Risk Assessment of Abdominal Wall Thickness Measured on Pre-Operative Computerized Tomography for Incisional Surgical Site Infection after Abdominal Surgery

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Background: *The surgical site infection (SSI) is a common complication of abdominal operation. It relates to increased hospital stay, increased healthcare cost, and decreased patient's quality of life. Obesity, usually defined by BMI, is known as one of the risks of SSI. However, the thickness of subcutaneous layers of abdominal wall might be an important local factor affecting the rate of SSI after the abdominal operations.*

Objective: *The objective of this study is to assess the importance of the abdominal wall thickness on incisional SSI rate.*

Material and Method: *The subjects of the present study were patients who had undergone major abdominal operations at Thammasat University Hospital between June 2013 and May 2014, and had been investigated with CT scans before their operations. The demographic data and clinical information of these patients were recorded. The thickness of subcutaneous fatty tissue from skin down to the most superficial layer of abdominal wall muscle at the surgical site was measured on CT images. The wound infectious complication was reviewed and categorized as superficial and deep incisional SSI following the definition from Centers for Disease Control and Prevention (CDC) guidelines. The significance of each potential factors on SSI rates was determined separately with student t-test for quantitative data and χ^2-test for categorical data. Then all factors, which had $p<0.10$, were included into the multivariate logistic regression analysis and were analyzed with significance at $p<0.05$.*

Results: *One hundred and thirty-nine patients were included in this study. They all underwent major abdominal surgery and had had pre-operative CT scans. Post-operative SSI was 25.2% (35/139), superficial and deep types in 27 and 8 patients, respectively. The comparison of abdominal wall thickness between patients with and without infection was significantly different (20.0±8.4 mm and 16.0±7.2 mm, respectively). When the thickness at 20 mm was used as the cut-off value, 43 of 139 patients had abdominal wall thickness ≥20 mm. The incidence of SSI of the thickness ≥20 mm group was 37.2% (16/43) and of the less thickness group was 19.8% (19/96), with $p<0.05$. The univariate analysis revealed that abdominal wall thickness ≥20 mm, body weight ≥60 kg, and wound classification were the important factors related to SSI after the abdominal operation. However, only abdominal wall thickness and wound classification were still significant by multivariate analysis.*

Conclusion: *The findings of this study confirmed the significance of the subcutaneous thickness of abdominal wall at the surgical site on the incidence of incisional SSI. The thickness ≥20 mm had an effect on increasing post operative SSI rate especially in contaminated operations. These findings could be helpful in making healthcare providers fully aware and thus exercise special attention in wound care or even develop new modalities to prevent SSI in patients with the aforementioned risks.*

Keywords: *Subcutaneous abdominal wall thickness, Surgical site infection, Wound infection*

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The surgical site infection (SSI) is one of the most common complications of surgical operative procedure. This condition can be established and categorized following the guidelines of Centers for Disease Control and Prevention (CDC) as shown in Table 1[1]. It relates to prolonged hospital stay, increased healthcare cost, decreased patient quality of life, and sometimes life-threatening conditions. The overall incidence of SSI was reported to be about 2-5%; SSI prolonged hospital stays by 9.7 days[2,3]. One report determined that SSI expense management accounted for 33.7%, the largest part of the cost of healthcare-associated infection[3].

From aforementioned reasons, many measures were established against post-operative

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Table 1. Guideline for prevention of surgical site infection by Centers for Disease Control and Prevention (CDC)[1]

Superficial incisional SSI
Infection occurs within 30 days after the operation and infection involves only skin or subcutaneous tissue of the incision and at least one of the following: 1) Purulent drainage, with or without laboratory confirmation, from the superficial incision 2) Organisms isolated from an aseptically obtained culture of fluid or tissue from the superficial incision 3) At least one of the following signs or symptoms of infection: pain or tenderness, localized swelling, redness, or heat and superficial incision is deliberately opened by surgeon, unless incision is culture-negative 4) Diagnosis of superficial incisional SSI by the surgeon or attending physician
Do not report the following conditions as SSI: 1) Stitch abscess (minimal inflammation and discharge confined to the points of suture penetration) 2) Infection of an episiotomy or newborn circumcision site 3) Infected burn wound 4) Incisional SSI that extends into the fascial and muscle layers (see deep incisional SSI)
Note: Specific criteria are used for identifying infected episiotomy and circumcision sites and burn wounds.
Deep incisional SSI
Infection occurs within 30 days after the operation if no implant is left in place or within 1 year if implant is in place and the infection appears to be related to the operation and infection involves deep soft tissues (e.g., fascial and muscle layers of the incision and at least one of the following: 1) Purulent drainage from the deep incision but not from the organ/space component of the surgical site 2) A deep incision spontaneously dehisces or is deliberately opened by a surgeon when the patient has at least one of the following signs or symptoms: fever (>38°C), localized pain, or tenderness, unless site is culture-negative 3) An abscess or other evidence of infection involving the deep incision is found on direct examination, during reoperation, or by histopathologic or radiologic examination 4) Diagnosis of a deep incisional SSI by a surgeon or attending physician
Note: 1) Report infection that involves both superficial and deep incision sites as deep incisional SSI. 2) Report an organ/space SSI that drains through the incision as a deep incisional SSI.
Organ/space SSI
Infection occurs within 30 days after the operation if no implant is left in place or within 1 year if implant is in place and the infection appears to be related to the operation and infection involves any part of the anatomy (e.g., organs or spaces), other than the incision, which was opened or manipulated during an operation and at least one of the following: 1) Purulent drainage from a drain that is placed through a stab wound into the organ/space 2) Organisms isolated from an aseptically obtained culture of fluid or tissue in the organ/space 3) An abscess or other evidence of infection involving the organ/space that is found on direct examination, during reoperation, or by histopathologic or radiologic examination 4) Diagnosis of an organ/space SSI by a surgeon or attending physician

SSI = surgical site infection

wound complications such as prophylactic antibiotic, patient skin preparation, aseptic operative technique, and sterile instrument. However, despite all methods used for an aseptic environment, the SSI still was discovered, especially in about 10-26.7% after major abdominal operation[4-8]. It related to other patient factors, for example, serious underlying disease, poor nutritional status or from immunosuppression. Moreover, peri-operative factors were also very important. Prolonged operative time, infectious process at operative field, or severe contamination made for the higher risk of post-operative infection.

Obesity, generally defined by high body mass index (BMI), seemed to be one of the risks of SSI. However, the thick subcutaneous layer of abdominal wall might also be a crucial local factor affecting the rate of SSI after the abdominal operations. In this study, the purpose is to assess the relationship between the abdominal wall thickness and the incidence of SSI after major abdominal surgery considering with other potentially important factors such as underlying disease, nutritional status, operative time and wound classification.

Material and Method

The subjects of the present study were the patients who had undergone major abdominal operations at Thammasat University Hospital between

June 2013 and May 2014, and had been investigated with CT scans before their operations. The demographic and anthropometric data and clinical information of these patients were reviewed. Then CT imaging of each patient was inspected and the thickness of subcutaneous fatty tissue from skin down to the most superficial layer of abdominal wall muscle at the surgical site was measured on CT images by using the ruler tool embedded in Picture Archiving and Communication System (PACS). The thickest part of the subcutaneous layer of abdominal wall was measured and recorded in millimeters. All basic data and pre-operative information were reported in proportion and mean with standard deviation depending on type of variables.

The wound infectious complication was diagnosed by attending surgeons and documented in the medical record. Then it was categorized as superficial and deep incisional SSI following the definition from CDC guidelines. The significance of each potential factor on SSI rate was determined separately with student t-test for numerical data and χ^2-test for categorical data. Then all factors, which had *p*-value <0.10, were included into the multivariate logistic, regression analysis and were analyzed with significance at $p<0.05$.

Results

During 1 year of study period, 150 patients met the inclusion criteria and their clinical information had been reviewed. All of them had pre-operative abdominal CT scan and underwent major abdominal operations. Eleven subjects were excluded because of incomplete documentation or poor quality imaging. Finally, there were 139 patients included in the present study, 91 male and 48 female. The demographic data, anthropometric data, laboratory result, measured abdominal wall thickness and operative time are shown in Table 2. In addition, Table 3 revealed the type and wound classification of the operations.

Post-operative SSI was found in 25.2% (35/139) of the cases, superficial and deep types in 27 and 8 patients, respectively. The comparison of each potentially important factor between the groups of patients with and without infection was analyzed by student t-test and demonstrated in Table 4. The significant differences were found from the comparison in terms of body weight, hematocrit, albumin and abdominal wall thickness. When the univariate analysis was performed, body weight ≥60 kg, abdominal wall thickness ≥20 mm, and wound classification provided the significant result at *p*-value <0.05 (Table 5). The incidence of SSI of the thickness ≥20 mm group was 37.2% (16/43) and of the less thickness group was

Table 2. Pre-operative and peri-operative data of 139 patients

Factors	Mean ± SD
Demographic and anthropometric data	
Age (years)	61.4±15.1
Body weight (kg)	59.3±10.7
Height (cm)	162.3±8.1
Body mass index (BMI) (kg/m^2)	22.5±3.7
Laboratory result	
Hematocrit (%)	34.9±6.2
Creatinine (mg/dl)	1.1±0.6
Albumin (g/dl)	3.3±0.6
Peri-operative factor	
Abdominal wall thickness	17.0±7.7
Operative time (minutes)	179.9±98.9

Table 3. Characteristics of the operations

Type of operations	
Colorectal surgery	52.5%
Hepatobiliary-pancreatic surgery	22.3%
Esophagogastric surgery	9.4%
Small bowel resection	5.8%
Intra-abdominal vascular surgery	4.3%
Soft tissue tumor removal	2.9%
Other	2.9%
Wound classification	
Wound class I	21.6%
II	68.3%
III	5.8%
IV	4.3%

Table 4. Comparison of numerical data between the groups of patient with and without SSI

Factors	With SSI	Without SSI	*p*-value
Age	60.9±12.5	61.6±15.9	0.83
Body weight	62.5±9.7	58.2±10.9	0.04
BMI	23.0±3.5	22.3±3.8	0.38
Hematocrit	37.2±6.1	34.1±6.1	0.01
Creatinine	1.0±0.4	1.1±0.7	0.34
Albumin	3.5±0.5	3.2±0.6	0.02
Abdominal wall thickness	20.0±8.4	16.0±7.2	0.01
Operative time	198.3±106.0	173.7±96.2	0.20

Table 5. Univariate analysis of each factors on SSI rate

Factors	Criteria	Patients in each group	SSI detected	SSI rate (%)	*p*-value
Age (years)	<60	56	17	30.4	0.28
	≥60	83	18	21.7	
Gender	Male	91	27	29.7	0.11
	Female	48	8	16.7	
Body weight (kg)	<60	74	12	16.2	0.01
	≥60	65	23	35.4	
Body mass index (kg/m^2)	<23	78	18	23.1	0.48
	≥23	60	17	28.3	
Underlying diabetes mellitus	Yes	31	9	29.0	0.58
	No	108	26	24.1	
Hematocrit (%)	<35	71	14	19.7	0.13
	≥35	68	21	30.9	
Creatinine (g/dl)	<1.0	76	19	25.0	0.96
	≥1.0	63	16	25.4	
Albumin	<3.5	66	12	18.2	0.07
	≥3.5	70	22	31.4	
Abdominal wall thickness (cm)	<20	96	19	19.8	0.01
	≥20	43	16	37.2	
Operative time (minutes)	<180	81	17	21.0	0.18
	≥180	58	18	31.0	
Wound classification	I	30	1	3.3	0.01
	II	95	31	32.6	
	III, IV	14	3	21.4	

Table 6. Multivariate analysis of potential factors

Factors	*p*-value
Abdominal wall thickness ≥2 cm	0.03
Wound classification	0.03
Albumin ≥3.5	0.07
Body weight ≥60 kg	0.29

19.8% (19/96), with $p<0.05$. For multivariate analysis, four potential variables which had *p*-value <0.10 were included. At this time, only abdominal wall thickness ≥20 mm and wound classification were the significant factors on the SSI rate as shown in Table 6.

Discussion

The findings of the present study confirmed the significance of the subcutaneous thickness of abdominal wall at surgical site and the wound classification on the incidence of incisional SSI. The thickness ≥20 mm had an effect on increasing post-operative SSI rates especially in contaminated operations. The measurement of this thickness was easily performed on abdominal CT images, which were ordered by physicians because of reasonable medical reasons for diagnosis. This procedure did not jeopardize the patients' safety more than they would take from being performed CT scan pre-operatively.

In a previous prospective study of 189 colorectal operations reported by Nystrom et al the infection rate was 20% in patients with subcutaneous fat layer ≥3.5 cm and only 6.8% when the thickness was less than 3 cm which were significantly different[9]. Similarly, Fujii et al assessed many factors thought to be predictive of incisional SSI after 152 colorectal operations by multivariate analysis[10]. They reported overall SSI rate was 19.1% and only the thickness of subcutaneous fat was independently associated with incisional SSI. BMI was significantly related with SSI on univariate analysis, but lost its significance on multivariate analysis. With the subcutaneous thickness more than 2 cm, the odds ratio was 2.81 with 95% CI at 1.04-7.59.

The obesity was assumed to be one of the risk factors of post operative wound infection. The studies of Israelsson and Jonsson[5], de Oliveira et al[11], and Smith et al[12] demonstrated higher BMI associated with the increased wound infection rate after abdominal surgery. The proposed reasons were poor tissue perfusion

in adipose tissue, which had less blood supply, more ischemia at suture line because of more tension, larger wound area and longer operative time. However, there were some studies failed to find the association of BMI and incisional SSI[7,8,13,14]. In consideration of aforementioned reasons, which might make obesity related to SSI, they were local factors exactly at the surgical incision. They should be affected by local fat accumulation at the abdominal wall rather than the obesity, which was the fat distribution throughout the body. Furthermore, BMI was calculated from body weight and height, and may not represent the fat distribution in the body accurately[15,16]. Although the subcutaneous thickness of abdominal wall had the strong correlation with BMI in the present study using Pearson correlation analysis, overweight and obesity by criteria of BMI ≥23 were not associated with increased SSI rate. Similarly, body weight correlated to abdominal thickness and was significant on SSI by univariate analysis, but not significant by multivariate analysis. Therefore, body weight and BMI might not be good predictive factors for incisional SSI.

The present study had some limitations. It was a retrospective study, then some potential confounding factors were not analysed or controlled. In addition, it had relatively small population, so it was difficult to perform subgroup analysis for more details. However, this would be very helpful to initiate the next research for developing new modalities to prevent SSI in patients with the mentioned risks such as higher dose of prophylactic antibiotics or subcutaneous placement of suctioned drain.

Conclusion

The finding of the association between subcutaneous abdominal wall thickness and incisional SSI rate would be helpful to aware the healthcare providers for more careful attention on wound care or even to develop any new modalities to prevent this morbidity. The abdominal wall measurement was easy, not time-consuming, and did not jeopardize the patients' safety. It can be simply performed at any medical centers and provides useful information.

What is already known in this topic?

There were many known factors of incisional SSI after major abdominal operations; obesity was thought to be one of them. However, for many reasons, the local factors at the surgical site such as the thickness of subcutaneous fat at abdominal wall might play an important role as a better predictive factor of SSI. While BMI and body weight represented fat distribution throughout the body, the subcutaneous fat thickness was the fatty tissue involved in surgical site directly. There have been previous reports supported the importance of abdominal wall thickness on incisional SSI after colorectal surgery. They applied this knowledge to develop a new method to prevent SSI such as small suctioned drain placed within the subcutaneous layer during surgical wound closure.

What this study adds?

A few studies previously reported on this issue. Our study has statistically confirmed by their findings of the significance of subcutaneous fat thickness. This study included the other types of abdominal operations, not only colorectal surgery. The patients with hepatobiliary-pancreas, esophagogastric, small bowel, and intra-abdominal vascular surgery were also enrolled. Therefore, this study had a greater variety of cases and furthermore covered all four surgical wound classes that were significantly important when added into the analysis.

Potential conflicts of interest

None.

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การประเมินความเสี่ยงของความหนาผนังหน้าท้องที่วัดจากภาพเอกซเรย์คอมพิวเตอร์ช่องท้องต่อการติดเชื้อของแผลผ่าตัด

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ภูมิหลัง: การติดเชื้อที่แผลผ่าตัดเป็นภาวะแทรกซ้อนที่พบได้บ่อยของการผ่าตัดช่องท้อง และเมื่อเกิดขึ้นทำให้ต้องนอนพักรักษาตัวในโรงพยาบาลนานขึ้น เพิ่มค่าใช้จ่ายและทำให้คุณภาพชีวิตแย่ลง ภาวะอ้วนพบว่าเป็นปัจจัยหนึ่งที่มีความสำคัญต่อการติดเชื้อที่แผลผ่าตัดช่องท้อง ซึ่งหากพิจารณาความเสี่ยงต่อการติดเชื้อที่แผลผ่าตัดโดยตรง ความหนาของชั้นไขมันใต้ผิวหนังที่บริเวณแผลผ่าตัดช่องท้องอาจเป็นปัจจัยที่สำคัญที่มีผลต่อการติดเชื้อของแผลผ่าตัดได้

วัสดุและวิธีการ: การศึกษานี้เป็นการเก็บข้อมูลผู้ป่วยที่เข้ารับการผ่าตัดช่องท้องที่โรงพยาบาลธรรมศาสตร์เฉลิมพระเกียรติ ในระหว่างเดือนมิถุนายน พ.ศ. 2556 และพฤษภาคม พ.ศ. 2557 ซึ่งต้องเป็นผู้ป่วยที่ได้ทำเอกซเรย์คอมพิวเตอร์ที่ช่องท้องก่อนการผ่าตัดด้วย มีการเก็บข้อมูลทางการรักษาพยาบาล และทำการวัดความหนาของชั้นไขมันใต้ผิวหนังในภาพเอกซเรย์คอมพิวเตอร์จากผิวหนังลงไปถึงชั้นบนสุดของชั้นกล้ามเนื้อของผนังหน้าท้องในบริเวณที่จะทำการผ่าตัด การวินิจฉัยและแบ่งประเภทของการติดเชื้อที่แผลผ่าตัดใช้ตามคำนิยามของศูนย์ควบคุมและป้องกันโรคในประเทศสหรัฐอเมริกา จากนั้นจะทำการวิเคราะห์ความสำคัญของตัวแปรแต่ละชนิดต่อการติดเชื้อโดยวิธีการทางสถิติ t-test และ χ^2-test รวมทั้งใช้การวิเคราะห์การถดถอยโลจิสติกเพื่อหาตัวแปรที่มีความสัมพันธ์กับการติดเชื้อที่แผลผ่าตัดอย่างมีนัยสำคัญทางสถิติ

ผลการศึกษา: มีผู้ป่วย 139 ราย ที่ได้ทำเอกซเรย์คอมพิวเตอร์และได้รับการผ่าตัดช่องท้องไป อัตราการติดเชื้อโดยรวมอยู่ที่ร้อยละ 25.2 เป็นชนิดตื้น 27 ราย และชนิดลึก 8 ราย การเปรียบเทียบความหนาของชั้นไขมันที่ผนังหน้าท้องระหว่างกลุ่มที่มีและไม่มีการติดเชื้อมีความแตกต่างกันอย่างมีนัยสำคัญ (20.0±8.4 มม. และ 16.0±7.2 มม. ตามลำดับ) หากแบ่งเป็น 2 กลุ่ม คือมีความหนาของชั้นไขมันน้อยกว่าและมากกว่าหรือเท่ากับ 20 มม. พบว่ากลุ่มหลังมีการติดเชื้อร้อยละ 37.2 ในขณะที่กลุ่มแรกมีเพียงร้อยละ 19.8 ซึ่งแตกต่างอย่างมีนัยสำคัญเช่นกัน นอกจากนี้ยังมีอีก 2 ปัจจัย ที่สัมพันธ์กับการติดเชื้อที่แผลผ่าตัด ได้แก่ น้ำหนักตั้งแต่ 60 กก. ขึ้นไป และชนิดของแผลผ่าตัดซึ่งแบ่งตามการปนเปื้อนที่แผลจากการวิเคราะห์การถดถอยโลจิสติกในขั้นตอนสุดท้ายมีเพียงความหนาของชั้นไขมัน และชนิดของแผลผ่าตัดเท่านั้นที่มีนัยสำคัญต่อการเกิดการติดเชื้อที่แผลผ่าตัดช่องท้อง

สรุป: จากการศึกษานี้พบว่าความหนาของชั้นไขมันที่ผนังหน้าท้องบริเวณที่จะทำการผ่าตัดมีความสัมพันธ์กับการติดเชื้อที่แผลผ่าตัดโดยเฉพาะที่ความหนาตั้งแต่ 20 มม. ขึ้นไป จึงน่าจะเป็นประโยชน์กับบุคลากรทางการแพทย์ที่ให้การดูแลรักษาผู้ป่วยหลังการผ่าตัดให้มีความเอาใจใส่มากขึ้นในกลุ่มที่มีความเสี่ยงสูง และอาจพัฒนาวิธีการใหม่ในการช่วยป้องกันการติดเชื้อที่แผลผ่าตัดได้ในภายหน้า