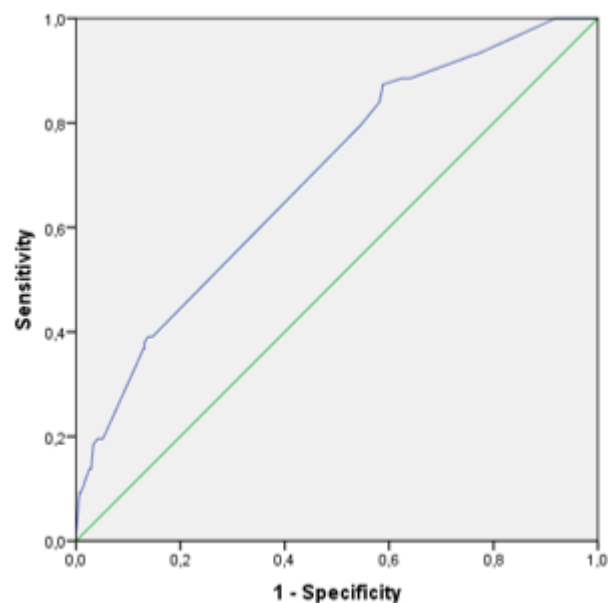


Figure 2; ROC Curve malnutrition

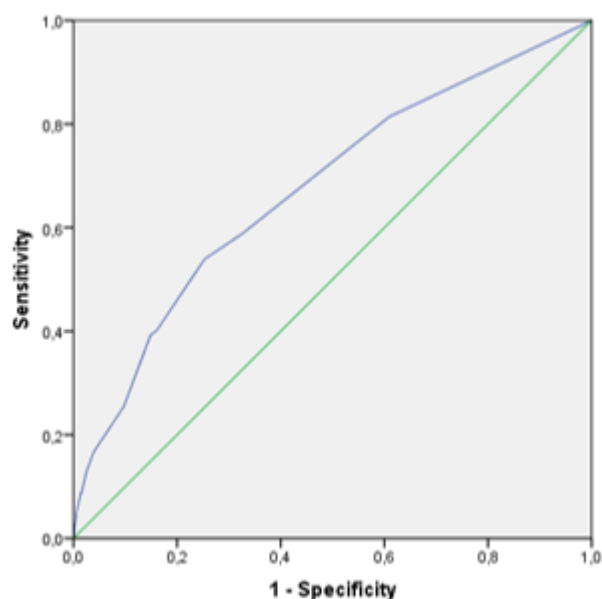


Figure 3; ROC Curve wound infection

APPENDIX

Appendix A

All preadmission variables considered as potential predictors of postoperative complications in GI patients

Potential predictors (operationalization) [missing]	
General	
Age (years) [0%]	Gender (male/female – 0/1) [0%]
Number of days between preoperative consult and surgery (days – number) [55.7%]	Other gastrointestinal procedures (yes/no – 1/0) [51.7%]
Re-operation within two years (yes/no – 1/0) [51.3%]	Hemoglobin‡ (Below value – yes/no) [57.3%]
Comorbidity	
≥2 Chronic diseases (yes/no – 1/0) [55.3%]	History of CVA/TIA (yes/no – 1/0) [55.0%]
Diabetes type 1 or 2 (yes/no – 1/0) [55.3%]	Open cholecystectomy (yes/no – 1/0) [51.3%]
History of renal failure (yes/no – 1/0) [55.0%]	ASA classification ¹ Score from 1 till 6 – 1/2/3/4/5/6 [51.5%]
Resources	
Glasses, Contact lenses (yes/no – 1/0) [55.8%]	Orthopedic Shoes (yes/no – 1/0) [52.6%]
Hearing Aid (yes/no – 1/0) [53.3%]	Means, such as: Insoles, Corset, Support Stocking, Stair Lift, Mobility Scooter (yes/no – 1/0) [54.2%]
Wheelchair (yes/no – 1/0) [52.6%]	Use of walking stick or walker (yes/no – 1/0) [53.4%]
Social Status	
Actively Supported ³ (yes/no – 1/0) [64.9%]	Depending on Informal Care (yes/no – 1/0) [58.9%]
Residential status: such as: Living alone, Live together, other (Living alone/Living together/other – 0/1/2) [52.6%]	
Frailty	
Impaired hearing (yes/no – 1/0) [70%]	Physical disability ² (yes/no – 1/0) [60.7%]
Impaired mobility ¹ (yes/no – 1/0) [53.6%]	Anxious for the Surgery or Anaesthesia (yes/no – 1/0) [53.4%]
Preoperative Depression (yes/no – 1/0) [52.5%]	Refuses information about the Surg. and Anaesthesia (yes/no – 1/0) [54.2%]
Medication	
Treatment with immunosuppressive medications (yes/no – 1/0) [56.6%]	Poly-pharmacy§ (yes/no – 1/0) [56.6%]
Use of benzodiazepines (yes/no – 1/0) [56.5%]	Use of diuretics (yes/no – 1/0) [56.0%]
Condition	
Unintentional weight loss (yes/no – 1/0) [51.6%]	Fat Percentage (yes/no – 1/0) [not collected]
Chewing problems (yes/no – 1/0) [51.6%]	Loss of Appetite † (yes/no – 1/0) [52.1%]
Insufficient Oral Intake (yes/no – 1/0) [52.8%]	5 % Weight Loss within 1 month (yes/no – 1/0) [not collected]
10% Weight Loss within 6 months (yes/no – 1/0) [52.4%]	Protein (Protein rate – number) [not collected]
Serum Albumin (Albumin rate – number) [not collected]	Leptin (Leptin rate – number) [not collected]
Transferrin (Transferrin rate – number) [not collected]	Mid-upper Arm Circumference (MAC) (mm) [not collected]
Insulin-like Growth Factor Binding (Rate – number) [not collected]	Triceps Skin Fold Thickness * MAC (mm*mm) [not collected]
Hand grip Strength [not collected]	
Complications	
Delirium (DOSS score) [82.8%]	
Malnutrition (MUST score) [86.1%]	
Wound infection (yes/no – 1/0) [69.8%]	

¹ASA classification: ASA Physical Status Classification

§) ≥ 3 Medication Prescriptions

†) Due to social conditions, loneliness or a deteriorated physical situation

‡) ♀ < 7.4 mmol, ♂ < 8.6 mmol

¹ A limitation in independent, purposeful physical movement of the body or of one or more extremities

² A *physical disability* is a limitation on a person's physical functioning, mobility, dexterity or stamina

³ At least weekly support from family, friend or other nearby people