Clinical Validation of the Comprehensive Complication Index as a Measure of Postoperative Morbidity at a Surgical Department

A Prospective Study

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Objective: Using clinical outcomes, to validate the comprehensive complication index (CCI) as a measure of postoperative morbidity in all patients undergoing surgery at a general surgery department.

Background: The Clavien-Dindo classification (CDC) is the most widely used system to assess postoperative morbidity. The CCI is a numerical scale based on the CDC. Once validated, it could be used universally to establish and compare the real postoperative complications of each surgical procedure.

Methods: Observational prospective cohort study. All patients who underwent surgery during the 1-year study period were included. All the complications graded with the CDC and related to the initial admission, or until discharge if the patient was readmitted within 90 days of surgery, were included. Surgical procedures were classified according to the operative severity score (OSS) as minor, moderate, major, or major+. The clinical validation of the CCI was performed by assessing its correlation with 4 different clinical outcomes.

Results: A total of 1850 patients were included: 513 (27.7%) presented complications and 101 (5.46%) were readmitted. In the multivariate analysis, the CCI and CDC were associated with postoperative stay, prolongation of postoperative stay, readmission, and disability in all OSS groups ($P < 0.001$). The CCI was superior to the CDC in all models except for prolongation of stay for OSS moderate and major+.

Conclusions: The CCI can be applied in all the procedures carried out at general surgery departments. It is able to determine the morbidity and allows the comparison of the outcomes at different services.

Keywords: Clavien-Dindo classification, comprehensive complication index, morbidity, postoperative complications, validation studies

(*Ann Surg* 2018;268:838–844)

Postoperative complications constitute a fundamental marker of surgical outcomes and quality of care. Classically, surgical complications have been reported in different ways, without any clear standardization[1]; studies have focused on specific techniques or have only included small series, or have recorded only the most serious complications. Thus, the systematic recording of postoperative morbidity of all the operations carried out at a service is an exceptional event.[2] Today, transparency in healthcare is an ethical and professional obligation, but we are not yet able to establish the frequency and/or severity of the complications of a particular surgical procedure at local, national, and global level. Being able to determine these variables would allow a global health improvement.

The Clavien-Dindo classification (CDC), described in 2004,[3] is the most widely used system for assessing postoperative morbidity, with 7968 citations.[4] It is an objective, simple, and reproducible system, but its disadvantage is that the entire postoperative course is defined by a single complication (the most serious one). The comprehensive complication index (CCI), described in 2013, incorporates all complications and their severity as recorded by the CDC, and summarizes the postoperative course on a numerical scale (0–100).[5] The CCI thus allows a definition and an overall comparison of the postoperative morbidity associated with a surgical procedure.

The present study aims to assess the clinical validity of the CCI by applying it to all the surgical interventions carried out at a general surgery service. Its validation and its subsequent application would allow the measurement of the morbidity associated with a particular surgical procedure at any service and the comparison of data with other services to design new measures to able to reduce morbidity rates.

METHODS

This prospective observational cohort study had the following endpoints:

Primary end-point. To determine the clinical validity of the CCI as a measure of postoperative morbidity in all patients operated upon at a surgery department.

Secondary end-point. To determine the frequency and severity of all complications according to the CDC and the CCI.

Recruitment. All patients in a reference area of 254,609 inhabitants who underwent surgery during the 1-year study (March 1, 2016 to February 28, 2017) period were included. The exclusion criteria are presented in Supplementary Digital Content 1, http://links.lww.com/SLA/B433. The study was carried out at the only public referral hospital in the area.

Analytical Methods Used to Test the Hypothesis

All the complications associated with the initial admission, or until discharge if the patient was readmitted within 90 days of surgery, were prospectively included. Baseline and surgical characteristics were described, as well as the complications observed at different time points (at 30 days, at 90 days, and at any time).

We reviewed the full text of all the articles published on the subject of the CCI in PubMed using a search strategy without limits with the term "Comprehensive Complication Index." The latest search, conducted on February 18, 2018, yielded 65 articles and 2 letters to the editor.

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Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's Web site (www.annalsofsurgery.com).

The authors report no conflicts of interest.

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ISSN: 0003-4932/18/26805-0838
DOI: 10.1097/SLA.0000000000002839

TABLE 1. Univariate Models

	Logistic Regression								Linear Regression
					Prolonged Postoperative LOS ($X > P_{75}$) According to the Operative Severity Score				
Variables	**Disability**	**Readmitted**	**Reoperation**	**Reintervention**	**Minor**	**Moderate**	**Major**	**Major+**	**Postoperative Hospital Stay**
CDC	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001
CCI	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	<0.001
Age	<0.001	<0.001	<0.001	<0.001	0.147	<0.001	0.001	0.010	<0.001
Sex	0.209	0.426	0.523	0.748	0.817	<0.001	0.483	0.170	0.868
ASA	<0.001	<0.001	<0.001	<0.001	0.024	<0.001	0.017	0.654	<0.001
Type of anesthesia	0.001	0.017	0.207	0.006	<0.001	0.246	0.877	0.569	<0.001
Surgery time	<0.001	<0.001	<0.001	<0.001	0.174	<0.001	<0.001	0.045	<0.001
Surgery shift	0.001	0.131	0.023	0.013	<0.001	0.240	0.049	–	<0.001
Approach	0.048	0.010	0.029	0.006	<0.001	<0.001	0.008	0.489	<0.001
Programming	0.130	0.001	0.001	0.440	<0.001	<0.001	<0.001	0.200	0.104
Operative severity score	<0.001	<0.001	<0.001	<0.001	–	–	–	–	<0.001
First surgeon	0.022	0.100	0.250	0.068	<0.001	0.524	0.720	0.554	0.009

The *P* values of each combination of dependent and independent variables are shown. CCI indicates Comprehensive Complication Index; CDC, Clavien-Dindo Classification.

Surgical procedures were classified according to the operative severity score (OSS) as minor, moderate, major, or major+.[6] The procedures included in each group are listed in Supplemental Digital Content 2, http://links.lww.com/SLA/B479.

It was considered prolonged postoperative length of stay (LOS): inpatient hospital stay greater than the 75th percentile of each of the OSS groups of the included.[7–9] Others definitions of the variables used are shown in the Supplemental Digital Content 3, http://links.lww.com/SLA/B480.

Surgeons were instructed to record all the complications according to the CDC and the CCI. To classify the complications, the scenarios described by Clavien et al,[3,10] the complementary criteria of the CDC established by the Japan Clinical Oncology Group[11] and the clinical scenarios proposed by Mentula and Leppäniemi[12] were used as support material. Any doubts were resolved in a clinical session. A form for registering each of the complications was included in the electronic medical record. The researchers reviewed all the complications recorded by the surgeons and nurses on this form and in the patients' clinical progress notes.

The CCI was calculated according to the formula described by the authors[5] instead of using the online calculator provided at http://cci.assessurgery.com and http://www.assessurgery.com/about_cci-calculator/.

To decide which outcomes to use for the clinical validation of the indexes, a literature review was carried out and a brainstorming session was held. The following variables were initially considered: disability, readmission, prolonged postoperative LOS, postoperative stay, reintervention, reoperation, and ICU stay. Although reintervention and reoperation had previously been used to clinically validate the CCI,[13] we omitted them because they both form part of the index under evaluation (ie, they appear as a grade in the CDC) and so their inclusion in the regression models would have induced a bias. ICU stay was also omitted due to the small sample size.

Thus, the clinical validation of the CDC and the CCI was finally based on their correlations with postoperative stay, prolonged postoperative LOS, re-admission, and disability.

The project was approved by the Research Ethics Committee of the hospital. Informed consent was not considered necessary. Patient data were anonymized before analysis.

Statistical Analysis

The Spearman rank correlation was used to assess the degree of interdependence between the CDC and the CCI. Linear and logistic regression models were carried out in regards to estimate the effect size (and 95% confidence interval [CI]) of each of the indices, adjusting by possible confounding factors when needed and shown as multivariate models. We assessed the variables listed in Table 1 as possible confounders. Linear regression models were created for quantitative variables and logistic regression models for qualitative variables.

The logistic regression models were validated by their discrimination capacity (the area under the receiver operating characteristic [ROC] curve) and their calibration (by the Hosmer-Lemeshow goodness-of-fit test), and the linear regression models by the coefficient of determination, R^2. A type I error of 5% was allowed for all the analyses (P value ≤ 0.05 was considered statistically significant). All the analyses were carried out with Stata v14.1. The statistical analysis is described in detail in the supplemental materials (Supplementary Digital Content 4, http://links.lww.com/SLA/B482).

RESULTS

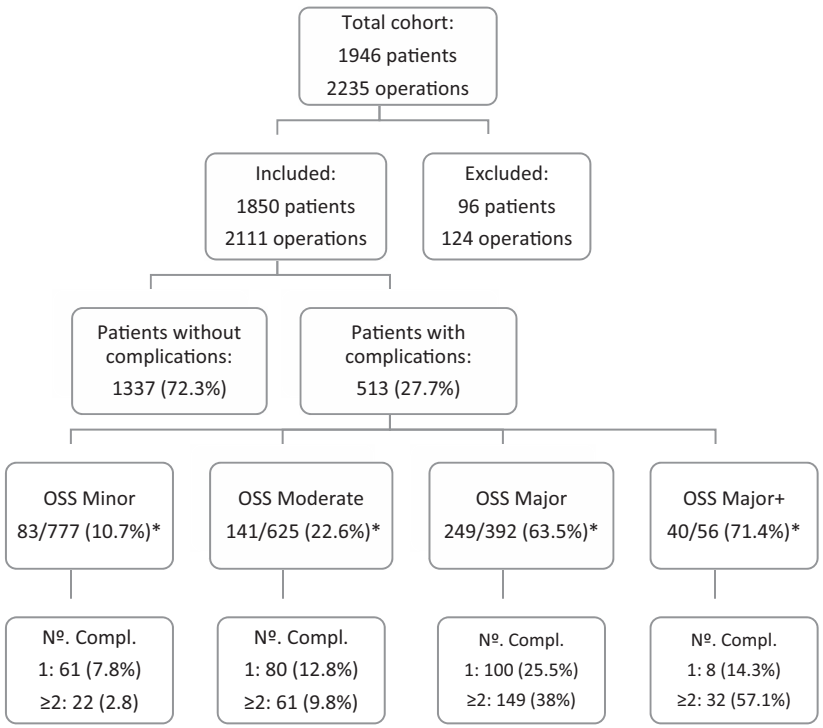
A total of 1850 patients and 2111 operations were included. Figure 1 shows the procedure of the selection of the cohort and the frequency of complications. The distribution of the series according to the OSS was 777 minor, 625 moderate, 392 major, and 56 major+. In all, 513 (27.7%) patients presented 1283 complications and 101 (5.46%) patients were readmitted. In the postoperative period, 42 patients (2.27%) died as a result of postoperative complications.

The maximum number of complications in a patient was 13. Of the 513 patients who presented complications, 249 (48.5%) presented 1 complication and 264 (51.5%) more than 1. The higher the CDC grade, the higher the percentage of multiple complications, except for grade V (Fig. 2).

The frequency of complications in general and the presence of more than 1 complication increased with the complexity of the OSS (see Supplemental Digital Content 5, http://links.lww.com/SLA/B481) (Fig. 1). Also, the CDC and the CCI increased with the complexity of the OSS (Table 2).

All the clinical terms considered (disability, readmission, reoperation, reintervention, postoperative stay, and prolonged postoperative LOS) were significantly associated with the CDC and the CCI and the complexity of the surgery. The other associations of the univariate analysis are shown in Table 1.

In the multivariate analysis, the CCI and the CDC were associated with postoperative stay (coefficient 95% CI,



OSS: Operative Severity Score. Nº. Compl: Number of complications.

* Percentages refer to the proportion of patients who developed any complication

FIGURE 1. Flow diagram of the selection of the cohort, patients with complications, and their distribution according to the operative severity score.

$P < 0.001$) and with prolonged LOS, readmission, and disability in all OSS groups (odds ratio 95% CI, $P < 0.001$). The adjusted R^2 ranged from 33.2% to 69.4% in the hospital stay model for all 4 OSS groups. In all cases, the CCI was superior to the CDC. The AUC-ROC was more than 90% in all the models except for the prolonged LOS after minor OSS (CDC and CCI) and after moderate OSS (CCI). The CCI was superior to the CDC in all cases except in the prolonged postoperative LOS model in OSS moderate and major+. In addition, the CDC was influenced by more confounding factors (Table 3).

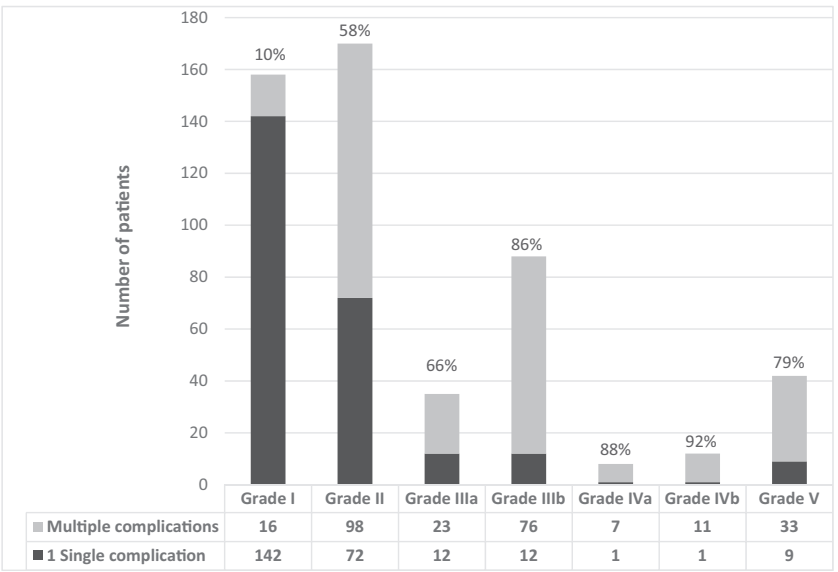


FIGURE 2. Distribution of patients who presented one or multiple complications according to Clavien-Dindo classification grade.

TABLE 2. Clavien-Dindo Classification and the Comprehensive Complication Index Scores According to the Operative Severity Score at the End of the Follow-up

	OSS Minor (n = 777)		OSS Moderate (n = 625)		OSS Major (n = 392)		OSS Major+ (n = 56)	
Variable	**Mean (SD)**		**Mean (SD)**		**Mean (SD)**		**Mean (SD)**	
Final CCI	**2.46 (9.97)**		**5.99 (15.76)**		**23.75 (28.33)**		**34.47 (33.39)**	
	N	**%**	**n**	**%**	**n**	**%**	**n**	**%**
CDC final								
Zero	694	89.33	484	77.44	143	36.48	16	28.57
Grade I	43	5.53	59	9.46	54	13.78	2	3.57
Grade II	15	1.93	43	6.89	94	23.98	18	32.14
Grade IIIa	4	0.51	13	2.08	15	3.83	3	5.36
Grade IIIb	17	2.19	16	2.56	50	12.76	5	8.93
Grade IVa	0	0	1	0.16	4	1.02	3	5.36
Grade IVb	0	0	2	0.32	8	2.04	2	3.57
Grade V	4	0.51	7	1.12	24	6.12	7	12.5

SD indicates standard deviation.

The multivariate models showed ($P < 0.001$) that an increase of 1 grade in the CDC or 1 point in the CCI increased the risk of disability by 2.50 times (95% CI 2.10, 2.97) and 1.09 times (95% CI 1.07, 1.10), respectively, and the risk of readmission by 2.76 (95% CI 2.40, 3.17) and 1.08 times (95% CI 1.07, 1.08) respectively. It also increased the risk of prolonged postoperative LOS in OSS minor by 2.44 (95% CI 1.78, 3.34) and 1.10 (95% CI 1.06, 1.14), in OSS moderate by 8.35 (95% CI 5.10; 13.67) and 1.18 times (95% CI 1.14; 1.23) in OSS major by 6.65 (95% CI 4.35, 10.17) and 1.23 times (95% CI 1.17, 1.30) and in OSS major+ by 4.33 (95% CI 1.82, 10.32) and 1.13 times (95% CI 1.04, 1.22) respectively (Table 3).

The increase of 1 grade in the CDC or 1 point in the CCI significantly increased the postoperative stay ($P < 0.001$): in OSS minor by 2.64 (95% CI 2.25, 3.03) and 0.29 days (95% CI 0.26; 0.33); in OSS moderate by 5.07 (95% CI 4.70, 5.45) and 0.48 days (95% CI 0.46, 0.51); OSS major by 6.76 (95% CI 5.96, 7.56) and 0.59 days (95% CI 0.54, 0.64); and OSS major+ by 6.98 (95% CI 4.74, 9.22) and 0.49 days (95% CI 0.32, 0.65), respectively.

The internal calibration was low in the disability and readmission models (Table 3).

The CDC and the CCI were strongly correlated in all the statistical models used: $r > 0.94$, $P < 0.001$ (see Supplementary Digital Content 6, http://links.lww.com/SLA/B483).

DISCUSSION

The CDC and CCI were strongly associated with the clinical outcomes included in this validation process.

The results of the validation cannot categorically identify the best index for assessing postoperative complications at a general surgery service, because in general the differences were small. In all cases, the CCI was, however, superior to the CDC except in the prolonged LOS model in the OSS moderate and major+. In addition, the CDC was influenced by more confounding factors.

In this study, 51.5% of the patients with complications presented more than 1 complication. A drawback of the CDC is that it considers only the most serious event and thus underestimates the morbidity in these patients compared to the CCI.

CDC and CCI scores increased with more complex surgery.

These findings support its applicability to the different interventions that are carried out at surgery services. Is now necessary to determine the extent to which the results can be generalized to other services.

The study has several limitations:

- Any negative event that occurred in a patient was considered as a complication, regardless of whether it was clearly associated with the surgical intervention. This approach may increase the estimation of morbidity, but it also substantially reduces the risk of a subjective interpretation.[3,14]
- Loss of complications: the complications that did not require admission were not recorded; neither were those that may have required admission to another hospital. However, the study was carried out at the only public referral hospital in the area.
- As the series includes pathologies and interventions of varying severity and complexity, we decided to divide the sample according to their OSS classification. However, this does not completely resolve the problem of the heterogeneity of the surgical procedures performed inside each of the groups.
- It is not possible to determine the subjective influence of the fact that the more accurate and careful the recording of morbidity by physicians and nurses, the higher the morbidity rates and thus the poorer the outcomes.
- Other clinical outcomes might be proposed for the validation of the CCI.

The additional information that the CCI provides in comparison to the CDC in patients with multiple complications has been previously reported by Clavien et al, who identified complications in 24% of the general surgical population. Of these patients, 44% had developed more than 1 complication at the time of discharge. As in the present series, the information obtained with the CCI increased with the complexity of the surgery and the observation time.[2]

The only study to have validated the CCI is the one by Slaman et al In a series of 621 patients undergoing esophagectomy, that study used hospital stay, prolonged hospital stay, ICU stay, prolongation of ICU stay, reintubation index, reintervention, and reoperation as clinical outcomes. The CDC and the CCI correlated moderately or strongly with all parameters, but the CCI showed a significantly higher correlation with hospital stay, prolongation of stay, reintervention, and reoperation than the CDC.[13]

The few validation studies of the CCI carried out to date have focused only on specific variables:

- *Hospital stay.* Slankamenac et al[15] found a significant association between the CCI and hospital stay and ICU stay in 3 randomized

TABLE 3. Multivariate Model of the Clinical Validation of the Comprehensive Complication Index

Model	Variable	CDC (Change Per Grade)	CCI (Change Per 1 Point)	CCI (Change Per 10 Points)
Disability				
	Adjusted for:	Surgical time	–	–
	OR (95% CI)	2.50 (2.10; 2.97)	1.09 (1.07; 1.10)	2.37 (1.97; 2.59)
	P value (OR)	<0.001	<0.001	<0.001
	AUC-ROC	95.06%	95.11%	95.11%
	P value (H-L)	0.0119	0.0001	0.0001
Readmission				
	Adjusted for:	–	–	–
	OR (95% CI)	2.76 (2.40; 3.17)	1.08 (1.07; 1.08)	2.16 (1.97; 2.16)
	P value (OR)	<0.001	<0.001	<0.001
	AUC-ROC	94.21%	94.67%	94.67%
	P value (H-L)	0.0000	0.0000	0.0000
Prolonged postoperative length of stay				
OSS minor				
	Adjusted for:	–	–	–
	OR (95% CI)	2.44 (1.78; 3.34)	1.10 (1.06; 1.14)	2.59 (1.97; 2.16)
	P value (OR)	<0.001	<0.001	<0.001
	AUC-ROC	62.67%	62.75%	62.75%
	P value (H-L)	–	–	–
OSS moderate				
	Adjusted for:	Surgical time, Approach	–	–
	OR (95% CI)	8.35 (5.10; 13.67)	1.18 (1.14; 1.23)	5.23 (3.71; 7.93)
	P value (OR)	<0.001	<0.001	<0.001
	AUC-ROC	91.75%	72.43%	72.43%
	P value (H-L)	0.9095	–	–
OSS major				
	Adjusted for:	ASA	–	–
	OR (95% CI)	6.65 (4.35; 10.17)	1.23 (1.17; 1.30)	7.93 (4.81; 13.79)
	P value (OR)	<0.001	<0.001	<0.001
	AUC-ROC	95.11%	97.79%	97.79%
	P value (H-L)	0.0758	0.7447	0.7447
OSS major+				
	Adjusted for:	–	–	–
	OR (95% CI)	4.33 (1.82; 10.32)	1.13 (1.04; 1.22)	3.39 (1.48; 7.30)
	P value (OR)	<0.001	<0.001	<0.001
	AUC-ROC	91.18%	90.10%	90.10%
	P value (H-L)	0.8135	0.7964	0.7964
Postoperative stay				
OSS minor				
	Adjusted for:	–	–	–
	Adjusted R^2	33.20%	43.60%	43.60%
	P value (coef.)	<0.001	<0.001	<0.001
	Coef. (95% CI)	2.64 (2.25; 3.03)	0.29 (0.26; 0.33)	2.9 (2.6; 3.3)
OSS moderate				
	Adjusted for:	ASA	–	–
	Adjusted R^2	62.60%	69.40%	69.40%
	P value (coef.)	<0.001	<0.001	<0.001
	Coef. (95% CI)	5.07 (4.70; 5.45)	0.48 (0.46; 0.51)	4.8 (4.6; 5.1)
OSS major				
	Adjusted for:	–	–	–
	Adjusted R^2	42.60%	59.40%	59.40%
	P value (coef.)	<0.001	<0.001	<0.001
	Coef. (95% CI)	6.76 (5.96; 7.56)	0.59 (0.54; 0.64)	5.9 (5.4; 6.4)
OSS major+				
	Adjusted for:	–	ASA	ASA
	Adjusted R^2	44.40%	56.30%	56.30%
	P value (coef.)	<0.001	<0.001	<0.001
	Coef. (95% CI)	6.98 (4.74; 9.22)	0.49 (0.32; 0.65)	4.9 (3.2; 6.5)

Logistic and linear regression models. Patients who died in all models and patients with stay less than 1 day in the models of prolongation of stay and postoperative stay were excluded. More details can be found in the Supplemental Digital Content 4, http://links.lww.com/SLA/B482.

AUC-ROC indicates area under the curve; OR, odds ratio; *P* value (H-L), Hosmer-Lemeshow calibration test *P* values; Prob, probability; R^2, coefficient of determination.

clinical trials evaluating pancreas, esophageal, and colon resections. Van Rooijen et al[16] associated the CCI with postoperative stay in a study of 139 patients undergoing colorectal surgery. In Kim et al's[17] prospective comparison of the CCI compared with the CDC in 1660 patients undergoing oncological gastrectomy, the CCI presented a stronger relationship with hospital stay than the CDC.

- *Readmission*. In a study of 259 patients undergoing hepatic resection, Raoof et al concluded that a CCI score of 15 or more

was associated with readmission at 30 days.[18] And in a study of 284 patients undergoing surgery for colorectal cancer Slankamenac et al[19] found that overall combined morbidity quantified by the CCI predicted readmission.

- The association of the CCI with disability has not been reported to date.

Thus, this study is the first to apply the CCI to all patients undergoing surgery at a general surgery service and to clinically validate this index in these patients.

To be able to compare outcomes at different services, it should be borne in mind that any index like the CCI that quantifies complications must be combined with a scale of severity or comorbidities. The CDC is an excellent system for grouping and grading complications and it has been validated for clinical use worldwide. It is easy to apply and, by definition, reduces the subjective tendency to minimize complications.[3] In addition, explanatory scenarios have been added for complex situations.[2,3,10–12] The CCI incorporates a formula that includes all the complications classified according to severity by the CDC, summarizing the postoperative evolution of a procedure on a scale of 0 to 100.[5] The incorporation of the CCI provides accurate and quantifiable information on the overall morbidity of surgical interventions carried out in a general surgery service. It can define the morbidity rates of a specific procedure or group of procedures, and allows comparisons with the rates recorded for other procedures or at other services. It is possible that the CCI may be improved, but the fact that it can be applied in the same way at all services as a measure of postoperative complications, it makes it fair.

Surgical services should systematically measure all their complications. The scientific community and society as a whole do not know the rate of complications associated with specific surgical procedures or with all surgical procedures in general, but this is one of the most important markers for the evaluation of quality of care and it should not be ignored. Transparency in the presentation of results is an ethical obligation and has a fundamental benefit in the dissemination of knowledge. Society needs to have objective, specific, and global information regarding the morbidity associated with different surgical interventions, and so scores such as the CCI are urgently needed in all surgical services.

ACKNOWLEDGMENTS

The authors thank the resident doctors and staff of the Surgery Department of the Hospital Universitario de Guadalajara for their help in the future project to systematically quantifying postoperative morbidity; David Arroyo Manzano and Javier Zamora Romero for their professional and patient collaboration for the statistical analysis; and Dra. María Sagrario Casas Pinillos of the Clinical Admissions Service of the University Hospital of Guadalajara for her collaboration, professionalism, and efficiency with the data acquisition and transmission.

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DISCUSSANTS

Xavier Rogiers (Gent, Belgium):

First of all, I would like to congratulate you on this paper, as it pursues the quest for objective quality control, which is so important to modern surgery.

One of the weaknesses of the CCI may be its dependence on the complete registration of all complications. Therefore, my first question is a very simple one. Since both the CDC and CCI significantly correlate with the all-important quality variables examined, do you think that the difference in the correlation justifies the added complexity, workload and sensitivity to the completeness of the complication registration of the CCI?

Second, you surpass the primary and secondary endpoints of your study in your conclusions. You state that the CCI allows for the comparison of outcomes at different services. Could you please comment on this?

Third, the CCI evaluates complication rates, rather than outcome, and at present, you only demonstrated a relationship to outcome in one center (with comparable patients, operation types, documentation, etc). Again, could you please comment on this?

Finally, the CCI documents a combination of complications, which are hidden in the background of their type and gravity. As such, a unit with good documentation of many small complications could

theoretically be rated equally as bad as the unit with bad documentation and repeated severe complications. So, is the documentation of CDC not more objective, relevant and apt for comparing services in the end? Is the use of the CDC or CCI really an ''either, or'' question, or are they complementary in your eyes? Is the CCI more a tool for health authorities and the CDC more a tool for surgeons?

Response From José M. Ramia Ángel (Guadalajara, Spain):

Thank you for your kind comments. I fully agree with you, in that I cannot ensure that our work can be used as a tool for comparison for other services and opinions. I also fully agree with you that this model has to be validated in more centers, in order to ensure that the models work perfectly. However, I think that there are other papers, which have validated this in a specific procedure. Thus, I think that the validation has been more or less done; yet, validating this in a general department of surgery could be needed in other centers to further verify this model.

With regard to the difficulty of performing the CCI, I think that it's not too much work because if you want to do things correctly, you need to record any complication that the patient has. If you do this using the Clavien-Dindo Classification, entering this data into the CCI calculator takes less than a minute. If haven't done your work perfectly beforehand and recorded all of the classifications, it's a problem. In other words, I think that recording all of the complications should be mandatory.

Finally, if you measure each complication, your data possibly increases the morbidity of your center. However, these data are realistic. I think that there are two very important points here. First, Professor Clavien's study demonstrates that 40% of the patients had more than one complication, and in our study, it was 51% of the patients. So, there is a large amount of patients with more than one complication. If you use the Clavien Classification, it doesn't perfectly study the morbidity of these patients. Second, for example, if you were to compare a single-port colecystectomy with a laparoscopic colocystectomy, it's very rare to have a 3B or 4 complication; however, you may have more than one complication Clavien I or II. For a patient, having one complication is not the same as having multiple complications. Therefore, I think that the CCI is slightly superior, not only statistically but also clinically, in the measurement of morbidity.

Pierre-Alain Clavien (Zurich, Switzerland):

Thank you, Professor Ramia Ángel, for testing the value of the CCI at your center, so that we may learn more about this cumulative index for overall morbidity. I had the privilege of reading your manuscript. In the methodology section, you state that the surgeons were responsible for recording the complications. There is strong evidence from our studies and those of others, which suggests that independent personnel, such as clinical or study nurses, are key to accurately record complications. Residents or surgeons are notoriously known to omit or minimize post-operative events, particularly when there are multiple events. Could you please tell us who recorded the complications at your center? If this was done by the surgeons, I would speculate that the value of the CCI was even stronger than what was documented in our series.

Response From José M. Ramia Ángel (Guadalajara, Spain):

We tried to collect every complication. The residents, surgeons and nurses recorded all of the complications in a special electronic form. However, two people – the author of this work and myself – reviewed the medical record and all of the daily notes about the patient, in order to confirm that no morbidity was left out of the form. We really believe that we have adequately recorded all of the patient's complications, even minimal ones.

Massimo Malagó (London, United Kingdom):

Thank you for the opportunity to comment on this paper. Congratulations on your study. I think that you provided us with a greater insight into the surgical complication field. I have a very simple question. I wish to know whether you have looked into the relation between complications and costs because the issue of cost is becoming more and more important, not only in private but also in public hospitals. Indeed, the system you propose should be used to compound costs. In the end, we are all more and more concerned with healthcare costs, particularly in public systems, such as the NHS. Did you correlate the CCI with cost?

Response From José M. Ramia Ángel (Guadalajara, Spain):

I have correlated it, but I did not inform you of this because the paper was 10,000 words. So, I couldn't cover everything. We have measured cost, and there is indeed a clear relationship between the CCI and cost. The CDC is very nice, but I think that the CCI is slightly better because measuring every complication is better when defining the problems of the patients and the cost of hospitalization.