International Surgery Journal
Robinson E et al. Int Surg J. 2022 Dec;9(12):2003-2009
http://www.ijsurgery.com

pISSN 2349-3305 | eISSN 2349-2902

DOI: https://dx.doi.org/10.18203/2349-2902.isj20223163

Original Research Article

NNIS risk score or COLA score: which predicts better the risk of surgical site infection among patients undergoing colorectal resection in a tertiary care hospital setting?

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Received: 22 October 2022
Accepted: 14 November 2022

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ABSTRACT

Background: By using predictive scores to identify and quantify risk of Surgical site infections (SSI), preventive measures can be directed effectively to improve patient outcome post operatively. This study was undertaken to compare the National Nosocomial Infections Surveillance (NNIS) risk index and COLA (contamination, obesity, laparotomy and ASA grade) scores to predict risk of SSI among patients undergoing colorectal resection.
Methods: A total of 77 patients who underwent colorectal resection at a tertiary care hospital were enrolled in this study. Wound surveillance was performed in all patients during the hospital stay and follow-up information for 30 days postoperatively was collected. Data analysis was done in SPSS version 20.0 for windows. Descriptive analysis was used to exhibit the clinical parameters. Differences between groups were tested by Pearson chi-square and fisher's exact test. ROC curves were utilized. All the statistical tests were examined with 5% ($p \leq 0.05$) level of significance.
Results: Incidence of overall SSI was 28.6%. Superficial SSI was more common (14.3%). Serious organ/deep space infection occurred only in 9.1%. Area under the curve (AUC) for NNIS score was 0.645 (95% CI: 0.510-0.781, $p<0.05$) and 0.611 for the COLA score. (95% CI: 0.472-0.750, $p>0.05$). Therefore, both these scores have less than acceptable accuracy in this data set to predict SSI.
Conclusions: The risk prediction models (NNIS, COLA) although simple, did not accurately predict the risk of SSI in the given study population.

Keywords: COLA score colorectal surgery, Risk prediction, Surgical site infection

INTRODUCTION

Colorectal surgeries are associated with high rates of surgical site infection (SSI) which widely ranges from 5% to 30% as reported in literature, causing post-operative morbidity.[1-3] In order to address this postoperative complication, a risk prediction index was formulated by Culver et al in 1991 called National nosocomial infections surveillance (NNIS) risk index. This risk index is composed of the following three criteria: American Society of Anesthesiologists grade of 3, 4, or 5; an operation classified as contaminated or dirty-infected; and a prolonged length of operation more than T hours (where T is approximate 75th percentile of duration of the specific operation being performed) and each operation is scored by counting the number of factors present. The score ranges from 0 to 3, with higher score associated with higher rate of SSI.[4] NNIS risk index does not consider specific factors for colorectal surgery. Hence Gervaz constructed a new scoring system for colorectal procedures called COLA score which is based on four risk factors predictive of SSI: contamination of wound, obesity, laparotomy and ASA grade and score ranged from 0 to 4. Risk of SSI ranged from less than 10% for score of zero and exceeded 40% for score of three or more. This COLA score has an advantage of including surgical approach in order to improve the predictive value.[5] This study was undertaken to compare the above-mentioned scores to predict risk of SSI among patients undergoing colorectal surgery.

METHODS

Study location, setting and duration

This observational study was a hospital-based study conducted in a 1250 bedded multispecialty tertiary-care hospital Kovai Medical Center and Hospital, Coimbatore, India from July 2018 to December 2019.

Inclusion and exclusion criteria

Patients aged above 18 years undergoing colorectal resection surgery (elective and emergency) willing to participate were included. Exclusion criteria for current study were; lost to follow-up, death of participating patient before postoperative 30th day, small bowel surgeries and minor procedures like stoma reversal and patient’s refusal.

Procedure

A total of 77 patients were enrolled in the study. Preoperative and intraoperative data were collected. All operations were performed by consultant surgeons. All patients received prophylactic intravenous antibiotics. During the postoperative period, patients were followed till the time of discharge in the ward. The wound was examined by the surgical resident of the operating team at least once a day till the day of discharge. Pus was sent for culture when present. 30 days SSI surveillance was continued by reviewing the patient during clinical visit to surgical OP. When encountered, such wound infections were managed by local wound wash, daily dressing, oral or intravenous antibiotic as appropriate based on culture sensitivity pattern.

Data analysis

The data was entered into excel sheet systematically and taken for statistical analysis using SPSS version 20.0 for windows. Descriptive analysis such as mean and percentage was used to exhibit the clinical parameters. Differences between groups were tested by Pearson chi-square and fisher’s exact test. ROC curves were utilized. AUC was used to test the accuracy of the scores. All the statistical tests were examined with 5% ($p \leq 0.05$) level of significance.

Definition of variables

SSI: it is defined as per centers for disease control and prevention (CDC) definition as infection involving the skin or subcutaneous tissue (superficial SSI) or fascial and muscle layers (deep SSI) of the surgical incision sites.

Table 1: Revised consensus guidelines for India.[8]

BMI	Class
<18.5	Underweight
18.5 - 22.9	Normal weight
23-24.9	Over weight
>25	Obese

Table 2: NNIS risk score.[4]

Risk factor	Score ascribed
Surgical wound classification	
Clean	0
Contaminated	1
ASA grade	
Grade 1 or 2	0
Grade 3 or above	1
Duration of surgery	
Less than 75th percentile of similar procedures	0
More than 75th percentile of similar procedures	1

Table 3: COLA score.[10]

Parameters	Score ascribed
Obesity	1
Contamination class 3-4	1
ASA grade 3-4	1
Open surgery	1

It should occur within 30 days of the operation and demonstrate at least 1 of the following: purulent discharge; organisms isolated in aseptically obtained wound cultures; at least 1 of the 4 cardinal signs of infection: erythema, heat, pain, and swelling of incision deliberately opened by surgeon; development of an abscess; or diagnosis of SSI by attending surgeon. The CDC definition describes three levels of SSI: level 1: superficial incisional, affecting the skin and subcutaneous tissue. These infections may be indicated by localized (Celsian) signs such as redness, pain, heat or swelling at the site of the incision or by the drainage of pus. Level 2: deep incisional, affecting the fascial and muscle layers. These infections may be indicated by the presence of pus or an abscess, fever with tenderness of the wound, or a separation of the edges of the incision exposing the deeper tissues. Level 3: organ or space infection, which involves any part of the anatomy other than the incision that is opened or manipulated during the surgical procedure, for example joint or peritoneum. These infections may be indicated by the drainage of pus or the formation of an abscess detected by histopathological or radiological examination or during re-operation.[6]

Table 4: Clinical characteristics and SSI association.

Variables	N (%)	With SSI N (%)	P value
Sex			
Female	19 (24.7)	5 (26.3)	>0.05*
Male	58 (75.3)	17 (29.3)	
ASA Grade[a]			
1	13 (16.9)	4 (30.8)	>0.05**
2	33 (42.9)	4 (30.8)	
3	30 (39)	4 (30.8)	
4	1 (1.3)	4 (30.8)	
BMI[b]			
<18.5	11 (14.2)	4 (36.4)	>0.05**
18.5-22.9	24 (31.2)	6 (25)	
23-24.9	16 (20.8)	4 (25)	
>25	26 (33.8)	8 (30.8)	
Surgical approach			
Open	32 (41.6)	11 (34.4)	>0.05**
Laparoscopic	32 (41.6)	6 (18.8)	
Robotic	13 (16.9)	5 (38.5)	
Prolonged length of operation[c]			
Yes	17 (22.1)	8 (47.1)	>0.05**
No	60 (77.9)	14 (23.3)	
Wound class			
Clean-contaminated	65 (84.4)	18 (27.7)	>0.05**
Contaminated	1 (1.3)	0 (0)	
Dirty	11 (14.3)	4 (36.4)	
Urgency of operation			
Elective	69 (89.6)	17 (24.6)	<0.05**
Emergency	8 (10.4)	5 (62.5)	
NNIS Score[d]			
0	31 (40.2)	5 (16.1)	>0.05**
1	33 (42.9)	11 (33.3)	
2	13 (16.9)	6 (46.2)	
3	0 (0)	0 (0)	
COLA score[e]			
0	18 (23.4)	3 (16.7)	>0.05**
1	32 (41.6)	9 (28.1)	
2	14 (18.1)	4 (28.6)	
3	10 (13)	5 (50)	
4	3 (3.9)	1 (33.3)	

*Pearson Chi-square test, **Fisher's exact test, a- American Society of Anesthesiologists' classification of Physical Health, b- Body mass index, c- duration of surgery beyond 270 mins was considered prolonged (75th percentile and above of the duration), d- National nosocomial infections surveillance, e- contamination of wound, obesity, laparotomy and ASA grade.

Surgical wounds are divided into four classes. Clean refers to an uninfected operative wound in which no inflammation is encountered and the respiratory, alimentary, genital or uninfected urinary tracts are not entered. In addition, clean wounds are primarily closed and, if necessary, drained with closed drainage. Operative incisional wounds that follow non- penetrating (blunt) trauma should be included in this category if they meet the criteria. Clean-contaminated refers to operative wounds in which the respiratory, alimentary, genital and urinary tracts are entered under controlled conditions and without unusual contamination. Specifically, operations involving the biliary tract, appendix, vagina and oropharynx are included in this category, provided no evidence of infection or major break in technique is encountered. Contaminated refers to open, fresh, accidental wounds. In addition, operations with major breaks in sterile technique (for example, open cardiac massage) or gross spillage from the gastrointestinal tract, and incisions in which acute, non- purulent inflammation is encountered, including necrotic tissue without evidence of purulent drainage (for example, dry gangrene), are included in this category. Dirty or infected includes old traumatic wounds with retained devitalized tissue and those that involve existing clinical infection or perforated viscera. This definition suggests that the organisms causing postoperative infection were present in the operative field before the operation.[7] Obesity: BMI was calculated in each patient. BMI= Weight in kg/height in metre.[2]

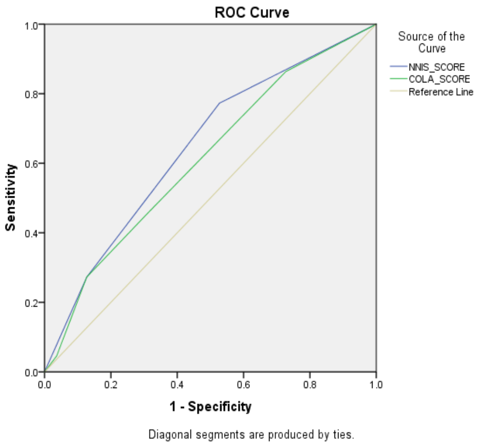

Figure 1: Receiver operating characteristic curve for NNIS and COLA score.

The American society of anaesthesiologists' (ASA) classification of physical health

ASA 1: A normal healthy patient. Example: Fit, nonobese (BMI under 30), a non-smoking patient with good exercise tolerance. ASA 2: A patient with a mild systemic disease. Example: Patient with no functional limitations and a well-controlled disease (e.g., treated hypertension, obesity with BMI under 35, frequent social drinker or is a cigarette smoker). ASA 3: A patient with a severe systemic disease that is not life-threatening. Example: Patient with some functional limitation as a result of disease (e.g., poorly treated hypertension or diabetes, morbid obesity, chronic renal failure, a bronchospastic disease with intermittent exacerbation, stable angina, implanted pacemaker). ASA 4: A patient with a severe systemic disease that is a constant threat to life. Example: Patient with functional limitation from severe, life-threatening disease (e.g., unstable angina, poorly controlled chronic obstructive pulmonary disease (COPD), symptomatic congestive heart failure (CHF), recent (less than three months ago) myocardial infarction or stroke. ASA 5: A moribund patient who is not expected to survive without the operation. The patient is not expected to survive beyond the next 24 hours without surgery. Examples: ruptured abdominal aortic aneurysm, massive trauma, and extensive intracranial hemorrhage with mass effect. ASA 6: A brain-dead patient whose organs are being removed with the intention of transplanting them into another patient. The addition of "E" to the ASAPS (e.g., ASA 2E) denotes an emergency surgical procedure.[9]

RESULTS

A total of 77 patients who underwent colorectal resection during the study period were included in this study. The study population was made up of 58 men and 19 women with a median age of 63 years (range 28-90 years). The incidence of overall SSI in this study population was 28.6%. It was observed that 14.3% developed superficial incisional SSI, 5.2% developed deep incisional SSI and 9.1% developed organ/deep space infection. The clinical characteristics of the included population and their association with SSI is summarized in (Table 4). ASA grade 2 consisted of 42.9% patients and highest rate of SSI was observed in the ASA grade 3 group. BMI ranged between 15.82 to 34.08. 26 patients (33.8%) were obese and among this, 8 patients (30.8%) developed SSI. The distribution of SSI in surgical approach was noted to be highest in the open group (50%) and lowest among the robotic group (22.7%).

The rate of Superficial incisional SSI among open, laparoscopic and robotic approach was as follows: 36.4%, 50%, 71.4% respectively. The rate of deep incisional SSI among open, laparoscopic and robotic approach was as follows: 45.5%, 25%, 0% respectively. The rate of Organ/deep SSI among open, laparoscopic and robotic approach was as follows: 18.2%, 25%, 28.6% respectively. However, all the above findings were not statistically significant ($p>0.05$). Of the 77, 8 (10.4%) patients underwent emergency colorectal surgery. 22.7% among the group with emergency surgery developed SSI and 5.5% among the group with elective surgery developed SSI. In the emergency group, 1 developed superficial SSI, 1 developed deep incisional SSI and 3 developed organ/ deep SSI, 12.5%, 12.5%, 37.5% respectively. The association of urgency of surgery with SSI was statistically significant ($p<0.05$). The rate of SSI for NNIS risk score 0 was 22.7%, for score 1 was 50%, score 2 was 27.3% and none for score 3. The rate of SSI for COLA score 0,1,2,3,4 was 13.6%, 40.9%, 18.2%, 22.7% and 4.5% respectively. Area under the curve (AUC) for NNIS score was 0.645 (95% CI: 0.510-0.781, $p<0.05$) and 0.611 for the COLA score. (95% CI: 0.472-0.750, $p>0.05$).

DISCUSSION

Impact of SSI

Surgical site infections are defined as infections occurring within 30 days after a surgical operation and affecting either the incision or deep tissue at the operation site. These infections may be superficial or deep incisional infections, or infections involving organs or body spaces.[11] SSIs account for 20% of all HAIs in hospitalized patients and are one among the most common hospital acquired infections among surgical patients.[12] SSIs may be of even greater consequence in developing countries including India, because surveillance rates of SSI in a study conducted by the

International Nosocomial Infection Control Consortium were higher for most surgical procedures compared with CDC-NHSN rates.[13,14] Colorectal surgical patients are at a higher risk of SSI. SSI has been highly correlated with post-operative morbidity resulting in increased hospital length of stay and post-operative mortality.[15,16] In 2004, Nespoli et al reported that the survival rates in patients who underwent surgery for removal of colon cancer were reduced in the presence of a surgical wound infection.[17] Thus, SSI negatively impacts the patient's quality of life and adds to the financial burden of healthcare in treating such infections as demonstrated by several studies.[18-20]

NNIS risk index

ASA grade, surgical wound class, procedure duration, age, body mass index (BMI) is among the colorectal SSI risk factors identified by the National Health and Safety Network (NHSN).[21] Several of these risk factors have been used to construct predictive scores to identify and quantify risk of SSI so that preventive measures can be directed effectively to improve patient outcome post operatively. One such score formulated for SSI prediction was NNIS risk index. NNIS risk index is not specific for colorectal procedures, rather it is a generic score applied to a wide range of surgical procedures.[22]

COLA score

The newer scoring system COLA was developed for colorectal procedures. When compared with NNIS risk index, the COLA score comprises of ASA grade, wound contamination (common to both the scores) and two other procedure specific risk factors - Obesity and surgical approach (laparoscopy versus open).

ASA grade and SSI

It was observed that rate of SSI was highest 40.0% in the ASA 3 group but not statistically significant. This finding was consistent with the finding of ASA >3 associated with increased risk of SSI as shown in the study by Watanabe et al.[23]

Wound contamination and SSI

Due to the inherent likelihood of microbial contamination at the operative site, large bowel surgeries are plagued by surgical site infection complicating the post-operative period. The 2014-2015 report on Surveillance of Surgical Site Infections in NHS Hospitals in England, published by Public Health England, reported colorectal surgery as the type of surgery with the highest risk of SSIs, with cumulative incidence risk in the last 5 years at 10.4%.[24] Among the study population, 84.4% had clean-contaminated wound, 1.3% had contaminated wound and 14.3% had dirty wound. 36.4% of dirty wounds developed infection. 27.7% of clean- contaminated wounds developed SSI. Thus, it was evident that SSI was higher with higher wound contamination.

BMI and SSI

Using a multicenter database of the Swiss association of laparoscopic and thoracoscopic surgery, Kurmann et al. investigated the risk factors for SSI in laparoscopic sigmoid resection for benign disease and found that operation time >40 min, BMI ≥27 kg/m^2 were significant risk factors for SSI in those patients.[25] Gurunathan et al further validated obesity as a risk factor through their meta-analysis among colorectal surgery patients and concluded that Overweight and obese patients carried at least 20% and 50% higher odds of developing SSI after colorectal surgery compared to normal weight patients, respectively.[26] In this study, ethnic specific criteria for classification of BMI were utilized. According to this revised consensus guidelines, BMI more than 25 was considered as obese.[8] Higher BMI was associated with higher incidence of SSI in this study.

Surgical approach and SSI

Regarding the surgical approach among the colorectal patients in this study, 41.6% (32) underwent open surgery while the remaining 58.4% (45) underwent minimally invasive approach (16.88% in robotic, 41.56% in laparoscopic). This is similar to the cohort in the study conducted by Bergquist et al.[27] It was observed that the distribution of SSI in surgical approach was noted to be highest in the open group (50%) and lowest among the robotic group (22.7%).

COLA and SSI

Saylam et al conducted a study among 92 patients to validate the COLA score for rectal surgery. In their study, SSI rates were 14.2%, 20.5%, 40.7%, 57.1% for COLA 1, 2, 3 and 4 scores respectively. The authors concluded that COLA scoring system showed good predictive power to detect patients with SSI. [(10)] A study among 534 patients undergoing colorectal surgery concluded that COLA score is at least as accurate as NNIS risk index. [(5)] Another study with a larger population size of 2376 colorectal surgical patients concluded that the predictive models did not accurately predict SSI.[27] These conflicting conclusions led to questioning the utility of such scoring systems.

What our study says

In this study, these scoring systems were utilized to predict SSI among the colorectal surgical patients to find out their accuracy, (Figure 1) depicts the ROC curve which summarizes the performance of NNIS risk index and COLA score. AUC is an effective way to summarise overall diagnostic accuracy of a test. It takes value between 0 and 1, where 1 reflects perfect accuracy and 0 reflects perfectly inaccurate test. In general, an AUC of 0.5 suggests no discrimination, 0.7 to 0.8 considered acceptable, more than 0.9 considered outstanding.[28] Area under the curve (AUC) for NNIS score was 0.645 (95%

CI: 0.510-0.781, p <0.05) and 0.611 for the COLA score. (95% CI: 0.472–0.750, p>0.05). Therefore, both these scores have less than acceptable accuracy in this data set to predict SSI. The types of SSI (superficial, deep, organ space) are described as actually distinct disease processes with their own driving factors and hence a single risk model may not accurately predict the SSI risk. Although, statistically NNIS and COLA scores do not have perfect accuracy, they are simple scoring systems which can be applied clinically with ease. Since prevention is preparedness in SSI, these scores still have a role till a more accurate prediction model is formulated. Continued wound surveillance in patients with risk factors of SSI undergoing colorectal surgery plays a vital role. Our study included elective and emergency cases but one limitation of this study is the small sample as it is a single centred study.

CONCLUSION

Both the predictive scoring systems, NNIS risk index and COLA score, have limited ability to accurately predict SSI in this independent data. However, they are simple to use clinically and shall remain to be useful till a more accurate prediction model is formulated.

ACKNOWLEDGEMENTS

Authors are grateful to their institution and mentors for their support. Authors would also like to thank Dr. Chelsia Chelladurai for her help in statistical analysis.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Robinson E, Rajkumar KS. NNIS risk score or COLA score: which predicts better the risk of surgical site infection among patients undergoing colorectal resection in a tertiary care hospital setting?. Int Surg J 2022;9:2003-9.