Supplementary Material

Surgical video and body composition do not yet add to conventional predictors of complications after robotic distal gastrectomy

Journal of Robotic Surgery

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Supplementary Table S1 Blocks 2 to 4 by operating surgeon and by 30-day complication status, including the individual KLASS-02-QC items

Characteristic	All (n = 127)	Surgeon A (n = 77)	Surgeon B (n = 40)	Surgeon C (n = 10)	p (surgeon)	No complication (n = 105)	Complication (n = 22)	p (outcome)
Block 2. Surgeon proficiency (KLASS-02-QC)								
Skill sub-score (max 5)	5 (5–5)	5 (5–5)	5 (4–5)	5 (5–5)	0.002	5 (5–5)	5 (4–5)	0.701
Perigastric sub-score (max 9)	6 (6–7)	6 (5–7)	6 (6–7)	8 (8–8)	<0.001	6 (6–7)	6 (5–6)	0.082
Extraperigastric sub-score (max 8)	7 (6–8)	7 (6–7)	7 (6–8)	7 (6–8)	0.141	7 (6–8)	7 (6–8)	0.172
Total score (max 22)[a]	18 (17–19)	18 (16–19)	18 (17–19)	20 (19–21)	0.004	18 (17–19)	18 (15–19)	0.111
Individual items, achieved, %								
Skill items								
Item 1	85.0	92.2	67.5	100.0	0.001	86.7	77.3	0.322
Item 3	98.4	98.7	97.5	100.0	1.000	99.0	95.5	0.318
Item 10	94.5	94.8	92.5	100.0	0.828	94.3	95.5	1.000
Item 20	96.1	93.5	100.0	100.0	0.244	95.2	100.0	0.586
Item 22	96.9	98.7	92.5	100.0	0.252	97.1	95.5	0.537
Perigastric items								
Item 2	21.3	15.6	25.0	50.0	0.034	22.9	13.6	0.406
Item 4	100.0	100.0	100.0	100.0	—[c]	100.0	100.0	—[c]
Item 5	81.1	72.7	92.5	100.0	0.011	81.9	77.3	0.564
Item 6	95.3	94.8	95.0	100.0	1.000	96.2	90.9	0.278
Item 7	34.6	29.9	32.5	80.0	0.008	38.1	18.2	0.088
Item 8	21.3	18.2	17.5	60.0	0.017	22.9	13.6	0.406
Item 9	81.1	70.1	97.5	100.0	<0.001	82.9	72.7	0.367
Item 11	100.0	100.0	100.0	100.0	—[c]	100.0	100.0	—[c]
Item 21	93.7	90.9	100.0	90.0	0.095	93.3	95.5	1.000
Extraperigastric items								
Item 12	100.0	100.0	100.0	100.0	—[c]	100.0	100.0	—[c]
Item 13	80.3	74.0	92.5	80.0	0.042	81.0	77.3	0.769
Item 14	99.2	98.7	100.0	100.0	1.000	99.0	100.0	1.000
Item 15	84.3	74.0	100.0	100.0	<0.001	86.7	72.7	0.115
Item 16	87.4	93.5	77.5	80.0	0.027	85.7	95.5	0.302
Item 17	99.2	100.0	97.5	100.0	0.394	99.0	100.0	1.000
Item 18	88.2	87.0	90.0	90.0	0.909	89.5	81.8	0.293
Item 19	46.5	44.2	52.5	40.0	0.698	50.5	27.3	0.060

Supplementary Table S1 (continued)

Characteristic	All (n = 127)	Surgeon A (n = 77)	Surgeon B (n = 40)	Surgeon C (n = 10)	p (surgeon)	No complication (n = 105)	Complication (n = 22)	p (outcome)
Block 3. CT body composition at L3								
VFA (cm²)	108.0 (62.2–155.0)	115.0 (60.9–166.0)	98.9 (50.4–141.5)	116.0 (96.0–155.0)	0.362	100.0 (60.9–148.0)	127.5 (98.2–211.5)	0.093
SFA (cm²)	112.0 (71.8–157.5)	111.0 (76.2–151.0)	114.5 (67.4–159.5)	144.5 (107.3–160.3)	0.725	115.0 (78.9–158.0)	98.5 (51.5–146.8)	0.123
SMA (cm²)	116.0 (93.4–145.0)	112.0 (91.5–139.0)	128.5 (96.8–157.0)	119.5 (99.6–143.0)	0.194	116.0 (90.5–145.0)	120.0 (110.0–144.8)	0.543
AC (cm)	84.1 (77.6–89.7)	84.0 (77.1–91.0)	83.8 (76.3–86.9)	86.2 (83.6–88.9)	0.401	84.0 (77.2–88.9)	85.9 (80.5–93.4)	0.371
Block 4. Video-derived workflow, global measures[b]								
Total console time (min)	175.3 (131.2–224.8)	142.4 (121.9–183.1)	264.8 (229.3–300.9)	166.4 (124.7–179.6)	<0.001	180.1 (135.9–236.8)	169.7 (121.9–191.7)	0.077
Total phase fragmentation (n)	72 (57–89)	65 (51–76)	87 (73–97)	83 (72–93)	<0.001	72 (57–89)	70 (54–89)	0.665

Continuous variables are median (interquartile range), compared by the Kruskal–Wallis test across surgeons and by the Mann–Whitney U test by outcome. Individual items are the percentage of operations in which the item was achieved, compared by Fisher's exact test. Item numbers follow the KLASS-02-QC instrument and are described in the table below.

[a] The total score is the sum of the three sub-scores and is shown for description only. Only the three sub-scores were entered into the models.

[b] The models used the 42 phase-level and global variables defined in Supplementary Table S2. Only the two global measures are shown here. The distributions of the 40 phase-level variables are shown in Fig. 2.

[c] Achieved in all 127 operations, so not tested.

AC abdominal circumference, CT computed tomography, KLASS-02-QC Korean Laparoendoscopic Gastrointestinal Surgery Study Group 02 quality control, L3 third lumbar vertebra, SFA subcutaneous fat area, SMA skeletal muscle area, VFA visceral fat area

Supplementary Table S1 (continued) KLASS-02-QC items

Item	Domain	Description	Item	Domain	Description
1	Skill	No injury to other organs	12	Extraperigastric	LN12a: lower half of the proper hepatic artery exposed
2	Perigastric	LN4sb: LGEA and LGEV divided below the first gastric branch	13	Extraperigastric	LN12a: left side of the portal vein exposed and cleared
3	Skill	No injury to the splenic flexure of the colon	14	Extraperigastric	LN8a: common hepatic artery exposed
4	Perigastric	LN6: branches of the RGEA and RGEV retrieved	15	Extraperigastric	LN8a: soft tissue above the upper border of the pancreas removed
5	Perigastric	LN6: RGEV divided just above its confluence with the ASPDV	16	Extraperigastric	LN9: retroperitoneal membrane divided along the right crus
6	Perigastric	LN6: RGEA divided just distal to the origin of the ASPDA	17	Extraperigastric	LN7: root of the left gastric artery exposed and ligated
7	Perigastric	LN6: lowest ASPDV identified and exposed	18	Extraperigastric	LN11p: proximal half of the splenic artery exposed
8	Perigastric	LN6: prepancreatic tissue above the lowest ASPDV removed	19	Extraperigastric	LN11p: splenic vein or dorsal pancreas exposed
9	Perigastric	LN6: prepancreatic tissue above the ASPDV–RGEV confluence removed	20	Skill	No thermal or forceps injury to the pancreas
10	Skill	No injury to the pancreatic parenchyma	21	Perigastric	LN3: soft tissue on the lesser curvature removed
11	Perigastric	LN5: root of the RGA identified and exposed	22	Skill	No thermal or blind-manipulation injury to the esophagus or stomach

ASPDA anterior superior pancreaticoduodenal artery, ASPDV anterior superior pancreaticoduodenal vein, KLASS-02-QC Korean Laparoendoscopic Gastrointestinal Surgery Study Group 02 quality control, LGEA left gastroepiploic artery, LGEV left gastroepiploic vein, LN lymph node station, RGA right gastric artery, RGEA right gastroepiploic artery, RGEV right gastroepiploic vein

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Supplementary Table S2 Operational definitions of the video-derived workflow variables (block 4) and the number of variables each contributes

Metric	Operational definition	Interpretation	Variables
SAU duration	Total time spent in a given SAU	Task-specific efficiency and a proxy for complexity	14
SAU segments	Number of separate segments in which a given SAU was performed (1 = performed without interruption)	Hesitation or instability during the task	14[a]
SFD duration	Total time spent in a given disruption category	Direct time loss and corrective workload	6
SFD events	Number of events in a given disruption category	How often the operation required corrective action	6
Total console time	Length of the whole console recording, including annotated intervals not defined as SAUs or SFDs (Table 2)	Overall operative duration	1
Total phase fragmentation	Number of segments across the whole recording, including annotated intervals not defined as SAUs or SFDs (Table 2)	Overall non-linearity of the surgical flow	1

The 14 SAUs and 6 SFD categories are listed in Table 2. The four reconstruction sub-phases (Billroth-I, Billroth-II, Billroth-II with Braun and Roux-en-Y) are mutually exclusive and were pooled into a single reconstruction phase (SAU13). In total, 14 + 14 + 6 + 6 + 1 + 1 = 42 variables were derived.

[a] For SAU14 (indocyanine green assessment), the count records activations of fluorescence imaging, which often last only 1–2 s, rather than segments of a task.

SAU semantic action unit, SFD surgical flow disruption

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Supplementary Table S3 Completed TRIPOD+AI checklist

Item	Checklist item	Location in the manuscript
TRIPOD+AI for Abstracts		
Abstract (TRIPOD+AI for Abstracts)		
1	Title: Identify the study as developing or evaluating the performance of a multivariable prediction model, the target population, and the outcome to be predicted	Title page, title
2	Background: Provide a brief explanation of the healthcare context and rationale for developing or evaluating the performance of all models	Abstract, 1st to 3rd sentences
3	Objectives: Specify the study objectives, including whether the study describes model development, evaluation, or both	Abstract, 3rd sentence
4	Methods: Describe the sources of data	Abstract, methods sentences
5	Methods: Describe the eligibility criteria and setting where the data were collected	Abstract, methods sentences
6	Methods: Specify the outcome to be predicted by the model, including time horizon of predictions in case of prognostic models	Abstract, methods sentences
7	Methods: Specify the type of model, a summary of the model-building steps, and the method for internal validation	Abstract, methods sentences
8	Methods: Specify the measures used to assess model performance (eg, discrimination, calibration, clinical utility)	Abstract, methods and results sentences
9	Results: Report the number of participants and outcome events	Abstract, methods and results sentences
10	Results: Summarise the predictors in the final model	Abstract, results sentences
11	Results: Report model performance estimates (with confidence intervals)	Abstract, results sentences
12	Discussion: Give an overall interpretation of the main results	Abstract, last sentence
13	Registration: Give the registration number and name of the registry or repository	Not reported
TRIPOD+AI main checklist		
Title		
1	Identify the study as developing or evaluating the performance of a multivariable prediction model, the target population, and the outcome to be predicted	Title page, title
Abstract		
2	See TRIPOD+AI for Abstracts checklist	Abstract
Introduction		
3a	Explain the healthcare context (including whether diagnostic or prognostic) and rationale for developing or evaluating the prediction model, including references to existing models	Introduction, 1st-4th paragraphs; Discussion, 2nd and 3rd paragraphs
3b	Describe the target population and the intended purpose of the prediction model in the context of the care pathway, including its intended users (eg, healthcare professionals, patients, public)	Introduction, 4th and 5th paragraphs; Discussion, 8th paragraph
3c	Describe any known health inequalities between sociodemographic groups	Not reported
4	Specify the study objectives, including whether the study describes the development or validation of a prediction model (or both)	Introduction, 5th paragraph
Methods		
5a	Describe the sources of data separately for the development and evaluation datasets (eg, randomised trial, cohort, routine care or registry data), the rationale for using these data, and representativeness of the data	Methods, Study design, patients and endpoint, 1st paragraph; Discussion, 8th paragraph
5b	Specify the dates of the collected participant data, including start and end of participant accrual; and, if applicable, end of follow-up	Methods, Study design, patients and endpoint, 1st and 2nd paragraphs
6a	Specify key elements of the study setting (eg, primary care, secondary care, general population) including the number and location of centres	Methods, Study design, patients and endpoint, 1st paragraph; Statements and Declarations, Ethics approval
6b	Describe the eligibility criteria for study participants	Methods, Study design, patients and endpoint, 1st paragraph
6c	Give details of any treatments received, and how they were handled during model development or evaluation, if relevant	Methods, Study design, patients and endpoint, 1st paragraph; Methods, Predictor blocks, 2nd paragraph
7	Describe any data pre-processing and quality checking, including whether this was similar across relevant sociodemographic groups	Methods, Predictor blocks, 3rd, 5th and 6th paragraphs; Methods, Statistical analysis, 2nd paragraph
8a	Clearly define the outcome that is being predicted and the time horizon, including how and when assessed, the rationale for choosing this outcome, and whether the method of outcome assessment is consistent across sociodemographic groups	Methods, Study design, patients and endpoint, 2nd paragraph

Supplementary Table S3 (continued)

Item	Checklist item	Location in the manuscript
8b	If outcome assessment requires subjective interpretation, describe the qualifications and demographic characteristics of the outcome assessors	Methods, Study design, patients and endpoint, 2nd paragraph
8c	Report any actions to blind assessment of the outcome to be predicted	Methods, Study design, patients and endpoint, 2nd paragraph
9a	Describe the choice of initial predictors (eg, literature, previous models, all available predictors) and any pre-selection of predictors before model building	Methods, Predictor blocks, 1st-7th paragraphs; Statements and Declarations, Ethics approval
9b	Clearly define all predictors, including how and when they were measured (and any actions to blind assessment of predictors for the outcome and other predictors)	Methods, Predictor blocks, 1st-6th paragraphs; Table 2; Supplementary Table S2
9c	If predictor measurement requires subjective interpretation, describe the qualifications and demographic characteristics of the predictor assessors	Methods, Predictor blocks, 1st and 5th paragraphs
10	Explain how the study size was arrived at (separately for development and evaluation), and justify that the study size was sufficient to answer the research question. Include details of any sample size calculation	Methods, Predictor blocks, 7th paragraph; Discussion, 6th and 8th paragraphs
11	Describe how missing data were handled. Provide reasons for omitting any data	Methods, Statistical analysis, 2nd paragraph; Methods, Study design, patients and endpoint, 1st paragraph
12a	Describe how the data were used (eg, for development and evaluation of model performance) in the analysis, including whether the data were partitioned, considering any sample size requirements	Methods, Statistical analysis, 4th, 6th and 7th paragraphs
12b	Depending on the type of model, describe how predictors were handled in the analyses (functional form, rescaling, transformation, or any standardisation)	Methods, Statistical analysis, 2nd paragraph; Methods, Predictor blocks, 2nd paragraph
12c	Specify the type of model, rationale†, all model building steps, including any hyperparameter tuning, and method for internal validation	Methods, Statistical analysis, 3rd and 4th paragraphs
12d	Describe if and how any heterogeneity in estimates of model parameter values and model performance was handled and quantified across clusters (eg, hospitals, countries). See TRIPOD-Cluster for additional considerations	Methods, Predictor blocks, 2nd paragraph; Discussion, 8th paragraph
12e	Specify all measures and plots used (and their rationale) to evaluate model performance (eg, discrimination, calibration, clinical utility) and, if relevant, to compare multiple models	Methods, Statistical analysis, 4th-7th paragraphs; Fig. 3
12f	Describe any model updating (eg, recalibration) arising from the model evaluation, either overall or for particular sociodemographic groups or settings	Not applicable
12g	For model evaluation, describe how the model predictions were calculated (eg, formula, code, object, application programming interface)	Not applicable
13	If class imbalance methods were used, state why and how this was done, and any subsequent methods to recalibrate the model or the model predictions	Methods, Statistical analysis, 3rd paragraph
14	Describe any approaches that were used to address model fairness and their rationale	Not reported
15	Specify the output of the prediction model (eg, probabilities, classification). Provide details and rationale for any classification and how the thresholds were identified	Methods, Statistical analysis, 4th paragraph; Results, Variables in the conventional model, 2nd paragraph
16	Identify any differences between the development and evaluation data in healthcare setting, eligibility criteria, outcome, and predictors	Not applicable
17	Name the institutional research board or ethics committee that approved the study and describe the participant informed consent or the ethics committee waiver of informed consent	Methods, Study design, patients and endpoint, 1st paragraph; Statements and Declarations, Ethics approval; Statements and Declarations, Consent to participate
Open science		
18a	Give the source of funding and the role of the funders for the present study	Statements and Declarations, Funding
18b	Declare any conflicts of interest and financial disclosures for all authors	Statements and Declarations, Competing Interests
18c	Indicate where the study protocol can be accessed or state that a protocol was not prepared	Statements and Declarations, Ethics approval
18d	Provide registration information for the study, including register name and registration number, or state that the study was not registered	Statements and Declarations, Ethics approval
18e	Provide details of the availability of the study data	Statements and Declarations, Data availability
18f	Provide details of the availability of the analytical code	Statements and Declarations, Code availability; Methods, Statistical analysis, 8th paragraph
Patient and public involvement		
19	Provide details of any patient and public involvement during the design, conduct, reporting, interpretation, or dissemination of the study or state no involvement	Statements and Declarations, Patient and public involvement
Results		
20a	Describe the flow of participants through the study, including the number of participants with and without the outcome and, if applicable, a summary of the follow-up time. A diagram may be helpful	Results, Patient characteristics, 1st paragraph; Table 1
20b	Report the characteristics overall and, where applicable, for each data source or setting, including the key dates, key predictors (including demographics), treatments received, sample size, number of outcome events, follow-up time, and amount of missing data. A table may be helpful. Report any differences across key demographic groups	Results, Patient characteristics, 1st paragraph; Table 1; Supplementary Table S1
20c	For model evaluation, show a comparison with the development data of the distribution of important predictors (demographics, predictors, and outcome)	Not applicable
21	Specify the number of participants and outcome events in each analysis (eg, for model development, hyperparameter tuning, model evaluation)	Methods, Study design, patients and endpoint, 2nd paragraph; Methods, Predictor blocks, 7th paragraph

Supplementary Table S3 (continued)

Item	Checklist item	Location in the manuscript
22	Provide details of the full prediction model (eg, formula, code, object, application programming interface) to allow predictions in new individuals and to enable third party evaluation and implementation, including any restrictions to access or reuse (eg, freely available, proprietary)	Results, Variables in the conventional model, 1st paragraph; Supplementary Table S4; Statements and Declarations, Code availability
23a	Report model performance estimates with confidence intervals, including for any key subgroups (eg, sociodemographic). Consider plots to aid presentation	Results, Discrimination across the 15 block combinations, 2nd and 3rd paragraphs; Results, Variables in the conventional model, 2nd paragraph; Fig. 3; Supplementary Table S4
23b	If examined, report results of any heterogeneity in model performance across clusters. See TRIPOD-Cluster for additional details	Not applicable
24	Report the results from any model updating, including the updated model and subsequent performance	Not applicable
Discussion		
25	Give an overall interpretation of the main results, including issues of fairness in the context of the objectives and previous studies	Discussion, 1st-7th paragraphs
26	Discuss any limitations of the study (such as a non-representative sample, sample size, overfitting, missing data) and their effects on any biases, statistical uncertainty, and generalisability	Discussion, 6th and 8th paragraphs
27a	Describe how poor quality or unavailable input data (eg, predictor values) should be assessed and handled when implementing the prediction model	Not applicable
27b	Specify whether users will be required to interact in the handling of the input data or use of the model, and what level of expertise is required of users	Methods, Predictor blocks, 1st and 5th paragraphs; Discussion, 6th and 8th paragraphs
27c	Discuss any next steps for future research, with a specific view to applicability and generalisability of the model	Discussion, 6th and 9th paragraphs

Checklist items follow Collins GS et al. TRIPOD+AI statement. BMJ 2024;385:e078378. Locations refer to manuscript sections, paragraphs, figures, tables and Supplementary Tables.

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Supplementary Table S4 All 15 block combinations for the prediction of Clavien–Dindo grade II or higher complications within 30 days

Blocks	Candidates	Nested AUC (95% range)	Permutation null median	p	Apparent AUC	Optimism	Retained, n	π > 0.50, n	Variables retained (π)
Combinations including block 1									
1 (clinicopathological)	12	0.698 (0.636–0.743)	0.522	0.015	0.804	0.106	5	3	ASA physical status (0.85), Male sex (0.73), Estimated blood loss (0.58), Billroth-II reconstruction (0.39), BMI (0.36)
1 + 2 (proficiency)	15	0.680 (0.606–0.726)	0.518	0.005	0.787	0.106	3	3	ASA physical status (0.79), Male sex (0.62), Estimated blood loss (0.52)
1 + 3 (body composition)	16	0.684 (0.607–0.725)	0.518	0.005	0.797	0.113	5	3	ASA physical status (0.82), Male sex (0.64), Estimated blood loss (0.54), Billroth-II reconstruction (0.36), BMI (0.29)
1 + 4 (workflow)	54	0.647 (0.569–0.715)	0.515	0.040	0.874	0.227	14	2	ASA physical status (0.69), Male sex (0.51), SAU01 segments (0.49), SAU02 duration (0.45), SAU10 duration (0.35), Estimated blood loss (0.35), SFD04 events (0.27), SFD03 duration (0.21), SAU05 segments (0.20), SFD06 events (0.19), BMI (0.16), SFD03 events (0.15), SAU03 segments (0.14), SAU06 segments (0.14)
1 + 2 + 3	19	0.664 (0.552–0.728)	0.515	0.010	0.793	0.129	5	2	ASA physical status (0.76), Male sex (0.59), Estimated blood loss (0.44), Billroth-II reconstruction (0.33), BMI (0.21)
1 + 2 + 4	57	0.639 (0.577–0.701)	0.513	0.040	0.844	0.205	6	1	ASA physical status (0.66), Male sex (0.48), SAU01 segments (0.46), SAU02 duration (0.40), Estimated blood loss (0.32), SAU10 duration (0.32)
1 + 3 + 4	58	0.643 (0.553–0.714)	0.518	0.040	0.864	0.221	7	1	ASA physical status (0.65), Male sex (0.47), SAU01 segments (0.45), SAU02 duration (0.43), Estimated blood loss (0.31), SAU10 duration (0.30), SFD04 events (0.25)
1 + 2 + 3 + 4	61	0.626 (0.510–0.709)	0.527	0.055	0.848	0.222	6	1	ASA physical status (0.66), Male sex (0.47), SAU01 segments (0.44), SAU02 duration (0.42), Estimated blood loss (0.31), SAU10 duration (0.31)
Combinations without block 1									
2 (proficiency)	3	0.512 (0.415–0.588)	0.500	0.463	0.500	−0.012	0	0	—
3 (body composition)	4	0.553 (0.468–0.668)	0.497	0.244	0.500	−0.053	0	0	—
4 (workflow)	42	0.524 (0.456–0.609)	0.515	0.463	0.500	−0.024	0	0	—
2 + 3	7	0.504 (0.436–0.584)	0.506	0.527	0.500	−0.004	0	0	—
2 + 4	45	0.513 (0.432–0.590)	0.517	0.512	0.500	−0.013	0	0	—
3 + 4	46	0.526 (0.428–0.590)	0.530	0.527	0.500	−0.026	0	0	—
2 + 3 + 4	49	0.513 (0.413–0.601)	0.514	0.502	0.500	−0.013	0	0	—

Nested AUC is the median across 50 repeats of nested cross-validation, with the 2.5th to 97.5th percentiles (95% range). The p column gives the empirical p value of the nested AUC against an outcome-permutation null of 200 permutations. Apparent AUC was obtained by fitting and evaluating each model in all 127 patients, and optimism is the apparent minus the nested AUC. Variables retained are those with a non-zero coefficient in the model fitted to all 127 patients, listed with their selection probability (π) across 1,000 stratified half-samples. π > 0.50, n, number of retained variables with π above 0.50.

ASA American Society of Anesthesiologists, AUC area under the receiver operating characteristic curve, BMI body mass index, SAU semantic action unit (codes in Table 2), SFD surgical flow disruption (codes in Table 2)