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Using the National Nosocomial Infections Surveillance risk index to determine risk factors associated with surgical site infections following gynecologic surgeries

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ABSTRACT

Objectives: We used the National Nosocomial Infections Surveillance (NNIS) risk index to determine risk factors associated with surgical site infections (SSIs) following gynecologic surgeries.

Material and methods: A retrospective study was conducted based on the medical records of 185 patients with SSIs, following gynecologic surgeries at a Grade A tertiary gynecologic and obstetric hospital in southwest China during September 2013–June 2021.

Results: Suspected risk factors associated with SSIs were: length of hospital stay, age, whether the patient had cancer, whether the patient had chemotherapy or high-dose antibiotic

therapy before surgery, duration of surgery, amount of blood loss, and whether a blood transfusion was done. It was found that SSIs were more likely to occur in cancer patients with an NNIS risk index score of 1 and in patients with preoperative chemotherapy and an NNIS risk index score of 2. Among the patients with an NNIS risk index score of 2, the older the patient, the higher incidence of SSIs.

Conclusions: Gynecologic surgery teams should pay more attention to the independent risk factors associated with SSIs determined by the NNIS risk index score to prevent SSIs following gynecologic surgeries, thus ensuring patient safety.

Key words: gynecology; surgical wound infection; risk factors

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INTRODUCTION

Surgical site infections (SSIs) are one of the most common nosocomial infections. SSI rates rank 2nd among nosocomial infections in Europe [1]. The rates of SSIs in patients following gynecologic and obstetric surgeries and laparoscopic gynecologic surgeries in China are 4.62% and 4.3%, respectively [2]. Following abdominal hysterectomies in the United States the rate is 6.18% [3]. Wan et al. [4] and Gu et al. [5] reported that SSI ranked 1st among infections after gynecologic and obstetric surgeries.

The National Nosocomial Infections Surveillance (NNIS) system is a helpful tool for predicting the incidence of SSIs. This study aimed to use the NNIS risk index to determine risk factors associated with SSIs following gynecologic surgeries.

MATERIAL AND METHODS

Study setting

This is a retrospective study based on the medical records of the patients. A total of 185 patients with SSIs, following gynecologic surgeries at a Grade A tertiary gynecologic and obstetric hospital in southwest China during September 2013–June 2021, were included in this study. Patients who underwent abdominal, transvaginal or laparoscopic surgery (including single-incision laparoscopic surgery) were included in this study. The exclusion criteria were as follows: (1) patients having transvaginal cervical or hysteroscopic surgery; (2) patients having preoperative infection; (3) patient having more than 30 days of hospital stay before surgery; (4) patients who were admitted to hospital for a second surgery; (5) patients who were transferred to an intensive care unit after surgery; or (6) patients who had no implant placed but had an incisional infection after 30 days following the surgery.

Study tools

Wound drainage samples were inoculated in conformity with China's National Guide to Clinical Laboratory Procedures. Pathogenic bacteria were identified from positive samples using VITEK® 2 Compact, a mass spectrometry microbial identification system manufactured by bioMérieux France.

Diagnosis criteria for SSIs and assessment of wound healing were subject to Diagnostic Criteria for Nosocomial Infections (Proposed) [6] issued by the Ministry of Health, the People's Republic of China, and The Hospital Statistics and the Grades of Healing of Incision [7].

The preoperative, intraoperative, and postoperative factors that may be associated with SSIs in patients following gynecologic surgeries were monitored using the following indicators: (1) *Patient information*: age, body mass index, length of hospital stay, history of previous abdominal surgery, whether the patient had heart disease, hypertension, diabetes mellitus, cancer, or malnutrition; (2) *Preoperative*: NNIS risk index score, anemia, white blood cell count and hemoglobin level, whether the patient had high-dose antibiotic therapy or chemotherapy, whether skin preparation was performed, and surgical wound class; (3) *Intraoperative*: type of anesthesia, duration of surgery, amount of blood loss, and whether

blood transfusion was used for the patient; (4) *Postoperative*: whether a wound drainage tube was inserted, and whether delayed suturing was used.

Data collection

Researchers collected data from the medical records of 185 patients. Researchers checked the data after data collection.

Statistical analysis

Data were analyzed using SPSS23.0. Classified variables were performed with the Wilcoxon rank sum test in single-factor analysis. Continuous variables that were normally distributed were analyzed with one-way analysis of variance. Continuous variables that were not normally distributed were analyzed with non-parametric tests on k-independent samples. Data with a p-value less than 0.05 were analyzed with multivariate logistic regression analysis. A statistically significant difference was defined as $p < 0.05$.

RESULTS

Incision data

Of the 185 gynecologic patients, 164 (88.65%), 11 (5.95%), and 10 (5.40%) underwent abdominal, transvaginal, and laparoscopic surgeries respectively. Superficial incisional, deep incisional, and organ/space SSI rates were 90.81% (168/185), 7.03 (13/185), and 2.16% (4/185) respectively. SSI symptoms were as follows: redness (or local heat), bleeding, fluid or purulent drainage (or had foul smell) from the incision; a severe infection caused the presence of necrotic tissue in the wound or occurrence of a tunneling wound; and fever. Wound healing graded as good, fair, and poor accounted for 58.92% (109/185), 36.76% (68/185) and 4.32% (8/185) respectively (Tab. 1).

Pathogenic bacteria

Of the 185 patients, one patient had alleviated symptoms of SSI after physical therapy, so her wound drainage was not sampled. Specimens of drainage from infected wounds in the other 184 patients were delivered for laboratory testing. No pathogenic bacteria were found in

one specimen, and two pathogenic bacteria co-existed in 13 specimens. A total of 196 pathogenic bacteria were isolated. *Staphylococcus epidermidis*, *Enterococcus faecalis*, *Escherichia coli*, *Staphylococcus aureus*, and *Pseudomonas aeruginosa*, and other pathogenic bacteria accounted for 27.04% (53/196), 16.84% (33/196), 14.29% (28/196), 10.20% (20/196), 8.16% (16/196) and 23.47% (46/196) respectively. Of those, 2 drug-resistant *Staphylococcus aureus* were identified and did not respond to beta-lactamases (including enzyme inhibitors) (Tab. 2).

Single-factor analysis

The suspected factors associated with SSIs in patients following gynecologic surgeries were length of hospital stay, age, whether the patient had cancer, whether the patient had chemotherapy or high-dose antibiotic therapy before surgery, duration of surgery, amount of blood loss, and whether blood transfusion was used for the patient during surgery. A statistically significant difference ($p < 0.05$) was identified (Tab. 3).

Multivariate analysis

The suspected risk factors associated with SSIs that were identified in the single-factor analysis were analyzed with multivariate logistic regression analysis by taking an NNIS risk index score of 0 as a reference. A statistically significant difference ($p < 0.05$) was identified (Tab. 4).

The incidence of SSIs in cancer patients with an NNIS risk index score of 1 was 2.663 times higher than that in non-cancer patients with an NNIS risk index score of 1. SSIs were more likely to occur in cancer patients with an NNIS risk index score of 1 than in those with an NNIS risk index score of 0. The incidence of SSIs in patients with preoperative chemotherapy and an NNIS risk index score of 2 was 5.622 times higher than that in patients who were not given chemotherapy before surgery and had an NNIS risk index score of 2. SSIs were more likely to occur in patients with preoperative chemotherapy and an NNIS risk index score of 2 compared to those with preoperative chemotherapy but having an NNIS risk index score of 0. The older the patient, the higher the incidence of SSI in the patient with an NNIS risk index score of 2 ($p = 0.009 < 0.05$). The risk coefficient was $0.071 > 0$.

Taking an NNIS risk index score of 0 as a reference, SSIs were more likely to occur in cancer patients with an NNIS risk index score of 1 and patients having preoperative chemotherapy and an NNIS risk index score of 2. Among the patients with an NNIS risk index score of 2, the older the patient, the higher incidence of SSI.

DISCUSSION

The NNIS system was established in the United States. It is a tool used to predict the incidence of SSIs in patients. The application of the NNIS system in predicting the incidence of SSIs after laparoscopic surgeries has been widely studied [8]. The Chinese Hospital Association advocated the use of the Surgical Safety Checklist and NNIS in 2009 [9], and the NNIS has been widely used in China since 2010 [10]. The NNIS risk index contains three components: surgical wound classification, American Society of Anesthesiologists physical status classification, and duration of surgery [8, 9]. The NNIS risk index score ranges from 0 to 3. Patient scored 1 for each of the three conditions: surgical wound class ≥ Class II (clean-contaminated), American Society of Anesthesiologists class ≥ P3 (a patient with severe systemic disease), and duration of surgery > 3 hours.

Taking an NNIS risk index score of 0 as a reference, this study shows that having cancer and an NNIS risk index score of 1, having preoperative chemotherapy and an NNIS risk index score of 2, and higher age, were the independent risk factors associated with the incidence of SSIs in patients following gynecologic surgeries. However, statistically significant differences were found in two indicators in patients with an NNIS risk index score of 2 and no statistically significant differences were found in the indicators in patients with an NNIS risk index score of 3. This was because the patients with NNIS risk index scores of 2 and 3 in this study in this study accounted for a low proportion: 13.51% (25/185) and 3.78% (7/185) respectively. The results of Ercole et al. [11] show that applicability of the NNIS risk index in SSIs is limited, so perhaps the indicators were not independent risk factors associated with SSIs. The results of Biscione et al. [12] show that extended scores can improve NNIS risk index's calibration. Wang et al. [13] found that the logistic and Poisson regression risk models are superior to the NNIS risk index model in the prediction of SSIs after cesarean section. A

large sample size (especially patients with NNIS risk index scores of 2 and 3) or a multi-center study will be needed for future research on the correlation between NNIS risk index scores and the incidence of SSIs in patients following gynecologic surgeries.

CONCLUSIONS

Gynecologic surgery team should pay more attention to the independent risk factors associated with SSIs determined by the NNIS risk index score to prevent SSIs following gynecologic surgeries, thus ensuring patient safety.

Article information and declarations

Ethics statement

This is a retrospective study based on medical records of the patients. Ethics approval is not needed for retrospective study.

Author contributions

JD designed the study. DW, JW and ML carried out the data collection. DW and JW carried out the data analysis. DW and ML drafted the manuscript. JW, JD, JR, and ZY revised the manuscript. All the authors read and approved the final manuscript.

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Conflict of interest

All authors declare that they have no conflicts of interest.

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Table 1. NNIS risk index scores of the gynecologic patients

	NNIS risk index score of 0	NNIS risk index score of 1	NNIS risk index score of 2	NNIS risk index score of 3
Surgical procedures				
Abdominal	42.68% (70/164)	42.07% (69/164)	12.20% (20/164)	3.05% (5/164)
Transvaginal	27.27% (3/11)	36.36% (4/11)	18.18% (2/11)	18.18% (2/11)
Laparoscopic	50.00% (5/10)	20.00% (2/10)	30.00% (3/10)	0.00% (0/10)
Site of infections				
Superficial incisions	43.45% (73/168)	41.07% (69/168)	11.90% (20/168)	3.57% (6/168)
Deep incisions	30.77% (4/13)	38.46% (5/13)	23.08% (3/13)	7.69% (1/13)
Organ/space incisions	25.00% (1/4)	25.00% (1/4)	50.00% (2/4)	0.00% (0/4)
Wood healing				
Good	42.20% (46/109)	35.78% (39/109)	16.51% (18/109)	5.50% (6/109)
Fair	42.65% (29/68)	47.06% (32/68)	8.82% (6/68)	1.47% (1/68)
Poor	37.50% (3/8)	50.00% (4/8)	12.50% (1/8)	0.00% (0/8)

Table 2. Constituent ratio of pathogenic bacteria in infected wounds

Pathogenic bacteria	Stain (n = 196)	Constituent ratio (%)
Staphylococcus epidermidis	53	27.04%
Enterococcus faecalis	33	16.84%
Escherichia coli	28	14.29%
Staphylococcus aureus	20	10.20%
Pseudomonas aeruginosa	16	8.16%
Coagulase-negative staphylococci	9	4.59%
Klebsiella pneumoniae	6	3.06%
Enterobacter aerogenies	5	2.55%
Staphylococcus lugdunensis	4	2.04%
Monilia albican	3	1.53%
Enterococcus faecium	3	1.53%
Morganella morganii subspecies	2	1.02%
Proteus mirabilis	2	1.02%
Enterobacter cloacae	2	1.02%
Others	10	5.10%
Total	196	100%

Table 3. Single-factor analysis of surgical site infections

Indicators		NNIS score of 0	NNIS score of 1	NNIS score of 2	NNIS score of 3	χ^2/Z	P
Age△		43.30 ± 11.14	43.48 ± 11.57	55.08 ± 10.80	54.86 ± 14.37	9.228	< 0.001*
Body mass index#		24.44 (23.34~26.67)	24.84 (21.64~27.89)	24.14 (22.03~26.36)	23.81 (21.23~25.89)	1.26	0.74
Length of hospital stay#		19.00 (15.00~24.00)	19.00 (15.00~26.00)	28 (19.50~32.00)	22.00 (14.00~35.00)	12.94	0.01*
Preoperative white blood cell count#		6.80 (5.68~8.45)	6.80 (5.60~8.50)	6.90 (5.80~9.15)	6.80 (4.80~8.60)	0.30	0.96
Preoperative hemoglobin level#		129.00 (119.00~135.25)	129.00 (114.00~137.00)	121.00 (103.50~130.50)	128.00 (120.00~136.00)	5.29	0.15
Prior abdominal surgery	Yes	18 (37.50%)	20 (41.67%)	8 (16.67%)	2 (4.17%)	–0.877	0.381
	No	60 (43.80%)	55 (40.15%)	17 (12.41%)	5 (3.65%)		
Heart disease	Yes	1 (20.00%)	2 (40.00%)	1 (20.00%)	1 (20.00%)	–1.414	0.157
	No	77 (42.78%)	73 (40.56%)	24 (13.33%)	6 (3.33%)		
Hypertension	Yes	9 (32.14%)	12 (42.86%)	5 (17.86%)	2 (7.14%)	–1.398	0.162

	No	69 (43.95%)	63 (40.13%)	20 (12.74%)	5 (3.18%)		
Diabetes	Yes	8 (44.44%)	5 (27.78%)	4 (22.22%)	1 (5.56%)	–0.341	0.733
mellitus	No	70 (41.92%)	70 (41.92%)	21 (12.57%)	6 (3.59%)		
Cancer	Yes	37 (30.58%)	55 (45.45%)	22 (18.18%)	7 (5.79%)	–4.725	< 0.001*
	No	41 (64.06%)	20 (31.25%)	3 (4.69%)	0 (0.00%)		
Malnutrition	Yes	1 (50.00%)	1 (50.00%)	0 (0.00%)	0 (0.00%)	–0.438	0.662
	No	77 (42.08%)	74 (40.44%)	25 (13.66%)	7 (3.83%)		
Anemia	Yes	11 (33.33%)	13 (39.39%)	8 (24.24%)	1 (3.03%)	–1.487	0.137
	No	67 (44.08%)	62 (40.79%)	17 (11.18%)	6 (3.95%)		
High-dose	Yes	0 (0.00%)	1 (33.33%)	2 (66.67%)	0 (0.00%)	–1.986	0.047*
antibiotic therapy before surgery	No	78 (42.86%)	74 (40.66%)	23 (12.64%)	7 (3.85%)		
Preoperative	Yes	6 (17.14%)	16 (45.71%)	10 (28.57%)	3 (8.57%)	–3.956	< 0.001*
chemotherapy	No	72 (48.00%)	59 (39.33%)	15 (10.00%)	4 (2.67%)		
Preoperative	Yes	75 (41.90%)	74 (41.34%)	24 (13.41%)	6 (3.35%)	–0.205	0.837
skin preparation	No	3 (50.00%)	1 (16.67%)	1 (16.67%)	1 (16.67%)		
Surgical	Class I	3 (75.00%)	1 (25.00%)	0 (0.00%)	0 (0.00%)	3.691	0.158
wound	Class II	73 (41.95%)	72 (41.38%)	23 (13.22%)	6 (3.45%)		
classification	Class III	2 (28.57%)	2 (28.57%)	2 (28.57%)	1 (14.29%)		
Type of	General	74 (41.81%)	72 (40.68%)	25 (14.12%)	6 (3.39%)	1.029	0.598
anesthesia	anesthesia						
	Combined spinal and epidural anaesthesia	2 (40.00%)	2 (40.00%)	0 (0.00%)	1 (20.00%)		
	Epidural anaesthetic	2 (66.67%)	1 (33.33%)	0 (0.00%)	0 (0.00%)		
Duration of	≥ 180 min	45 (34.35%)	56 (42.75%)	23 (17.56%)	7 (5.34%)	–3.860	< 0.001*
surgery	< 180 min	33 (61.11%)	19 (35.19%)	2 (3.70%)	0 (0.00%)		
	≥ 500 mL	27 (33.75%)	36 (45.00%)	13 (16.25%)	4 (5.00%)	–2.062	0.039*

Amount of blood loss during surgery	< 500 mL	51 (48.57%)	39 (37.14%)	12 (11.43%)	3 (2.86%)		
Blood transfusion during surgery	Yes	8 (25.81%)	14 (45.16%)	7 (22.58%)	2 (6.45%)	–2.317	0.021*
	No	70 (45.45%)	61 (39.61%)	18 (11.69%)	5 (3.25%)		
Wound drainage tube insertion after surgery	Yes	77 (42.08%)	74 (40.44%)	25 (13.66%)	7 (3.83%)	–0.438	0.662
	No	1 (50.00%)	1 (50.00%)	0 (0.00%)	0 (0.00%)		
Delayed suture to close the wound	Yes	6 (66.67%)	2 (22.22%)	1 (11.11%)	0 (0.00%)	–1.393	0.163
	No	72 (40.91%)	73 (41.48%)	24 (13.64%)	7 (3.98%)		

*p < 0.05; #Non-normal distribution after Skewness-Kurtosis normality test; △Normal distribution after Skewness-Kurtosis normality test

Table 4. Multivariate logistic regression analysis of suspected risk factors associated with surgical site infections — taking NNIS risk index score of 0 as a reference

NNIS[a]	Suspected risk factors	B	Standard error	Wald	Degree of freedom	p	Odds ratio	95% confidence interval for the odds ratio	
								Lower limit	Upper limit
Score of 1	Intercept	0.013	0.812	0.000	1	0.987			
	Length of hospital stay	–0.010	0.026	0.152	1	0.696	0.990	0.940	1.042
	Age	–0.018	0.017	1.210	1	0.271	0.982	0.950	1.014
	Cancer (no)	0.979	0.472	4.302	1	0.038	2.663	1.055	6.719
	Preoperative chemotherapy (no)	0.718	0.543	1.749	1	0.186	2.050	0.707	5.942

	High-dose antibiotic therapy before surgery (no)	16.706	4446.713	.000	1	0.997	17998276.523	0.000	.[b]
	Duration of surgery ≥ 180 min (< 180 min)	0.266	0.463	0.330	1	0.566	1.305	0.527	3.232
	Blood loss ≥ 500 m (< 500 mL)	–0.034	0.437	0.006	1	0.938	0.966	0.411	2.275
	Blood transfusion (no)	0.603	0.571	1.117	1	0.291	1.829	0.597	5.600
Score of 2	Intercept	–7.478	1.648	20.579	1	0.000			
	Length of hospital stay	0.049	0.036	1.820	1	0.177	1.050	0.978	1.127
	Age	0.071	0.027	6.855	1	0.009	1.074	1.018	1.133
	Cancer (no)	0.070	0.821	0.007	1	0.932	1.072	0.215	5.360
	Preoperative chemotherapy (no)	1.727	0.686	6.327	1	0.012	5.622	1.464	21.586
	High-dose antibiotic therapy before surgery (no)	16.797	4446.713	0.000	1	0.997	19708794.152	0.000	.[b]
	Duration of surgery ≥ 180 min (< 180 min)	1.246	0.937	1.770	1	0.183	3.478	0.554	21.817
	Blood loss ≥ 500 mL (< 500 mL)	0.303	0.717	0.179	1	0.672	1.354	0.332	5.518
	Blood transfusion (no)	0.676	0.823	0.675	1	0.411	1.966	0.392	9.873
Score of 3	Intercept	–26.561	184.070	0.021	1	0.885			
	Length of hospital stay	0.079	0.055	2.048	1	0.152	1.082	0.971	1.205
	Age	0.066	0.042	2.459	1	0.117	1.068	0.984	1.160
	Cancer (no)	9.486	128.652	0.005	1	0.941	13179.207	4.085E–106	4.252E+113
	Preoperative chemotherapy (no)	1.287	1.010	1.624	1	0.202	3.623	0.500	26.232
	High-dose antibiotic therapy before surgery (no)	–1.910	0.000	.	1		0.148	0.148	0.148
	Duration of surgery ≥ 180 min (< 180 min)	9.317	131.645	0.005	1	0.944	11123.681	9.766E–109	1.267E+116
	Blood loss ≥ 500 mL (< 500 mL)	0.700	1.183	0.350	1	0.554	2.014	0.198	20.474
	Blood transfusion (no)	0.779	1.191	0.428	1	0.513	2.180	0.211	22.523

[a]Reference category: NNIS risk index score of 0; [b]A floating point overflow occurred while evaluating this statistic. Therefore, its value was set to a system missing value