



Evaluating postoperative outcome assessment tools in hepato-pancreato-biliary surgery: A comparative analysis of the comprehensive complication index and Clavien–Dindo classification in a cohort of 1240 patients at a tertiary care center

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Introduction: The comprehensive complication index (CCI) has emerged as a new tool for reporting postoperative complications. The aim of this study is to evaluate and compare the efficacy of CCI and Clavien–Dindo Classification (CDC) in measuring postoperative outcomes in patients undergoing hepato-pancreato-biliary (HPB) surgery.

Materials and methods: In this single-centered, prospective, comparative study conducted between January 2022 and March 2023, 1240 patients underwent HPB surgery, including laparoscopic cholecystectomies and complex HPB surgery. Postoperative complications were evaluated utilizing the CCI and CDC indices, and their relationships with length of ICU stay, hospital stay, and return to activity were compared.

Results: A total of 117 patients (9.44%) experienced complications of varying grades. There was a strong correlation between CCI and CDC ($r = 0.982$, $P < 0.001$). Both CCI and CDC demonstrated a strong correlation with the length of hospital stay, ICU stay, and return to normal activity. While CCI showed a better correlation with the length of hospital stay ($r = 0.706$ vs. 0.695) and return to normal activity ($r = 0.620$ vs. 0.611) than CDC, the difference was not statistically significant.

Conclusion: CCI exhibited a stronger correlation with the length of stay and return to activity; however, no statistically significant advantage was observed over CDC.

Keywords: Clavien–Dindo classification, comprehensive complication index, HPB surgery, postoperative outcomes

Introduction

Complications are an unavoidable and undesirable aspect of surgical practice that can have various negative consequences^[1]. In addition to prolonging hospital stays and increasing the cost of hospital admission, complications can also compromise the patient's quality of life^[2]. Hepato-pancreato-biliary (HPB) surgeries encompass a broad range of procedures, ranging from simple to highly complex operations^[1]. Thus, proper objective assessment of postoperative morbidity is crucial in determining

HIGHLIGHTS

- Both comprehensive complication index (CCI) and Clavien–Dindo Classification (CDC) prove effective in measuring postoperative complications and outcomes in hepato-pancreato-biliary surgeries.
- CCI exhibits stronger correlations with length of stay and return to normal activity, while CDC is more closely linked to ICU stay duration.
- Despite CDC's simplicity, the study indicates that CCI may offer a more comprehensive assessment.

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Sponsorships or competing interests that may be relevant to content are disclosed at the end of this article.

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Annals of Medicine & Surgery (2024) 86:3288–3293

Received 12 December 2023; Accepted 18 April 2024

Published online 29 April 2024

<http://dx.doi.org/10.1097/MS9.0000000000002116>

the success of a surgical procedure, making it essential to have an accurate and effective method of evaluation^[3–7]. In 1992, Clavien *et al.* made the first attempt to systematically grade the severity of surgical complications, which was later modified by Dindo *et al.* in 2004 in a widely cited publication that categorized surgical complications into five levels of severity^[8]. However, the Clavien–Dindo Classification (CDC) assigns a single grade to the most severe postoperative complication, which may overlook other complications of lesser severity that contribute to a patient's overall morbidity^[9]. In 2013, a new comprehensive scoring system for surgical complications, known as the comprehensive complication index (CCI), was introduced by Slankamenac *et al.*, which condenses all postoperative complications into a single

score that ranges from 0 to 100, where 0 denotes no complications and 100 represents mortality^[10,11]. This study aims to compare the efficacy of the CDC with the CCI in representing postoperative outcomes in patients undergoing HPB surgeries.

Materials and methods

This prospective comparative study enrolled a total of 1240 patients who underwent HPB surgeries, ranging from simple laparoscopic cholecystectomies to complex HPB surgeries including pancreaticoduodenectomies and liver resections, in Kathmandu Medical College Teaching Hospital between January 2022 and March 2023. The sample size was calculated based on the prevalence rate of complications associated with HPB surgeries, and patients were selected using the purposive sampling method. All patients provided informed consent for their data to be utilized for research purposes. Prior to commencing the study, ethical clearance was obtained from the Institutional Review Board (IRB number: 0812202104). In adherence to the principles of rigorous reporting, this study conformed to the Strengthening The Reporting Of Cohort Studies in Surgery (STROCSS) 2021 guidelines^[12]. The demographics of all patients, including age, sex, BMI, American Society of Anesthesiologists (ASA) grade, and Charlson's comorbidity index, were noted. At the time of patient discharge, the duration of stay in the ICU and the overall length of stay (LOS) following the surgical procedure were documented. The patients' postoperative complications were recorded using both the CDC system and the CCI index, with the latter calculated utilizing the CCI calculator available online at <https://www.cci-calculator.com/cciCalculator>. In cases of multiple complications, the higher grade was assigned to each case as per the CDC system. The patient's return to activity was noted during their outpatient department visits.

For statistical analysis, Spearman's correlation coefficient was utilized to determine the degree of correlation of CDC and CCI with the LOS, ICU stay, and time required to return to normal activities. In addition, a linear regression analysis was performed to assess the ability of CDC and CCI to predict the outcome variables, with the results reported as the beta coefficient and a scatter plot created to demonstrate the strength of the correlation. Next, receiver operating characteristic curve analysis was employed to compare the ability of CDC and CCI to predict the LOS, ICU stay, and time to normal activity, using the area under the curve (AUC) as the measure of predictive accuracy. To evaluate the strength of the effect size, reference values of 'moderate' (0.40–0.59), 'strong' (0.60–0.79), and 'very strong' (0.80–1.00) were used, as per previous literature^[13]. To examine the difference between the correlation coefficients of CDC and CCI with the LOS, ICU stay, and time to return to normal activity, a Hotelling's two-sample dependent test for correlations was utilized. The significance level was set at $P < 0.05$. The calculations were conducted using SPSS software version 25.1.

Results

During the study period, 1240 patients underwent HPB surgeries for various indications ranging from benign to malignant diseases in the Department of gastrointestinal and general surgery of Kathmandu Medical College Teaching Hospital. Among the 1240 patients, 801 were female and 439 were male, with an F:M ratio of 1.82:1. The patient's ages ranged from 18 to 87 years,

Table 1

Baseline characteristics and outcome variables of patients

Variables	Number	Percentage (%)
Age (years)		
< 50	824	66.5
> 50	416	33.5
Mean \pm SD	43.31 \pm 15.34 years	
Sex		
Male	439	64.6
Female	801	35.4
BMI (kg/m ²)		
< 18.5	66	5.32
18.5–24.9	964	77.74
25–29.9	198	15.97
> 30	12	0.97
ASA		
1	645	52.02
2	490	39.52
3	99	7.98
4	6	0.48
Charlson's comorbidity index		
0	427	34.44
1–4	779	62.82
> 4	34	2.74
Variable (Minimum - Maximum)	Number	Mean \pm SD
CCI (0–100)	1240	2.88 \pm 10.94
ICU stay (0–8)	1240	0.21 \pm 0.66
LOS (1–20)	1240	1.76 \pm 1.86
Return to normal activity (3–26)	1237	8.31 \pm 3.15

ASA, American Society of Anesthesiologists; CCI, Charlson's comorbidity index; LOS, Length of stay.

with a mean of 43.31 \pm 15.34 years (mean \pm SD). The majority of patients (87.5%) had ASA-1 and ASA-2 status, and one-third of the patients had no co-morbidities ($n = 427$, 34.44%). The mean BMI of the patient was 22.4 kg/m², with 77.74% of the patients having a normal BMI. The majority of the surgeries were performed on an elective basis ($n = 1054$; 85%). The postoperative LOS ranged from one to 20 days (mean \pm SD: 1.76 \pm 1.86). The LOS in the ICU ranged from 0–8 days (mean \pm SD: 0.21 \pm 0.66). Patients were followed up on an outpatient basis, and their time to return to normal activity was noted, which ranged from 3 to 26 days (mean \pm SD: 8.31 \pm 3.15) (Table 1).

One thousand one hundred twenty-three patients had no complications, and 88 patients had minor complications (less than grade III complications as per CDC grading). Only 29 patients (2.3%) had complications greater than or equal to CDC-III, including three deaths (0.2%) (Table 2).

Table 2

Postoperative complications as per CDC grading

CDC grade	Number	Percentage
0	1123	90.6
I	39	3.1
II	49	4.0
IIIa	17	1.4
IIIb	3	0.2
IVa	4	0.3
IVb	2	0.2
V	3	0.2

CDC, Clavien–Dindo classification.

Table 3
Spearman's Rho correlation coefficient

Outcomes variables	CCI		CDC	
	r	P	r	P
ICU stay	0.565	<0.001	0.570	<0.001
LOS	0.706	<0.001	0.695	<0.001
Return to normal activity	0.620	<0.001	0.611	<0.001

CCI, Charlson's comorbidity index; CDC, Clavien–Dindo classification; LOS, Length of stay.

The CCIs and CDC grading of all patients were correlated with postoperative outcomes in terms of LOS at the hospital, ICU stay, and return to normal activity using Spearman's rho correlation test. The CCI had a strong association with postoperative LOS ($r=0.706, P<0.001$) and return to normal activity ($r=0.620, P<0.001$) and a moderate association with length of ICU stay ($r=0.565, P<0.001$). Similarly, CDC grading also had a strong association with postoperative LOS ($r=0.695, P<0.001$) and return to normal activity ($r=0.611, P<0.001$) and a moderate association with length of ICU stay ($r=0.570, P<0.001$) (Table 3).

To predict the outcome variables using CCI and CDC grading, a linear regression analysis was employed, and the results were reported in terms of the correlation coefficient (r^2) and beta coefficient (β). Both CCI and CDC grading demonstrated statistically significant correlations with the LOS, length of ICU stay, and return to normal activity ($P<0.001$) in terms of postoperative stay (Table 4). The predictive accuracy in terms of outcome variables of CCI and CDC are presented in Figure 1 and Figure 2, respectively.

To evaluate the predictive accuracy of CCI and CDC, the complications were categorized as major (CDC > III, CCI > 30) and minor (CDC <III, CCI <30). CCI demonstrated good predictive accuracy for the LOS (AUC: 0.939, $P<0.001$), ICU stay (AUC: 0.812, $P<0.001$), and time to return to normal activity (AUC: 0.904, $P<0.001$) (Table 5). Likewise, the CDC also exhibited similar predictive accuracy for LOS (AUC: 0.965, $P<0.001$), ICU stay (AUC: 0.952, $P<0.001$), and return to normal activity (AUC: 0.948, $P<0.001$) (Table 6). Figure 3 shows the correlation between various parameters.

A significant correlation was found between CCI and CDC ($r=0.982, P<0.001$), with both measures demonstrating a strong correlation with the LOS, ICU stay, and return to

Table 4
Prediction of variables using linear regression analysis

Independent variable	Outcome variables	r^2	β	95% CI for β		P
				Lower bound	Upper bound	
CDC	ICU stay	0.453	0.679	0.638	0.721	<0.001
CCI		0.386	0.038	0.035	0.041	<0.001
CDC	LOS	0.501	2.001	1.890	2.112	<0.001
CCI		0.424	0.111	0.104	0.118	<0.001
CDC	Return to normal activity	0.362	3.073	2.845	3.301	<0.001
CCI		0.281	0.170	0.154	0.185	<0.001

CCI, Charlson's comorbidity index; CDC, Clavien–Dindo classification.

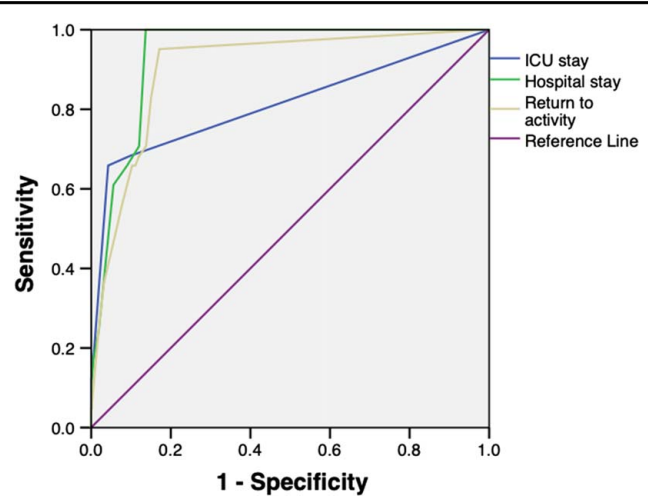


Figure 1. Predictive accuracy in terms of outcome variables of comprehensive complication index.

normal activity. CCI exhibited better predictability for the length of hospital stay and return to normal activity compared to CDC, although the difference was not statistically significant. Conversely, the CDC showed better predictability for ICU stays, but this difference was also not statistically significant (Table 7).

Discussion

This study provides evidence that both CDC and CCI are useful indices for assessing postoperative outcomes. The analysis of the data revealed that CCI had stronger correlations with the LOS and return to normal activity, whereas CDC displayed a slightly stronger correlation with the length of ICU stay. However, no significant statistical difference was observed between the two measures. A significant limitation of the CDC is that it solely records the most severe grade of complication, which may not accurately reflect the actual morbidity experienced by patients

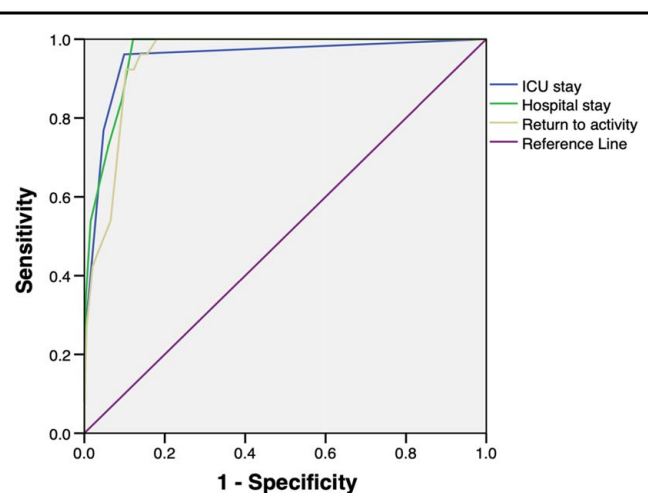


Figure 2. Predictive accuracy in terms of outcome variables of Clavien–Dindo Classification.

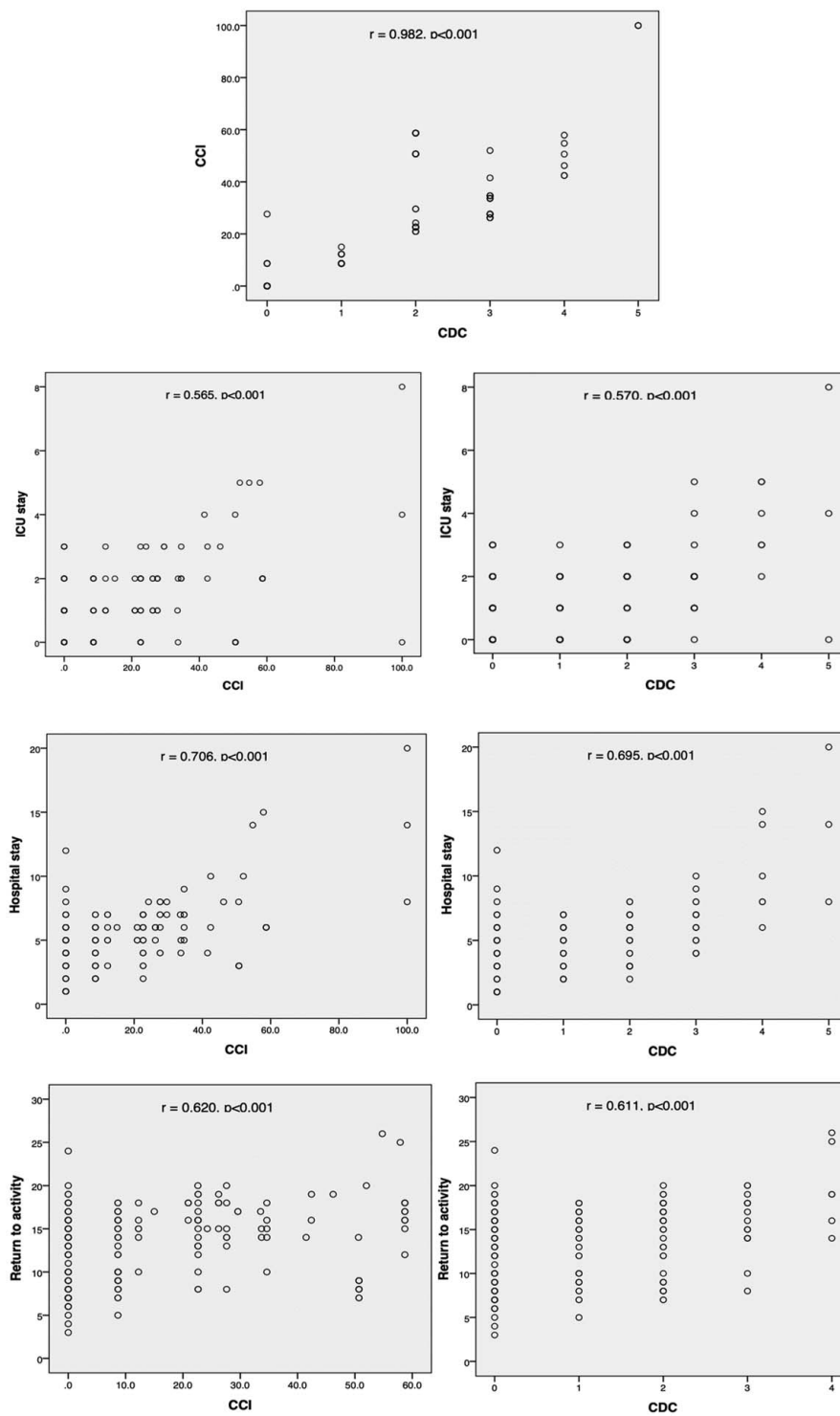


Figure 3. Correlation between various parameters.

who may have multiple complications at the same time. To overcome this limitation, CCI was introduced in 2014, which takes into account all major and minor complications after surgery, providing a more comprehensive representation of the true overall morbidity of a surgical procedure compared to the CDC^[6].

Studies in the past have reported a stronger correlation between CCI and hospital stay compared to CDC; however, all these studies were conducted in a homogenous group of patients^[13,14]. Similarly, a multicenter pancreatic fistula trial reported a strong correlation between CCI and LOS, with an unadjusted difference of 0.26 (95% CI: 0.18–0.35, $P < 0.001$)^[15].

Table 5
Predictive accuracy in terms of outcome variables of CCI

Outcome variables	AUC ^a	Standard error	P	Asymptotic 95% CI	
				Lower bound	Upper bound
ICU stay	0.812	0.045	<0.001	0.724	0.901
LOS	0.939	0.009	<0.001	0.921	0.957
Return to normal activity	0.904	0.022	<0.001	0.862	0.946

^aAUC, area under the curve; LOS, length of stay.

In another study, after esophagectomy, the authors observed a significant correlation between CCI and LOS (0.69, $P < 0.001$) in comparison to CDC (0.60, $P < 0.001$)^[16]. However, no statistically significant difference was noted between the strength of the correlation of CDC and CCI with the outcome variables upon a comparison of the two grading systems, which corroborates with the result of our study^[17]. In addition, a study carried out in Belgium concluded that the CCI was a superior predictor for in-hospital costs and length of ICU stay, whereas the CDC exhibited greater predictability for the length of hospital stay in colorectal resections^[4]. A study conducted in South Korea investigated the comparative effectiveness of CCI and CDC in predicting the severity of postoperative complications after pancreatectomy with similarity to our study, demonstrating a significant and strong association between CCI and CDC ($r = 0.938$, $P < 0.001$), with CCI displaying a more pronounced correlation with LOS than CDC^[15]. Likewise, Ray *et al.* conducted a study in India on patients undergoing gastrointestinal surgeries and found that both CCI and CDC had a significant correlation with the LOS, length of ICU stay, and return to normal activity. The predictive accuracy of CCI for LOS (AUC: 0.89, $P < 0.001$), ICU stay (AUC: 0.85, $P < 0.001$), and time to normal activity (AUC: 0.76, $P < 0.001$) was comparable to that of CDC (AUC: 0.90; $P < 0.001$, AUC: 0.87, $P < 0.001$, AUC: 0.77, $P < 0.001$), both of which were comparable to the results of our study. The authors concluded that, due to the simplicity of grading in CDC, it remains the more commonly used measure for assessing the severity of complications and outcomes in comparison to CCI^[18].

It is noteworthy that our study observed a lower proportion of patients with major complications in comparison to other studies that have evaluated complications in hepatopancreaticobiliary surgeries. This disparity may be attributed to the wide range of HPB surgeries that were included in our study, spanning from simple laparoscopic cholecystectomies and hepatic cyst deroofing

Table 6
Predictive accuracy in terms of outcome variables of CDC.

Outcome variables	AUC ^a	Standard error	P	Asymptotic 95% CI	
				Lower bound	Upper bound
ICU stay	0.952	0.023	<0.001	0.907	0.996
LOS	0.965	0.008	<0.001	0.948	0.981
Return to normal activity	0.948	0.010	<0.001	0.928	0.968

^aAUC, area under the curve; LOS, length of stay.**Table 7**
Comparison of correlation coefficients between CCI, CDC with ICU stay, LOS, and return to activity using Hotelling's *t*-test

Outcome variables	CCI	CDC	P
	r	r	
ICU stay	0.565	0.570	0.168
LOS	0.706	0.695	0.201
Return to normal activity	0.620	0.611	0.347

CCI, Charlson's comorbidity index; CDC, Clavien–Dindo classification; LOS, length of stay. Using Spearman rho correlation coefficient values.

Weiss, B.A. (2011). Hotelling's *t*-test and Steiger's Z test calculator [Computer software]. Available from <https://blogs.gwu.edu/weissba/teaching/calculators/hotellings-t-and-steigers-z-tests/>.

to complex liver resections and pancreaticoduodenectomies. We contend that the heterogeneity of cases enhances the reliability and applicability of our findings to the actual clinical setting when comparing CCI and CDC. The two scoring systems exhibit comparable effectiveness in accurately representing postoperative complications. Although the CDC is expeditious to evaluate and simpler to use, the CCI encompasses all complications, providing a more comprehensive representation of the true outcome of the surgery. Therefore, we advocate for the utilization of both scoring systems when evaluating a surgical procedure to report postoperative outcomes comprehensively.

Our study is subject to limitations, the first of which is its single-center nature. Also, from a statistical standpoint, there may be discrepancies when comparing the ordinal scale CDC with the interval scale CCI. This difference is apparent in the beta coefficient of the CCI, which appears to be notably lower than the beta coefficient of the CDC. This discrepancy can be attributed to the nature of the data rather than an actual disparity between the two scoring systems. Additionally, the comparison of surgeries of varying complexity could be a potential confounding factor in the results, leading to insignificant differences in the correlation coefficients and predictive accuracy. However, we believe that the heterogeneity of surgical procedures strengthens the study's relevance to real-world circumstances in the utilization of these scoring systems.

Conclusion

Both CCI and CDC are effective tools for accurately measuring postoperative complications in patients undergoing HPB surgeries. Although CDC is comparatively simpler to employ, CCI has the potential to provide a more comprehensive representation of postoperative outcomes compared to CDC, as it encompasses all complications. Additional studies are warranted to establish the validity of CCI in favor of CDC in accurately representing postoperative complications.

Ethical approval

Ethical clearance was obtained from the Institutional Review Board (IRB number: 0812202104) of KMCTH on 16 December 2021.

Patient consent

Written informed consent was obtained from the patient for publication and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

Sources of funding

None.

Author contribution

All authors contributed in collection and analysis of data, drafting and revising the paper, gave final approval of the version to be published and agree to be accountable for all aspects of the work.

Conflicts of interest disclosure

None of the authors has any conflict of interest to disclose. We confirm that we have read the Journal's position on issues involved in ethical publication and affirm that this report is consistent with those guidelines.

Research registration unique identifying number (UIN)

1. Name of the registry: Researchregistry.
2. Unique identifying number or registration ID: research-registry9778.
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Data availability statement

The manuscript data used to support the findings of this study is available from the corresponding author upon request.

Provenance and peer review

Not commissioned, externally peer-reviewed.

Acknowledgements

To all the patients who have contributed to this study and our colleagues.

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