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Comparison of abdominal depth with subcutaneous fat thickness in predicting surgical site infection among patients undergoing hepatopancreatobiliary surgery: a prospective observational study

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Introduction: Surgical site infection (SSI) is a significant cause of postoperative morbidity resulting in an increased hospital stay and cost. Various measures have been used to predict SSI such as subcutaneous fat thickness (SCFT) and abdominal depth (AD) in case of abdominal surgeries. The objective of the study was to compare SCFT with AD to predict SSI in HPB surgeries.

Methods: A prospective observational study was conducted from February 2020 to February 2021, which included 76 patients who underwent elective open hepatopancreatobiliary surgeries. SCFT and AD at the level of the umbilicus were measured preoperatively using the computed tomography abdomen. The occurrence of SSI was evaluated in correlation with SCFT and AD. SCFT and AD were compared using the receiver operating characteristic curve for prediction of SSI.

Results: Twenty-five (32.3%) patients who underwent elective HPB surgeries developed SSI. 72% of the SSI were superficial. In multivariate analysis, only SCFT was associated with SSI, which was statistically significant. It was compared with AD using the receiver operating characteristic curve where SCFT proved to be better at predicting SSI (AUC = 0.884) with cut-off = 2.13 cm, sensitivity 84%, and specificity 86%), compared to AD with an AUC of 0.449.

Conclusion: SSI is the common cause of increased morbidity following hepato-pancreato-biliary surgeries with risk factors including SCFT and AD. Approximately one-third of patient developed SSI, with most the common being superficial SSI. SCFT at the incision site was associated with an increased rate of SSI and the better predictor for SSI as compared with the AD.

Keywords: abdominal depth, hepatopancreatobiliary surgery, subcutaneous fat thickness, surgical site infection

Introduction

Surgical site infection (SSI) is one of the most common complications after a surgical intervention[1]. SSI occurs in 3–5% of all surgical patients and up to 33% of patients undergoing abdominal surgery[2]. The cost of SSIs may almost triple the individual's overall healthcare costs[3]. SSI significantly hampers the benefits of surgical management in addition to reducing patient's satisfaction[4]. Therefore, identification of risk factors of SSI with an early intervention is a valuable step. The risk of SSI has traditionally been associated with wound classification. The majority of HPB surgeries are clean-contaminated wounds[5]. In literature, SSI rates for clean cases ranged from 1 to 5%, for clean-contaminated 3–11%, contaminated 10–17%, and dirty/infected greater than 27%.

Despite improvements in mortality following hepatic, pancreatic, and complex biliary surgery, rates of overall morbidity and SSI subsequent to these procedures remain high[6]. Historically, the rate of SSIs occurring within 30 days of HPB surgery has been high, reaching 20–40%[7,8]. The frequency of SSIs varies greatly and depends on the author and the particular surgical specialty studied. In HPB-surgery, SSI rates of 25.1% after pancreatoduodenectomy[9] and 23.2% after hepatic and pancreatic resections have been reported[10].

HIGHLIGHTS

- Surgical site infection (SSI) is a very common complication following any surgery.
- SSI occurs in one-third of patient who undergo hepato-pancreatobiliary surgeries.
- Subcutaneous fat thickness is better than abdominal depth in predicting SSI.

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Despite improvements in infection prevention, SSI is associated with substantial morbidity and mortality and also impose significant demands on healthcare resources. SSI increases treatment cost, adds the requirement of intervention including surgical and extra nursing care; thereby contributing to an increased overall healthcare budget[11]. Continuous vigilance is therefore required to minimize the incidence of such infections. This requires a systematic approach, with attention to multiple risk factors related to the patient, the procedure, and the hospital environment[12].

Obesity is a significant healthcare issue. Strong evidence indicates the association between obesity and poorer surgical outcomes, especially wound healing[13]. Obesity, regardless of the definition used, is thought to increase SSI risk[14]. Several studies postulate the mechanisms by which obesity increases the risk of SSI. Intrinsic tenuous anatomic properties and poor vascularity of adipose tissue are the potential factors[15]. Possible mechanisms are related to a reduced ability to support necessary mechanisms of the healing cascade because of relative vascular insufficiency, which leads to decreased oxygen tension and decreased collagen synthesis[16].

Despite the fact that BMI is typically used to define obesity, it is clearly a wide variation in describing body composition. BMI is a nonspecific assessment of body composition that does not directly measure adiposity. The assessment of obesity does not depend merely on measuring an individual's total body mass but also on body composition and fat distribution. Targeted measures of body composition such as the amount of subcutaneous fat thickness (SCFT) at the surgical site may improve assessments for SSI risk compared with less specific metrics such as BMI[17].

The statistical association between visceral fat and the depth of the abdomen has been studied by many researchers[18,19]. It is thought that the deeper the abdominal cavity, the more difficult the surgery will be and hence take a long time that may lead to an increased risk of SSI. There are various methods to measure visceral fat. In this study, we expect that the abdominal depth is indirectly co-related with the visceral fat.

Similarly, the SCFT at the incision site would be associated with an infection risk. Some studies have concluded that the risk of SSI increases with increased thickness of subcutaneous fat (SCFT). Also, the type of surgery and site of measurement of SCFT have varied in different studies. Anatomical variations of the abdomen exists in individuals including SCFT, rectus abdominis thickness, abdomen depth (AD), etc. Some studies have explored the relationship between individual abdominal anatomic characteristics, including SCFT and abdominal depth, in predicting SSI[20]. This is the study done to compare between SCFT and AD as a predictor of SSI.

Methods

This was a prospective observational study conducted in one of the tertiary care centers in Nepal from February 2020 to February 2021. Enrollment of the population was started once ethical clearance was provided by the Institutional Review Committee (IRC). The work has been reported in line with the strengthening the reporting of cohort, cross-sectional, and case–control studies in surgery (STROCSS) criteria[21].

The study enrolled all patients who were planned for elective open hepatopancreatobiliary (HPB) surgeries in the GI and General Surgery department of Tribhuvan University Teaching Hospital, one of the tertiary care centers in Nepal. All the patients above 16 years of age whose computed tomography (CT) abdomen images were accessible in the scanner console for measurement of SCFT and AD were included. Those patients who fulfilled the inclusion criteria were selected consecutively. Patients undergoing laparoscopic HPB surgeries, re-operated cases, immunocompromised patients, and those who refused to give consent were excluded. Apart from SCFT and AD other study variables were age, BMI, nutritional risk index, serum albumin, hemoglobin, intraoperative blood loss, duration of surgery, and history of smoking and alcohol.

Considering the prevalence of surgical site infection following abdominal surgeries including HPB surgeries at our center (Tribhuvan University Teaching Hospital) to be 23% ($P=0.23$)[22], CI of 95% ($Z=1.96$), acceptable sample error of 10% ($e=0.1$) and dropout rate of 10%, the sample size was calculated to be 76 by using the formula: sample size $(n)=z^2p(1-p)/e^2$.

Intervention and considerations

Preoperatively, all patients had CT abdomen done, SCFT and AD were measured in CT console by a radiologist. To reduce error, measurement was done thrice and the mean value was taken. AD was measured as a sagittal distance between the bottom of the umbilicus and the top of the vertebra and SCFT was measured as the largest sagittal distance between the parietal and visceral sides of subcutaneous fat at the level of the umbilicus (Fig. 1).

All patients were given a single dose of intravenous ceftriaxone 1 gm as a prophylactic antibiotic 30 min prior to surgery. The dose was repeated after 4 h in the case of prolonged surgery. Surgeries were performed under general anesthesia. Painting of the surgical site was done by using povidone-iodine 10%

Figure 1. Measurement of AD and SCFT in computed tomography image. AD, abdominal depth; SCFT, subcutaneous fat thickness.

solution. The type of abdominal incision was selected depending on the preoperative diagnosis and choice of the operating surgeon. Surgeries were performed by four experienced surgeon's team in all four units in the department.

The presence of SSI was diagnosed as per criteria given by CDC[23]. Postoperatively, the first assessment of the wound was done on the second postoperative day. After that, wound dressing was done every alternate day, provided no SSI and on a daily basis if SSI was present. Swab/wound discharge was sent for culture and sensitivity on first suspicion of SSI. Antibiotics were upgraded according to the culture and sensitivity report. After discharge from the hospital, they were followed for 1 month and examined for SSI, which was the primary outcome of this study.

Data collection was done using a proforma and statistical analysis by SPSS version 24. The data were expressed as a mean with a 95% CI for continuous variables. An unpaired Student's *t*-test analyzed continuous variables. Categorical data was analyzed using χ^2test. AD and SCFT were compared by drawing the ROC curve and measuring the AUC. *P*-value <0.05 was considered to be statistically significant.

Results

A total of 80 patients planned for HPB surgeries were enrolled for the study. Two patients had previous surgeries with a midline incision and another two patients whose CT images were unavailable in CT console were also excluded. Seventy-six patients were included in the study for statistical analysis.

The mean age of the patients was 53 ± 13.04 years, ranging from 21 to 78 years, with 33 (43.4%) males, and 43 (56.6%) females. The mean BMI was 21.51 ± 2.74 kg/m^2. According to the WHO classification of BMI for the Asian population[24], 9 (11.8%) patients were obese, (10.5%) patients were overweight, 49 (64.5%) had a normal BMI, and 10 (13.2%) patients were underweight.

The most common diagnosis among all patients who underwent HPB surgery was ampullary carcinoma in 32 (42.1%) patients. Distal cholangiocarcinoma, chronic pancreatitis, choledochal cyst, and carcinoma head of the pancreas were among the other diagnoses. And the most common surgery was Whipple's procedure, which constitutes 75% of all cases. The other surgical procedures were Roux-en-Y hepaticojejunostomy, distal pancreatectomy, open CBD exploration, hepatectomy, and Frey's procedure. Most of the surgeries were performed using a midline incision (84.21%). Other incisions were reverse L incision and the right subcostal incision.

In this study, 25 (32.9%) patients developed SSI. Among the incidence of SSI, 72% were superficial type. Similarly, deep SSI and organ space SSI were identified in 16 and 12%, respectively. All patient who had SSI, either swab or collected fluid sample was sent for culture and sensitivity test. Twenty cases were culture positive, whereas five cases had no growth in culture till 48 h. The most common organism isolated was *Escherichia coli* in 35% of cases. The growth of multiple microbes was found in 30% of cases. Other organisms isolated were *Klebsiella* spp., *Citrobacter* spp., *Pseudomonas aeruginosa*, *Proteus* spp., etc.

Comparison of SSI and non-SSI groups

Based on various preoperative and intraoperative variables, SSI and non-SSI groups were compared. There is no sex predominance in either of the group. Among patients who had a smoking history, 53.3% developed SSI. Among nonsmoker, 27.9% of patients developed SSI ($P = 0.073$). As per analysis both groups were comparable as shown (Table 1).

A comparison of SSI and the non-SSI group showed a higher SCFT in the SSI group (2.49 ± 0.49) than in the non-SSI group (1.73 ± 0.45) and was statistically significant ($P = 0.001$). There is no statistically significant difference with abdominal depth between these two groups. Preoperative variables showed higher albumin and nutritional risk index in the SSI group, but was statistically insignificant. There was a slightly longer hospital stay and more intraoperative blood loss in the SSI group than in the non-SSI group; however, it was statistically insignificant.

Analysis of the ROC curve

To investigate the predictive ability for SSI, SCFT, and AD were introduced into ROC curve analysis. It was demonstrated that SCFT exhibited the best performance in SSI prediction (AUC = 0.884, 95% CI: 0.80–0.97, cut-off = 2.13 cm, sensitivity = 84%, specificity = 86%), compared to AD with an AUC of 0.449 (Fig. 2, Table 2).

Discussion

In our study, the incidence of SSI in open HPB surgeries was 25 (32.89%). The SSI rates in HPB surgeries of 25.1% after pancreatoduodenectomy[9] and 23.2% after hepatic and pancreatic resections have been reported[10]. Comparatively, the present study showed a higher infection rate at our center.Studies have suggested the role of subcutaneous fat in the occurrence of SSI. Our study has tried to highlight the impact of subcutaneous fat burden at the incision site and its relation to the development of SSI. A recent study by Mehta *et al.*[25] concluded that body fat distribution had a greater impact on SSI development than BMI. They believe that it was because the BMI calculation includes muscle mass and does not always correspond to the amount of fat

Table 1

Comparison of variables among SSI and non-SSI group.

Categories	SSI	Non-SSI	*P*
Male (%)	14 (18.4)	19 (25)	0.145
Female (%)	11 (14.4)	32 (42.1)	
Smoker (%)	8 (10.5)	7 (9.2)	0.073
Non-smoker (%)	17 (22.3)	44 (57.8)	
Alcohol (%)	15 (19.7)	11 (14.4)	0.303
Nonalcohol (%)	36 (47.3)	14 (18.4)	
Malignancy (%)	18 (23.6)	43 (56.5)	0.231
Nonmalignancy (%)	7 (9.2)	8 (10.5)	
Age (mean ± SD)	49.20 ± 13.83	54.29 ± 12.94	0.119
BMI (mean ± SD)	21.99 ± 2.59	21.28 ± 2.80	0.276
Hemoglobin level (mean ± SD)	12.19 ± 1.47	12.30 ± 1.63	0.788
Albumin level (mean ± SD)	39.08 ± 5.71	37.06 ± 5.98	0.164
NRI score (mean ± SD)	103.244 ± 11.45	98.39 ± 10.73	0.074
SCFT (mean ± SD)	2.49 ± 0.49 cm	1.73 ± 0.45 cm	0.001
AD (mean ± SD)	7.61 ± 2.13 cm	8.04 ± 1.98 cm	0.384
Duration of surgery	76.83 ± 211.82 mins	84.07 ± 216.31 mins	0.891
Blood loss (mean ± SD)	504.00 ± 220.76 ml	476.47 ± 207.45 ml	0.596
Hospital stay (mean ± SD)	15.48 ± 4.85 days	14.69 ± 8.54 days	0.668

AD, abdominal depth; NRI, nutritional risk index; SCFT, subcutaneous fat thickness; SSI, surgical site infection.

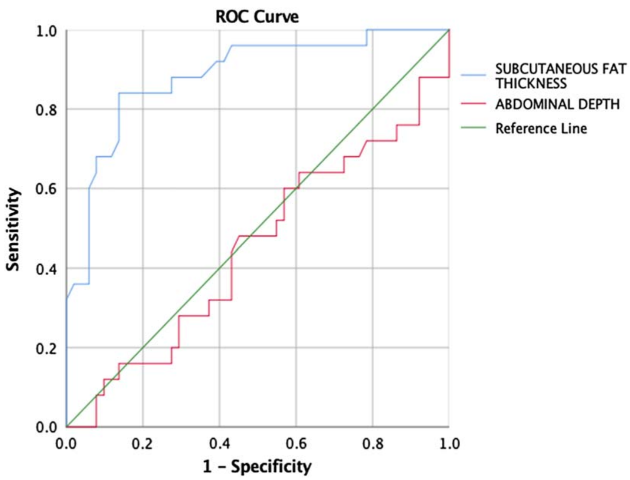

Figure 2. ROC curve comparing subcutaneous fat thickness and abdominal depth for prediction of SSI. ROC, receiver operating characteristic.

present. Nakagawa *et al.*[26] showed that SCFT is an independent risk factor for SSI in patients undergoing colorectal surgery, which was consistent with findings from Lee *et al.*[27] and Fujii *et al.*[28]. Tongyoo *et al.*[29] discovered that the subcutaneous thickness of the abdominal wall was associated with the SSI rate, especially in contaminated incisions. The present study demonstrated that body fat distribution at the surgical site is an important clinical marker for SSI development.

Kwaan *et al.*[30] found that abdominal wall thickness is positively associated with SSI incidence after colorectal surgery but loses its significance on multivariate analysis. Furthermore, Osterhoff *et al.*[31] concluded that SCFT does not influence SSI incidence. Our data demonstrated that patients in the SSI group exhibited higher SCFT, an independent risk factor for SSI, and may serve as a biomarker for SSI prediction.

Lee *et al.*, in 2011, evaluated abdominal subcutaneous fat as a predictor for SSI in patients undergoing midline laparotomy. Overall, SSIs were observed in 12.5% ($n = 82$) of the population. Patients with superficial incisional SSI had significantly high SCFT compared with those without superficial incisional SSI (22.8 mm vs. 20.0 mm, $P = 0.049$).Logistic regression demonstrated that patients with increased SCFT had significantly greater odds of developing a superficial incisional SSI (odds ratio = 1.76 per 10% increase, 95% CI: 1.10–2.83, $P = 0.019$)[27].

Several proposed mechanisms could explain why increased fat at the surgical incision site may increase the risk of SSI. These include increased technical difficulty, increased tissue trauma, increased tension on the wound, decreased circulation and oxygenation at the local wound site, and local immunosuppression related to large populations of adipocytes. A thick subcutaneous fat layer may also lead to longer drainage periods and the formation of seroma and sinus tracts[10–12].

Table 2

Area under curve and the standard error of ROC curve.

	Area	Standard error	95% CI	P
SCFT	0.884	0.042	0.801–0.967	< 0.001
AD	0.449	0.072	0.307–0.590	0.469

AD, abdominal depth; ROC, receiver operating characteristic; SCFT, subcutaneous fat thickness.

In the study done by Song Liu *et al.*[20], abdominal depth was co-related with postoperative SSI. And showed a higher SCFT among patients who developed SSI than those who did not though it was statistically insignificant. However, in our study there was no co-relation of abdominal depth with the development of SSI.

At a cut-off of 2.2 cm, we have the higher sensitivity of 83.3% and specificity of 76.9% for predicting SSI. Thus, it can be used as a screening tool to predict the SSI. This shows that the actual thickness of fat at the surgical site represented a significant risk factor for SSI development.

SSIs are a common complication following HPB surgeries. Potentially, a surgeon may appreciate the SCFT on a preoperative CT scan, which could help for preoperative counseling, intraoperative clinical decision-making, and the vigilant care of the wound to prevent SSI. With the preoperative assessment of risk factors like SCFT, proper surgical techniques can be opted like minimal handling of soft tissues, minimal use of cautery at the subcutaneous plane, adequate peritoneal/subcutaneous lavage or use of a subcutaneous drain to minimize the risk of major wound complications like delayed primary closure, SSI, etc.

The major limitation of this study being single-center study with only elective open HPB surgeries performed by multiple operating surgeons. Further studies are recommended for a better derivement of the outcomes. Another limitation we are aware of, is the small sample size. Therefore, we suggest further more studies in the future.

Conclusion

SSI is the most common complication following hepato-pancreato-biliary surgeries with risk factors including the SCFT and abdominal depth. Approximately one-third of patient undergoing HPB surgery developed SSI with the most common being superficial SSI. SCFT at the incision site was associated with an increased rate of SSI and the better predictor for SSI than abdominal depth.

Ethical approval

Ethical approval was taken from Institutional Review Committee, Institute of Medicine, Kathmandu, Nepal. (Reference no: 330 (6–11) E2 076/077).

Consent

Written informed consent was obtained from the patients for publication and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

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Author contribution

S.D., S.G., A.H., and R.K.: were involved in study design, data collection, analysis and interpretation, writing manuscript; P.P., B.K., R.V., P.N., R.D.K., and P.N.: were involved in data analysis and manuscript revision; P.B.S.K.: was involved in data analysis and final manuscript editing. All authors approved the final submission.

Conflicts of interest disclosure

The authors declare that they have no financial conflicts of interest with regard to the content of this report.

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Guarantor

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Will be available on request from the concerned authority.

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