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A Retrospective Study from 2 Tertiary Hospitals in China to Evaluate the Risk Factors for Surgical Site Infections After Abdominal Hysterectomy in 188 Patients

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Manuscript Preparation E
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Conflict of interest: None declared

Background: Surgical site infections in patients after abdominal hysterectomy can increase medical expenses and increase the risk of death in patients. This retrospective study from 2 grade A tertiary hospitals in China aimed to evaluate the risk factors for postoperative surgical site infections (SSIs) in 188 patients undergoing abdominal hysterectomy between September 2013 and June 2021.


Material/Methods: Of the 188 patients, 94 patients with SSIs were classified into the infected group, and 94 patients without SSIs were classified into the control group. Wound drainage was sampled for bacterial isolation and culture.

Results: The suspected risk factors for SSIs after abdominal hysterectomy were body mass index, whether the patient had comorbidities of diabetes mellitus, cancer, or hypoproteinemia, surgical wound classification, whether preoperative skin preparation was performed, whether the patient had chemotherapy, length of incision, amount of blood loss during surgery, duration of surgery, necessity of a second surgery, whether a wound drainage tube was inserted, and whether delayed suturing was used in wound. Of them, body mass index (OR=1.133; 95% CI: 1.012~1.266; $P=0.029$), more than 3 hours of surgery (OR=0.261; 95% CI: 0.108~0.631; $P=0.003$), and wound drainage tube insertion (OR=0.223; 95% CI: 0.094~0.531; $P=0.001$) were the independent risk factors.

Conclusions: The findings support previous studies and showed that risk factors for SSIs after abdominal hysterectomy included increased patient BMI, increased operation duration, and the number of surgical drainage tubes used.

Keywords: **Gynecology • Hysterectomy • Laparotomy • Risk Factors • Surgical Wound Infection**

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Background

Hysterectomy is one of the most common surgical procedures performed for women [1].

A woman's risk of having a hysterectomy in her lifetime is around 45% [2]. Laparotomy, which requires a wide view of the surgical area and exposure of pelvic anatomy, has been commonly used to treat gynecologic malignant tumors such as uterine, endometrial, and ovarian cancer [3].

A recent study has shown that the incidence rate of surgical site infections after hysterectomy is 6.18-9.61% [4,5]. High body mass index, the amount of blood loss during surgery, low hematocrit levels, and anemia can increase the incidence of surgical site infections after hysterectomy [6]. Among the different types of hysterectomy, laparoscopic hysterectomy results in lower rates of surgical site infections compared with abdominal hysterectomy and vaginal hysterectomy [6]. Surgical site infections not only increase medical expenses, including the surgery and drug costs [7], but also increase the morbidity, mortality, and readmission rates [1]. Therefore, this retrospective study from 2 grade A tertiary hospitals in China aimed to evaluate the risk factors for postoperative surgical site infections in 188 patients undergoing abdominal hysterectomy between September 2013 and June 2021.

Material and Methods

Ethics Approval

This study was carried out in accordance with the Declaration of Helsinki. Ethics approval of this study was received from the Medical Ethics Committee of West China Second University Hospital, Sichuan University (No. YXKY2021LSP [178]). Before the research procedures started, the patients were verbally informed of the purpose and significance of this study and were asked to give us voluntary consent to collect their data for this study. The verbal informed consent process was witnessed by the head nurse of the Gynecology Department. Verbal informed consent was obtained from all patients included in this study. The verbal informed process was approved by the Medical Ethics Committee of West China Second University Hospital, Sichuan University. Data collected were confidential and used only by this study.

Study Setting

A total of 188 patients undergoing abdominal hysterectomy at 2 grade A tertiary hospitals in China between September 2013 and June 2021 were included in this study.

Inclusion criteria were: (1) elective surgery; (2) general anesthesia; (3) Class II surgical wound; (4) abdominal hysterectomy; and (5) preoperative prediction showed that status of wound healing would be good.

Exclusion criteria were: (1) obstetric patients having abdominal procedure for gynecological diseases; (2) patients having multi-incision/single-incision laparoscopic hysterectomy; or (3) patients having vaginal hysterectomy and preoperative infection.

Study Tools

Of the 188 patients, 94 patients with surgical site infections were classified into the infected group, and 94 patients without surgical site infections were classified into the control group. Wound drainage samples were inoculated on blood agar plates, MacConkey agar plates, and Sabouraud's medium produced by Guangzhou Detgerm Microbiological Science, Ltd., China. Bacterial isolation and culture were performed according to the China's National Guide to Clinical Laboratory Procedures. VITEK® 2 Compact, which is a mass spectrometry microbial identification system produced by bioMérieux France, was used to identify pathogenic bacteria from positive samples.

Surgical wound healing and infection were identified according to surgical wound healing status, hospital statistics [8], and the Identifying Criteria for Nosocomial Infection (Tentative) issued by the National Health Commission of the People's Republic of China [9].

High-risk factors for surgical site infections in this study were monitored using the following indicators: age, body mass index (BMI), whether the patient had comorbidities of heart disease, hypertension, diabetes mellitus, cancer, malnutrition, anemia, or hypoproteinemia, preoperative white blood cell count and hemoglobin level, surgical wound classification, whether preoperative skin preparation was performed, whether the patient had chemotherapy, prior abdominal surgery or high-dose antibiotic therapy, length of incision, amount of blood loss during surgery, duration of surgery, necessity of a second surgery, whether a wound drainage tube was inserted, and whether delayed suturing was used.

Data Collection

Data were collected by the researchers from the patients' medical records. The researchers had more than 7 years of clinical experience in obstetrics and gynecology and more than 4 years of experience in nosocomial infection control.

Statistical Analysis

Data were analyzed using SPSS19.0. The incidence of surgical site infections was expressed with n (%). If continuous variables

Table 1. Superficial incisional, deep incisional, and organ/space surgical site infection rates in patients after abdominal surgery.

	Superficial incisional surgical site infection rate (n=88)	Deep incisional surgical site infection rate (n=5)	Organ/space surgical site infection rate (n=1)
Surgical procedures			
Total abdominal hysterectomy	6.82% (6/88)		
Extr fascial abdominal hysterectomy	34.09% (30/88)	20.00% (1/5)	100.00% (1/1)
Abdominal radical hysterectomy	38.64% (34/88)	80% (4/5)	
Abdominal modified radical hysterectomy	18.18 (16/88)		
Conversion to laparotomy during the laparoscopic hysterectomy	2.27% (2/88)		
Wound healing grade			
Good	64.77% (57/88)	40.00% (2/5)	100.00% (1/1)
Fair	31.82% (28/88)	60.00% (3/5)	
Poor	3.41% (3/88)		

were found to not be normally distributed after normality test in single-factor analysis, then non-parametric tests on 2 independent groups were used. Classified variables were performed with the chi-square (χ^2) test. Data with a *P* value less than 0.1 were analyzed with multivariate binary logistic regression analysis. A statistically significant difference was defined as *P*<0.05.

Results

Clinical Data of Patients Undergoing Abdominal Hysterectomy

Symptoms of surgical site infections in the 94 patients after abdominal hysterectomy were as follows: redness, swelling, pain, bleeding, fluid or purulent drainage (or had foul smell) from the incision; serious infection can cause the presence of necrotic tissue in the wound, poor wound healing, or occurrence of a tunneling wound. The average age of the 94 patients with surgical site infections was 46.57 ± 8.86 , and the quartiles of their inpatient days were 20 (15.75-24.25) days. Superficial incisional, deep incisional, and organ/space surgical site infection rates were 93.62% (88/94), 5.32% (5/94), and 1.06% (1/94), respectively. Most of the superficial incisional surgical site infections occurred after radical hysterectomy and extrafascial hysterectomy, and wound healing was mainly graded as good; most of the deep incisional surgical site infections occurred after radical hysterectomy and wound healing was mainly graded as fair; and most of the organ/space surgical site infections occurred after extrafascial hysterectomy and wound healing was mainly graded as good, as shown in **Table 1**.

Table 2. Constituent ratio of pathogenic bacteria in infected wounds in patients after abdominal hysterectomy.

Pathogenic bacteria	Strain (n=99)	Constituent ratio (%)
<i>Staphylococcus epidermidis</i>	37	37.37%
<i>Enterococcus faecalis</i>	19	19.19%
<i>Escherichia coli</i>	11	11.11%
<i>Staphylococcus aureus</i>	7	7.07%
<i>Pseudomonas aeruginosa</i>	6	6.06%
<i>Enterobacter aerogenes</i>	4	4.04%
<i>Coagulase-negative staphylococci</i>	4	4.04%
<i>Klebsiella pneumoniae</i>	3	3.03%
<i>Enterococcus faecium</i>	2	2.02%
Others	6	6.06%
Total	99	100%

Pathogenic Bacteria Causing Surgical Site Infections

Specimens of drainage from infected wounds in the 94 patients after abdominal hysterectomy were delivered for laboratory testing. A total of 99 pathogenic bacteria were isolated. *Staphylococcus epidermidis*, *Enterococcus faecalis*, *Escherichia coli*, *Staphylococcus aureus*, and *Pseudomonas aeruginosa*, which accounted for 37.37% (37/99), 19.19% (10/99), 11.11%

Table 3. Single-factor analysis of possible high-risk factors for surgical site infections in patients after abdominal hysterectomy.

		Not infected (n=94)	Infected (n=94)	χ^2/Z	P
Age	>50	35 (58.33%)	25 (41.67%)	2.448	0.118
	≤50	59 (46.09%)	69 (53.91%)		
Body mass index*		23.44 (21.92~25.02)	24.63 (21.93~26.59)	-2.183	0.029**
Heart disease	Yes	2 (66.67%)	1 (33.33%)	0.339	0.561
	No	92 (49.73%)	93 (50.27%)		
Hypertension	Yes	12 (52.17%)	11 (47.83%)	0.050	0.824
	No	82 (49.70%)	83 (50.30%)		
Diabetes mellitus	Yes	2 (18.18%)	9 (81.82%)	4.731	0.030**
	No	92 (51.98%)	85 (48.02%)		
Cancer	Yes	61 (43.57%)	79 (56.43%)	9.064	0.003**
	No	33 (68.75%)	15 (31.25%)		
Malnutrition	Yes	0 (0.00%)	2 (100.00%)	2.022	0.155
	No	94 (49.46%)	92 (50.54%)		
Anemia	Yes	15 (42.86%)	20 (57.14%)	0.878	0.349
	No	79 (51.63%)	74 (48.37%)		
Hypoproteinemia	Yes	0 (0.00%)	4 (100.00%)	4.087	0.043**
	No	94 (51.09%)	90 (48.91%)		
Preoperative white blood cell count*		6.4 (5.20~7.73)	6.9 (5.70~8.25)	-1.563	0.118
Preoperative haemoglobin level*		129 (117.75~138.00)	127.50 (113.75~136.00)	-0.720	0.472
Surgical wound classification	Class III	0 (0.00%)	3 (100.00%)	3.049	0.081**
	Class II	94 (50.81%)	91 (49.19%)		
Preoperative skin preparation	Yes	94 (50.81%)	91 (49.19%)	3.049	0.081**
	No	0 (0.00%)	3 (100.00%)		
Preoperative chemotherapy	Yes	9 (27.27%)	24 (72.73%)	8.270	0.004**
	No	85 (54.84%)	70 (45.16%)		
Prior abdominal surgery	Yes	17 (44.74%)	21 (55.26%)	0.528	0.468
	No	77 (51.33%)	73 (48.67%)		
High-dose antibiotic therapy before surgery	Yes	0 (0.00%)	1 (100.00%)	1.005	0.316
	No	94 (50.27%)	93 (49.73%)		
Length of incision*		15.00 (10.00~20.00)	20.00 (15.00~20.00)	-3.950	<0.001**
Blood loss	>500 ml	21 (34.43%)	40 (65.57%)	8.761	0.003**
	≤500ml	73 (57.48%)	54 (42.52%)		
Duration of surgery	>3 hours	45 (36.29%)	79 (63.71%)	27.385	<0.001**
	≤3 hours	49 (76.56%)	15 (23.44%)		

Table 3 continued. Single-factor analysis of possible high-risk factors for surgical site infections in patients after abdominal hysterectomy.

		Not infected (n=94)	Infected (n=94)	χ^2/Z	P
Necessity of a second surgery	Yes	0 (0.00%)	4 (100.00%)	4.087	0.043**
	No	94 (51.09%)	90 (48.91%)		
Wound drainage tube insertion	Yes	48 (37.21%)	81 (62.79%)	26.899	<0.001**
	No	46 (77.97%)	13 (22.03%)		
Delayed suture to close the wound	Yes	0 (0.00%)	4 (100.00%)	4.087	0.043**
	No	94 (51.09%)	90 (48.91%)		

* Non-normal distribution after normality test; ** $P < 0.1$.

Table 4. Binary logistic regression analysis of high-risk factors for surgical site infections in patients after abdominal hysterectomy.

	B	S.E.	P	OR	95% CI of EXP (B)	
					Lower limit	Upper limit
Constant	80.097	36893.362	0.998	6.108E34		
Body mass index	0.123	0.056	0.029	1.131	1.012	1.263
Diabetes mellitus (No)	-0.883	0.862	0.306	0.414	0.076	2.242
Cancer (No)	0.000	0.578	0.999	1.000	0.322	3.103
Hypoproteinemia (No)	-20.053	18822.220	0.999	0.000	0.000	
Surgical wound classification (Class II)	-20.809	20966.961	0.999	0.000	0.000	
Preoperative skin preparation (No)	21.600	22680.535	0.999	2.402	0.000	
Preoperative chemotherapy (No)	-0.673	0.503	0.181	0.510	0.190	1.367
Length of incision	0.020	0.047	0.678	1.020	0.929	1.119
Blood loss >500 ml (≤ 500 ml)	-0.013	0.415	0.975	0.987	0.437	2.228
Duration of surgery >3 hours (≤ 3 hours)	-1.343	0.451	0.003	0.261	0.108	0.631
Necessity of a second surgery (No)	-20.514	16803.325	0.999	0.000	0.000	
Wound drainage tube insertion after surgery (No)	-1.499	0.442	0.001	0.223	0.094	0.531
Delayed suture to close the wound (No)	-19.927	16878.417	0.999	0.000	0.000	

S.E. – standard error; OR – odds ratio; 95% CI – 95% confidence interval.

(11/99), 7.07% (7/99), and 6.06% (6/99), respectively, were the main pathogenic bacteria. Among them, 1 multidrug-resistant *Staphylococcus aureus* was found. Details are presented in **Table 2**.

Single-Factor Analysis of Possible High-Risk Factors for Surgical Site Infections in Patients After Abdominal Hysterectomy

Single-factor analysis was performed for the possible high-risk factors for surgical site infections in patients after abdominal hysterectomy. The suspected factors influencing surgical site infections in patients after abdominal hysterectomy were BMI, whether the patient had comorbidities of diabetes mellitus, cancer, or hypoproteinemia, surgical wound classification,

whether preoperative skin preparation was performed, whether the patient had chemotherapy, length of incision, the amount of blood loss during surgery, duration of surgery, necessity of a second surgery, whether a wound drainage tube was inserted, and whether delayed suturing was used. A statistically significant difference ($P < 0.1$) was found, as shown in **Table 3**.

Multivariate Analysis of Possible High-Risk Factors for Surgical Site Infections in Patients After Abdominal Hysterectomy

The suspected factors influencing surgical site infections in the single-factor analysis were considered as the independent variables in the binary logistic regression analysis. The

results showed that BMI, more than 3 hours of surgery, and wound drainage tube insertion were the independent factors influencing surgical site infections after abdominal hysterectomy. A statistically significant difference ($P < 0.05$) was found, as shown in **Table 4**.

Per 0.123 increase in preoperative BMI ($P = 0.029$), incidence of surgical site infections increased by 1.131 times; incidence of surgical site infections after more than 3 hours of surgery was 0.261 times higher than that after less than 3 hours of surgery ($P = 0.003$); and incidence of surgical site infections after inserting a wound drainage tube was 0.223 times higher than that without wound drainage tube ($P = 0.001$).

Our results predicted that BMI, more than 3 hours of surgery, and wound drainage tube insertion after surgery are factors influencing surgical site infections in patients after abdominal hysterectomy. The prediction accuracy was 73.40%, indicating a good accuracy and valuable prediction.

Discussion

The surgical site can be exposed to endogenous bacteria, depending on the mode of hysterectomy [10]. Surgical site infection rates in patients after gynecological surgeries in different regions and hospitals vary according to data volume, surgical skills, and wound infection prevention and control measures [11]. Several studies have shown that surgical site infection rates in gynecological surgeries are 1-14.47% [12,13].

Surgical site infections can be caused by patient-related factors, surgical teams, and environment. This study has shown that BMI and duration of surgery are the risk factors for surgical site infections after abdominal hysterectomy, which is consistent with the results of Göksever et al [6] and Wei et al [11]. It is advisable to control preoperative BMI and reduce operative time and not to insert unnecessary wound drainage tube after surgery. However, Göksever et al [6] did not provide the exact degrees of influence. The degrees of influence of these factors in this study are different from those reported by Wei et al [11], possibly because our results were from a retrospective case control study but the results of Wei et al [11] were from a descriptive study.

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Abdominal hysterectomy has a higher surgical site infection rate than other types of hysterectomy [6]. Conversion to laparotomy during laparoscopic hysterectomy is more likely to occur with high-volume surgeons than with low-volume surgeons [14]. It is suggested that surgeons should improve their surgical skills. Laparoscopic hysterectomy requires small incision, less blood loss during surgery, and small surgical area, and it causes fewer complications after surgery, make patients recover quickly, and improves patient satisfaction; therefore, it is worth promoting [15-18].

Limitations

This study did not show that the comorbidities of diabetes mellitus, cancer or hypoproteinemia, class III surgical wound, preoperative chemotherapy, preoperative skin preparation, length of incision, blood loss greater than 500 mL during surgery, a second surgery, and delayed suture in wound are the independent factors influencing surgical site infections after abdominal hysterectomy ($P > 0.05$), but this does not mean that they are not possible independent risk factors for surgical site infections. Göksever et al [6] reported that diabetes mellitus, blood loss during surgery, and low hematocrit level were the risk factors for surgical site infections after abdominal hysterectomy. Our study was a retrospective study of 188 cases from 2 hospitals in China, so a small amount of data was collected for this study. We hope the sample size will increase in order to further evaluate the results.

Conclusions

The findings of this study support previous studies and showed that risk factors for surgical site infections after abdominal hysterectomy included increased patient BMI, increased operation duration, and the number of surgical drainage tubes used. Preoperative BMI control in patients, reducing operative time, and avoiding unnecessary wound drainage tube insertion after surgery are recommended to prevent surgical site infections after abdominal hysterectomy.

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