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SCIENTIFIC ARTICLE

CR-POSSUM and Surgical Apgar Score as predictive factors for patients' allocation after colorectal surgery

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KEYWORDS
CR-POSSUM;
Apgar;
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Abstract
Background and objectives: Surgical patients frequently require admission in high-dependency units or intensive care units. Resources are scarce and there are no universally accepted admission criteria, so patients' allocation must be optimized. The purpose of this study was to investigate the relationship between postoperative destination of patients submitted to colorectal surgery and the scores ColoRectal Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity (CR-POSSUM) and Surgical Apgar Score (SAS) and, secondarily find cut-offs to aid this allocation.
Methods: A cross-sectional prospective observational study, including all adult patients undergoing colorectal surgery during a 2 years period. Data collected from the electronic clinical process and anesthesia records.
Results: A total of 358 patients were included. Median score for SAS was 8 and CR-POSSUM had a median mortality probability of 4.5%. Immediate admission on high-dependency units/intensive care units occurred in 51 patients and late admission in 18. Scores from ward and high-dependency units/intensive care units patients were statistically different (SAS: 8 vs. 7, $p < 0.001$; CR-POSSUM: 4.4% vs. 15.9%, $p < 0.001$). Both scores were found to be predictors of immediate postoperative destination ($p < 0.001$). Concerning immediate high-dependency units/intensive care units admission, CR-POSSUM showed a strong association (AUC 0.78, $p = 0.034$) with a $\geq$9.16 cut-off point (sensitivity: 62.5%; specificity: 75.2%), outperforming SAS (AUC 0.67, $p = 0.048$), with a $\leq$7 cut-off point (sensitivity: 67.3%; specificity: 56.1%).

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Conclusions: Both CR-POSSUM and SAS were associated with the clinical decision to admit a patient to the high-dependency units/intensive care units immediately after surgery. CR-POSSUM alone showed a better discriminative capacity.

PALAVRAS-CHAVE
CR-POSSUM;
Apgar;
Triagem pós-operatória;
Terapia intensiva

Escore CR-POSSUM e Índice de Apgar Cirúrgico como fatores preditivos para a alocação de pacientes após cirurgia colorretal

Resumo
Justificativa e objetivos: Os pacientes cirúrgicos com frequência precisam de internação em unidade de alta dependência ou unidade de terapia intensiva. Os recursos são escassos e não há critérios de admissão universalmente aceitos; portanto, a alocação dos pacientes precisa ser aprimorada. O objetivo primário deste estudo foi investigar a relação entre o destino dos pacientes após cirurgia colorretal e o Índice de Apgar Cirúrgico (IAC) e o escore CR-POSSUM — do Inglês *ColoRectal Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity* — e, secundariamente, descobrir pontos de corte para auxiliar essa alocação.
Métodos: Estudo prospectivo de observação transversal, incluiu todos os pacientes adultos submetidos à cirurgia colorretal durante um período de dois anos. Os dados foram coletados do prontuário clínico eletrônico e dos registros de anestesia.
Resultados: Foram incluídos 358 pacientes. A mediana para o IAC foi 8 e para a probabilidade de mortalidade no CR-POSSUM, 4,5%. A admissão imediata em unidade de alta dependência/unidade de terapia intensiva ocorreu em 51 pacientes e a admissão tardia em 18. Os escores dos pacientes na enfermaria e na unidade de alta dependência/unidade de terapia intensiva foram estatisticamente diferentes (tempo de internação: 8 *vs.* 7, $p < 0{,}001$; CR-POSSUM: 4,4% *vs.* 15,9%, $p < 0{,}001$). Os dois escores foram preditivos do destino imediato pós-cirurgia ($p < 0{,}001$). Em relação à admissão imediata em UAD/UTI, CR-POSSUM mostrou uma forte associação (ASC 0,78; $p = 0{,}034$) com um ponto de corte $\geq$ 9,16 (sensibilidade: 62,5%; especificidade: 75,2%), superou o IAC (ASC 0,67, $p = 0{,}048$), com ponto de corte $\leq$ 7 (sensibilidade: 67,3%; especificidade: 56,1%).
Conclusões: Tanto o CR-POSSUM quanto o IAC foram associados à decisão clínica de admitir um paciente em unidade de alta dependência/unidade de terapia intensiva imediatamente após a cirurgia. CR-POSSUM isolado mostrou uma capacidade discriminativa melhor.

Introduction

After colorectal surgery, namely major and complex major procedures,[1] patients frequently require a high level of postoperative care, such as admission in high-dependency or intensive care units. Correct triage to these units and general wards is often a challenge for anesthesiologists, surgeons and intensivists. There are no universally accepted allocation criteria and mandatory admissions to HDU/ICU could carry a risk of overuse. These decisions must be taken on an individualized basis. Furthermore, the world's current economic context implies that these resources are scarce and the demand is largely greater than the supply in most countries. Optimization of this triage may contribute to better outcomes and decreased morbidity and mortality. It also might facilitate resource allocation, identification of patients who would benefit the most from higher levels of postoperative care and consequently improve hospital management strategies.

Many clinical information and perioperative factors are taken into account in the postoperative destination decision, including preoperative patient status, comorbidities, surgical procedure, need for postoperative monitoring, intraoperative complications and available hospital facilities.[2] Some authors have suggested that scoring systems validated to predict postoperative morbidity and/or mortality may help this triage by estimating either population or individual risk.[3–6] However it must be taken into consideration that most were originally validated for patient prognosis or audit purposes.[2,7,8]

The SAS was developed as a predictor of postoperative morbidity and mortality and includes only intraoperative variables: lowest heart rate, lowest mean arterial pressure and estimated blood loss (Table 1). In a 0–10 scale, a lower score predicts a poorer prognosis. Although it is only calculable at the end of the surgery, it has the advantage of being a simple score.[3,9,10] The original Physiological and Operative Severity Score for the enUmeration of Mortality and

Table 1 Surgical Apgar Score[a].[10]

	0	1	2	3	4
Estimated blood loss (mL)	>1000	601–1000	101–600	≤100	
Lowest mean arterial pressure (mmHg)	>40	40–54	55–69	≥70	
Lowest heart rate (bpm)	>85[b]	76–85	66–75	56–65	≤55[b]

[a] The score is the sum of the points for each category in the course of a procedure.
[b] Occurrence of pathologic bradyarrhythmia, including sinus arrest, atrioventricular block or dissociation, junctional or ventricular escape rhythms, and asystole also receive 0 points for lowest heart rate.

Table 2 CR-POSSUM scoring system.[1]

	Score				
	1	2	3	4	8
Physiological score					
Age group (years)	≤60		61–70	71–80	≥81
Cardiac Failure	None or mild	Moderate	Severe		
Systolic blood pressure (mmHg)	100–170	>170 or 90–99	<90		
Pulse (beats.min^{-1})	40–100	101–120	>120 or <40		
Urea (mmol.L^{-1})	≤ 10	10.1–15.0	>15		
Hemoglobin (g.dL^{-1})	13–16	10–12.9 or 16.1–18	<10 or >18		
Operative Severity Score					
Operative severity	Minor		Intermediate	Major	Complex major
Peritoneal soiling	None or serous fluid	Local pus	Free pus or feces		
Operative urgency	Elective		Urgent		Emergent
Cancer Staging	No cancer or Dukes' A-B	Dukes' C	Dukes' D		

CR-POSSUM equation: $\ln[R/(1-R)] = -9.167 * (0.338 \times PS) + (0.308 \times OSS)$, where PS is the total Physiological Score and OSS is the total Operative Severity Score.

Morbidity (POSSUM) was the basis to develop CR-POSSUM. This was simplified and designed to better fit patients undergoing colorectal surgery. CR-POSSUM uses a six-factor, four-grade Physiological Score and a four-factor, four-grade Operative Severity Score, in order to calculate the predicted mortality for a given patient (Table 2).[1,8,11] Neither of these scores uses admission in HDU/ICU as a variable or outcome measure. A low SAS and a high CR-POSSUM predict poorer outcomes.

The primary goal of our study was to investigate the relationship between the post-operative level of care and the CR-POSSUM and SAS, in patients who underwent colorectal surgery. As a secondary goal we aimed to find a cut-off in both scores, which could help define postoperative allocation of these patients.

Methods

A cross-sectional prospective observational study was conducted, including all adult patients (≥18 years old), undergoing elective and urgent/emergent, major (right or left hemicolectomy, transverse or sigmoid colectomy, Hartmann's procedure) or complex major (rectum anterior resection, abdominoperineal excision of rectum, subtotal or total colectomy) colorectal surgery at our center.[1] Excluding criteria were non-colorectal surgery, ambulatory surgery and minor/intermediate colorectal procedures. Sample size was defined by temporal criteria; no previous data was available concerning HDU/ICU admission of colorectal surgery patients' at our center. Recruitment occurred from 1st of April 2014 to 31st of March 2016. The Hospital Ethics Committee approved the study (067-DEFI/098-CES).

Data was collected from the electronic clinical process and anesthesia records, and included age, gender, Body Mass Index (BMI), American Society of Anesthesiologists (ASA) physical status, surgical procedure and technique, type of anesthesia, surgical duration, intraoperative complications (Table 4), postoperative destination (general ward, HDU/ICU), later admission to HDU/ICU, total time at an HDU/ICU, total hospital stay, postoperative morbidity (Table 5) and mortality at 30 days after surgery. All data needed for SAS and CR-POSSUM was also collected, as detailed in Tables 1 and 2.

The attending anesthesiologist and surgeon, independently of the study, made patient triage to postoperative destination. As there are no standard criteria defined in our institution, triage was done as the usual clinical practice. Doctors in charge decided according to patients' comorbidities, intraoperative events, clinical experience and HDU/ICU-bed availability. Immediate HDU/ICU admission after surgery was divided into predictable or unpredictable. It was considered unpredictable when the admission to HDU/ICU was not planned preoperatively but needed due to intraoperative events or when considering patients in urgent settings, in which programming HDU/ICU admission is not

Table 3 Patients and procedures' characteristics.

Characteristics	No. of patients (%)
BMI (kg.m^{-2})[a]	
<18.5	10 (2.9%)
18.5–24.9	150 (44%)
25–29.9	120 (35.2%)
≥30	61 (17.9%)
ASA physical status	
I	18 (5%)
II	200 (55.9%)
III	122 (34.1%)
IV	18 (5%)
Type of surgery	
Elective	293 (81.8%)
Urgent/emergent	65 (18.2%)
Surgical procedure	
Major	
Partial colectomy	145 (40.5%)
Sigmoid colectomy	90 (25.1%)
Complex major	
Total colectomy	24 (9.5%)
Anterior rectum ressection	80 (22.3%)
Abdominoperineal excision of rectum	9 (2.5%)
Type of anesthesia	
General	264 (73.7%)
Combined	94 (26.3%)
SAS[a]	
0–2	0 (0%)
3–4	21 (6%)
5–6	64 (18.2%)
7–8	167 (47.4%)
9–10	100 (28.4%)
CR-POSSUM[a]	
0–4.9%	196 (55.7%)
5–9.9%	54 (15.3%)
10–14.9%	34 (9.7%)
15–19.9%	20 (5.7%)
20–24.9%	14 (4%)
≥25%	34 (9.7%)
Immediate postoperative destination	
Ward	307 (85.8%)
HDU	32 (8.9%)
ICU	19 (5.3%)
Late HDU/ICU admission (>24 h)	
No	340 (95%)
Yes	18 (5%)
Intraoperative complications	
No	320 (89.4%)
Yes	38 (10.6%)
Postoperative complications	
No	273 (76.3%)
Yes	85 (23.7%)
30 days outcome	
Discharge	314 (87.7%)
Still hospitalized	35 (9.8%)
Death	9 (2.5%)

ASA, American Society of Anesthesiologists; BMI, Body Mass Index; CR-POSSUM, Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity; HDU, High-Dependency Unit; ICU, Intensive Care Unit; SAS, Surgical Apgar Score.

[a] There are 17 missings in BMI and 6 in SAS and CR-POSSUM.

Table 4 Intraoperative complications.

Complications	No. of patients (%)
Cardiovascular	
Dysrhythmias	8
Shock with vasopressors' support	11
Cardiac arrest	1
Respiratory	
Hypoxia during difficult airway management	2
Subcutaneous emphysema	3
Pulmonary aspiration	1
Bronchospasm	1
Hematologic	
Need for urgent transfusion	7
Other minor complications	4

possible in advance. Later HDU/ICU admissions comprised patients who initially went to the general ward following surgery but had to be transferred after 24 h. Patients had a medical appointment 30 days after surgery, and follow-up was registered according to the information written on the electronic clinical process.

None of the investigators who collected data took part of the anesthetic procedures or any other clinical care or decision. This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

Primary outcome was defined as immediate HDU/ICU admission (predicted or unpredictable) and secondary outcome as late HDU/ICU admission.

Patients' demographic characteristics and results are presented as median (interquartile range). Categorical variables are presented as number and percentage. Variables such as SAS and CR-POSSUM were analyzed continuously and in groups. SAS data groups were defined as 0–2, 3–4, 5–6, 7–8, 9–10. CR-POSSUM data groups were defined according to mortality risk as 0–4.9%, 5–9.9%, 10–14.9%, 15–19.9%, 20–24.9% and ≥25%. Admission into HDU and ICU were analyzed as a single group. Patients with missing data hindering scores' calculation were excluded from that analysis.

Normality of the variables was assessed using the Kolmogorov–Smirnov test. Since most variables followed a non-normal distribution, non-parametric Mann–Whitney test was used for comparisons between groups. The Spearman Rho Correlation analysis was performed to assess the correlation between variables. A logistic regression and the Chi-square Hosmer and Lemeshow (HL) goodness of fit test were performed to assess the prediction performance of SAS and CR-POSSUM (independent variables) for immediate postoperative patient allocation to HDU/ICU (dependent variables). Receiver Operating Characteristic (ROC) curve analysis was used to assess the specificity and sensitivity of both scores. Database management and statistical analyses were performed using IBM® SPSS® Statistics version 24. A p-value <0.05 was considered statistically significant.

Results

A total of 358 patients met the criteria for study inclusion. Mostly were men (53.4%), with a median age of 66 years (37–66) and a BMI of 25.3 $kg.m^{-2}$ (22.4–28.4). The majority of patients (60.9%) were assigned an ASA classification I–II. Most surgeries (81.8%) were performed in an elective setting. The median duration of surgery was 173 min (130–230). Median duration of stay at HDU/ICU and total hospital stay was respectively 5 days (2–9) and 9 days (7–14). The characteristics of patients and surgical procedures are described in Table 3.

The SAS and CR-POSSUM score were available in 352 patients (6 patients with missing data, 1.7%). SAS had a median of 8 (7–9), with 75.8% of patients ($n = 267$) with a score ≥ 7. CR-POSSUM score presented a median value of predicted mortality of 4.54% (2.30–11.29). Most patients (55.7%, $n = 196$) presented a CR-POSSUM mortality probability $\leq 5\%$.

Follow-up was completed for all patients. Intraoperative and postoperative complications were present, respectively, in 10.6% ($n = 38$) and 23.7% ($n = 85$) of patients (Tables 4 and 5). The overall mortality at 30 days was 2.5% ($n = 9$).

Immediate admission on HDU/ICU after surgery occurred in 14.2% ($n = 51$) of patients, being unpredicted in 56.9% ($n = 29$). Late admissions on HDU/ICU occurred in 5% ($n = 18$) of patients. As compared to elective surgery, patients who underwent urgent surgery needed to be admitted to HDU/ICU more frequently during hospitalization (43.1% vs. 9.9%, $p < 0.001$). A higher prevalence of postoperative complications was registered among patients who were immediately admitted to HDU/ICU. From these 62% ($n = 31$) had postoperative complication, vs. only 33% ($n = 6$) of the late admitted on HDU/ICU patients, and 16.6% ($n = 48$) of the ward patients ($p < 0.001$).

When analyzing the association between SAS and CR-POSSUM and immediate postoperative destination, statistically significant difference was found between ward and HDU/ICU patients (SAS: ward 8 vs. HDU/ICU 7, $p < 0.001$; CR-POSSUM: ward 4.42% vs. HDU/ICU 15.9%, $p < 0.001$). A logistic regression was performed and both scores were found to be predictors for immediate postoperative destination ($p < 0.001$).

Table 5 Postoperative complications and mortality at 30 days.

Complications	No. of patients (%)
Cardiovascular	37 (10.3%)
Cardiac ischemia	3 (0.8%)
Acute decompensated heart failure	11 (3.1%)
Need for vasopressors	18 (5%)
Cardioversion/defibrillation	5 (1.4%)
Respiratory	38 (10.6%)
Pulmonary infection	8 (2.2%)
Ventilatory support	30 (8.4%)
Renal	20 (5.6%)
Acute kidney injury	10 (2.8%)
Acute on chronic kidney disease	9 (2.5%)
Dialysis	1 (0.3%)
Hematologic	41 (11.4%)
Transfusion	38 (10.6%)
Coagulopathy	3 (0.8%)
Neurologic	10 (2.8%)
Cognitive dysfunction	10 (2.8%)
Infectious	84 (23.5%)
Surgical site infection	56 (15.6%)
Other infection	28 (7.8%)
Surgical re-intervention	42 (11.7%)
Hospital readmission < 30 days	13 (3.6%)
Hospital readmission + surgical re-intervention	8 (2.2%)
Hospitalization period > 30 days	35 (9.8%)
Death	9 (2.5%)

Only CR-POSSUM showed a significant statistical difference with late HDU/ICU admission (without late admission with a CR-POSSUM of 4.5% vs. with late admission in HDU/ICU with a CR-POSSUM of 10.9%, $p = 0.042$). Regarding SAS both groups had a median of 8 ($p = 0.905$).

Patients with postoperative complications showed both significantly lower SAS and higher CR-POSSUM scores (SAS 8 vs. 7, $p = 0.003$; CR-POSSUM 4.29% vs. 6.80%, $p < 0.001$).

Receiver Operating Characteristic (ROC) curve analysis demonstrated that CR-POSSUM was strongly associated with immediate HDU/ICU admission (AUC 0.78, $p = 0.034$, 95% CI 0.714–0.846) with a ≥ 9.16 cut-off point (sensitivity: 62.5%; specificity: 75.2%). This value also corresponds to percentile 74.75 of ward patients and percentile 37.15 of HDU/ICU patients. For SAS an association with immediate HDU/ICU admission was also found (using ''10-SAS'' to compare both curves: AUC 0.668, $p = 0.048$, 95% CI 0.574–0.762). A cut-off point was defined for SAS ≤ 7, with a sensitivity of 67.3% and a specificity of 56.1%. This corresponds to percentile 25 of ward patients and percentile 50 of HDU/ICU patients. ROC curves for ''CR-POSSUM'' and ''10-SAS'' are presented in Fig. 1.

The CR-POSSUM and SAS were found to have a significant negative association between them, as expected ($p < 0.001$, with a Spearman Rho correlation coefficient of -0.213).

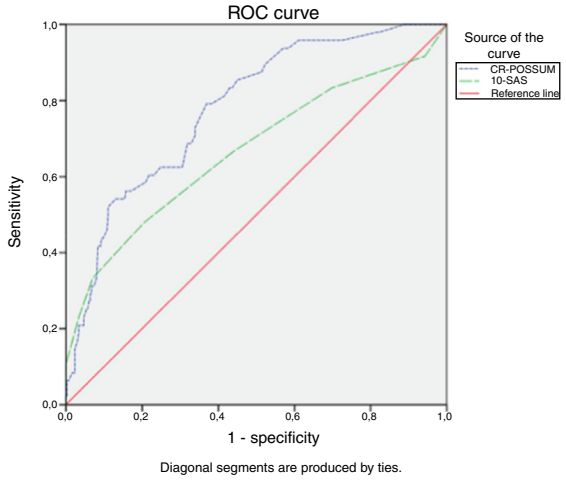

Figure 1 ROC curves of CR-POSSUM and 10-SAS for immediate High-dependency units/Intensive care units admission (CR-POSSUM: AUC 0.78, $p = 0.034$, 95% CI 0.71–0.85; 10-SAS: AUC 0.67, $p = 0.048$, 95% CI 0.57–0.76).

The combined performance of SAS and CR-POSSUM as a prognostic score was tested, being well calibrated (HL χ^2 statistic: $\chi^2 = 6.167$; degrees of freedom = 8; $p = 0.629$). When applied together both scores could correctly predict 87% of postoperative immediate destination, however this occurred mainly due to a correct prediction of the ward patients and not the HDU/ICU (ward 98.3% vs. HDU/ICU 16.7%).

Discussion and conclusion

Our study demonstrates that both CR-POSSUM and SAS are associated with the clinical decision to admit a patient to the HDU/ICU immediately after colorectal surgery, with a low SAS and a high CR-POSSUM being associated with higher likelihood of this allocation. CR-POSSUM alone clearly outperformed SAS, showing a better discriminative capacity in this task. SAS showed not only a lower AUC but also lower values of sensitivity and sensibility concerning the cut-offs defined.

Some authors have been focusing on HDU/ICU admission criteria and development of predictive scores in the last years.[4,5,12–14] Sobol et al. found that SAS was associated with immediate admission on ICU of patients submitted to intra-abdominal surgical procedures. Although with only moderate discrimination by itself, it proved to be more useful when analyzed together with other clinical variables.[4] Regenbogen et al. also found a relationship between SAS and the occurrence of postoperative complications before and after discharge.[13] Haddow et al. went further and described that the use of SAS as an additional criteria in the decision process of triage showed a non-significant trend toward a more immediate admission in critical care units without however finding any difference concerning clinical outcomes.[5]

Concerning late HDU/ICU admissions, only CR-POSSUM was found to show an association in our study. This might suggest that variables obtained preoperatively related to the patient and surgical procedure might play a more important role than intraoperative events in subsequent deterioration of patients during the postoperative period. Literature is still discrepant in this point. Even though Sobol et al. had already suggested this limitation of SAS, Wanderer et al. reported a relationship between SAS and unplanned postoperative ICU admission with a ROC curve AUC of 0.696.[4,12]

Our study revealed 14.2% of patients immediately admitted to HDU/ICU after surgery, and 5% late admitted. There is plenty literature concerning rates of postoperative HDU/ICU admission, presenting very different results.[12,15–17] This is comprehensible as there are not yet universally accepted standardized admission criteria, different surgical populations are evaluated and hospital available infrastructures are not always equivalent. Although referring only to urgent abdominal procedures, Swart et al. presents similar rates of immediate and late ICU admission.[17] Sobol et al. considering major intra-abdominal surgery also found similar rates (9.6% immediate admission, 5.2% late admission).[15]

Postoperative complications were more frequent among patients with immediate HDU/ICU admission compared to the late admitted ones. Wanderer et al. published that his sample of unplanned admitted patients had more ICU-free days and a similar mortality.[12] However, most studies show that later admissions lead to worse outcomes.[15,18]

A major strength of this study is, undoubtedly, the simplicity of the scores under study. Both CR-POSSUM and SAS do not require complex data and were designed specifically to suit surgical patients. SAS has already been validated in numerous settings.[4,9,10,13,19,20] In most studies it shows a moderate discriminative capacity concerning postoperative complications.[9,10,14,19] Its predictability is however sometimes inferior to other scores individually or analyzed in association, and some authors suggest that might be related to is simplicity.[4,10,21] Some characteristics of SAS that might contribute to this is being a whole-number scale with low amplitude. As already stated CR-POSSUM is a simplified version of POSSUM that shows a more accurate mortality prediction in patients who underwent colorectal surgery.[1,16,22–24] When comparing to CR-POSSUM, SAS has the disadvantage of being calculated only after the end of surgery. Identifying earlier predictors of postoperative need for HDU/ICU admission might facilitate resource allocation and management, diminishing delays on providing the best treatment needed, therefore improving patient outcomes.[25] However, not infrequently, the final triage decision is in fact postponed in order to consider intraoperative course and patient recovery.

Our study is innovative and aims to a very practical goal: help, simplify and make postoperative allocation of patients more objective. Due to the absence of standard, universally accepted criteria, this tends to be a very subjective decision that, as previously stated, depends on many factors, such as patient comorbidities, bed availability, physicians on charge, institutional policies. Given the constant possibility of under and overuse of medical resources and the current focus on quality, costs and auditing, there is a continuing need to evaluate our clinical practices and to improve them, specially if possible with simple tools such as these scores. Our work focus on a specific population, patients with major and complex major colorectal surgery, that comprises a considerable percentage of our hospital's target. As so, its utility in our daily practice is comprehensible.

We acknowledge that the current study presents some limitations. Firstly, it was conducted in a single surgical center, with a small sample, and concerns only colorectal surgery. There is an over-representation of low-risk patients (ASA 1–2, SAS $\geq$7, CR-POSSUM < 10%), and a substantially larger proportion of patients admitted to general wards than HDU/ICU, which might differ from other surgical centers. Since no standard uniform criteria were used to justify HDU/ICU admissions, results might not apply to institutions with different ICU allocation criteria. Having this in mind, the cut-offs defined must be understood as exploratory and in need for future validation.

Further studies in different patient groups and even with other scores are needed in order to define the best predictive model for HDU/ICU allocation purposes. Subsequent studies should validate scores to help this triage and also evaluate whether more standardized allocations contribute to better outcomes for patients. A future approach could focus on the postoperative complications that might be preventable or treatable in an HDU/ICU context. This would be not only relevant to validate our cut-off applicability but also to monitor our practice and improve it, having measurable clinical outcomes in hands.

Postoperative resources allocation will still be an up-to-date issue. Not only from an economic point of view but also as hospitals aim at providing the best postoperative care needed as to improve patient's clinical outcomes. The constant risk of misuse of medical resources creates a continuing need to evaluate, improve and simplify our clinical practices. The use of these simple scores as adjuvant of our clinical decision for postoperative admissions might make these decisions not only more uniform, but also more likely to provide the better health care for our patients.

Conflicts of interest

The authors declare no conflicts of interest.

References

1. Tekkis P, Prytherch D, Kocher H, et al. Development of a dedicated risk-adjustment scoring system for colorectal surgery (colorectal POSSUM). Br J Surg. 2004;91:1174–82.
2. Sobol J, Wunsch H. Triage of high-risk surgical patients for intensive care. Crit Care. 2011;15:217.
3. Barnett S, Moonesinghe S. Clinical risk scores to guide perioperative management. Postgrad Med J. 2011;87:535–41.
4. Sobol J, Gershengorn H, Wunsch H, et al. The Surgical Apgar Score is strongly associated with intensive care unit admission after high-risk intraabdominal surgery. Anesth Analg. 2013;117:438–46.
5. Haddow J, Adwan H, Clark S, et al. Use of the surgical Apgar score to guide postoperative care. Ann R Coll Surg Engl. 2014;96:352–8.
6. Kose I, ZIncircioglu C, Çakmak M, et al. Postoperative patients in the intensive care unit: identifying those who do not really need it. J Crit Care. 2015;30:1295–8.
7. Williams C, Wheeler D. Criteria for ICU admission and severity of illness scoring. Surgery. 2009;27:201–6.
8. Copeland G, Jones D, Walters M. POSSUM: a scoring system for surgical audit. Br J Surg. 1991;78:355–60.
9. Regenbogen S, Ehrenfeld J, Lipsitz S, et al. Utility of the surgical apgar score. Validation in 4119 patients. Arch Surg. 2009;144:30–6.
10. Gawande A, Kwaan M, Regenbogen S, et al. An apgar score for surgery. J Am Coll Surg. 2007;204:201–8.
11. Vather R, Zaergar-Shostari K, Adegbola S, et al. Comparison of the POSSUM. P-POSSUM and CR-POSSUM scoring systems as predictors of postoperative mortality in patients undergoing major colorectal surgery. Anz J Surg. 2006;76:812–6.
12. Wanderer J, Anderson-Dam J, Levine W, et al. Development and validation of an intraoperative predictive model for unplanned postoperative intensive care. Anesthesiology. 2013;119:516–24.
13. Regenbogen S, Bordeianou L, Hutter M, et al. The intraoperative surgical Apgar Score predicts post-discharge complications after colon and rectal resection. Surgery. 2010;148:559–66.
14. Thorn C, Chan M, Sinha N, et al. Utility of the surgical Apgar Score in a district general hospital. World J Surg. 2012;36:1066–73.
15. Sobol J, Wunsch H, Li G. Causes and outcomes of later ICU admissions after major intra-abdominal surgery. Crit Care Med. 2013;41.
16. Dale CD, McLoone P, Sloan B, et al. Critical care provision after colorectal cancer surgery. BMC Anesthesiol. 2016;16:94.
17. Swart M, Carlisle JB, Goddard J. Using predicted 30 day mortality to plan postoperative colorectal surgery care: a cohort study. Br J Anaesth. 2017;118:100–4.
18. Cardoso L, Grion C, Matsuo T, et al. Impact of delayed admission to intensive care units on mortality of critically ill patients: a cohort study. Crit Care. 2011;15:R28.
19. Moonesinghe S, Mythen M, Das P, et al. Risk stratification tools for predicting morbidity and mortality in adult patients undergoing major surgery: qualitative systematic review. Anesthesiology. 2013;119:959–81.
20. Reynolds P, Sanders N, Schildcrout J, et al. Expansion of the Surgical Apgar Score across all surgical subspecialties as a means to predict postoperative mortality. Anesthesiology. 2011;114:1305–12.
21. Jering M, Marolen K, Shotwell M, et al. Combining the ASA physical classification system and continuous intraoperative surgical apgar score measurement in predicting postoperative risk. J Med Syst. 2015;39.
22. Horzic M, Kopljar M, Cupurdija K, et al. Comparison of P-POSSUM and Cr-POSSUM scores in patients undergoing colorectal cancer resection. Arch Surg. 2007;142:1043–8.
23. Tez M, Yoldas O, Gocmen E, et al. Evaluation of P-POSSUM and CR-POSSUM scores in patients with colorectal cancer undergoing resection. World J Surg. 2006;30:2266–9.
24. Yan J, Wang YX, Li ZP. Predictive value of the POSSUM, P-POSSUM, cr-POSSUM, APACHE II and ACPGBI scoring systems in colorectal cancer resection. J Int Med Res. 2011;39:1464–73.
25. Capuzzo M, Moreno R, Alvisi R. Admission and discharge of critically ill patients. Curr Opin Crit Care. 2010;16:499–504.