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Standardization and Selection of High-risk Patients for Surgical Wound Infections in Plastic Surgery

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Background: The aim of the present study was to show that the Infection Risk Index (IRI), based on only 3 factors (wound classification, American Society of Anesthesiologists score, and duration of surgery), can be used to standardize selection of infection high-risk patients undergoing different surgical procedures in Plastic Surgery.

Methods: In our Division of Plastic Surgery at Modena University Hospital, we studied 3 groups of patients: Group A (122 post-bariatric abdominoplasties), Group B (223 bilateral reduction mammoplasties), and Group C (201 tissue losses with first intention healing). For each group, we compared surgical site infection (SSI) rate and ratio between patients with 0 or 1 risk factors (IRI score 0 or 1) and patients with 2 or 3 risk factors (IRI score 2 or 3).

Results: In group A, patients with IRI score 0–1 showed an SSI Ratio of 2.97%, whereas patients with IRI score 2–3 developed an SSI ratio of 27.27%. In group B, patients with IRI score 0–1 showed an SSI ratio of 2.99%, whereas patients with IRI score 2–3 developed an SSI ratio of 18.18%. In group C, patients with IRI score 0–1 showed an SSI ratio of 7.62%, whereas patients with IRI score 2–3 developed an SSI ratio of 30.77%.

Conclusions: Existing infection risk calculators are procedure-specific and time-consuming. IRI score is simple, fast, and unspecific but is able to identify patients at high or low risk of postoperative infections. Our results suggest the utility of IRI score in refining the infection risk stratification profile in Plastic Surgery. *(Plast Reconstr Surg Glob Open 2021;9:e3472; doi: 10.1097/GOX.0000000000003472; Published online 23 March 2021.)*

INTRODUCTION

Infection at the surgical site in plastic surgery can give a suboptimal aesthetic outcome, but it can also impair patient psychosocial well-being, can delay hospital discharge, and may lead to readmission and further surgery. In high-risk patients, an improvement in identification, prevention, and management of surgical wound infections is mandatory in order to reduce infections.[1–4] An implementation of postoperative care is necessary, including close monitoring and assessment, antibiotic prophylaxis, use of nonirritant medical care products, selection of the appropriate disinfectant, and application of specific devices (such as incisional NPWT). Evaluation by the surgeon that a patient has a "low" or a "high risk" of infection at surgical site may not reflect the real risk, because it depends on surgeon skills. This limitation can be overcome by using a risk index.[5] The risk of infection has been shown to be related to several factors.[6–17] Different risk calculators for postoperative complications, specific to particular types of surgery, were created by considering several known risk factors.[18–21]

Even if the calculators are usually accessed via the internet,[20,21] in our department we have a low physician compliance for using existing risk calculators in all patients for different reasons. Every risk calculator is specific for a particular kind of surgery (eg, abdominoplasty, breast reconstruction). Plastic surgery ranges from cosmetic to reconstructive procedures of all body parts, and the surgeon has to refer to several different scores. Furthermore, often these scores include a lot of different risk factors. Many surgeons consider the record of all scores and relative risk factors too time-consuming, and

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Received for publication October 30, 2020; accepted January 13, 2021.

DOI: 10.1097/GOX.0000000000003472

Disclosure: *The authors have no financial interest to declare in relation to the content of this article. No funding is reported for the present study.*

the selection of infection high-risk patients is based on their own experience.

We have found a lot of interest in the Infection Risk Index (IRI) proposed by the National Nosocomial Infections Surveillance,[22–24] which was developed to predict surgical site infection (SSI) risk of the patient and to compare surgical infection rates among surgeons, among institutions, or across time. Patients are scored either 0 or 1 for each of the 3 categories that are based on the results of preoperative assessment, surgical wound classification, and duration of operation. Patients can therefore receive a score for IRI in the range 0 (low risk of SSI) to 3 (highest risk of SSI). Surgical infection rate increases from patients with none of the risk factors, to patients with all 3 risks. Actually, IRI score is applied in the European protocol for the surveillance of SSI, which ensures standardization of definitions, data collection, and reporting.[25]

The aim of the present study is to prove that IRI score can be used to standardize selection of infection high-risk patients undergoing different surgical procedures in our department.

MATERIAL AND METHODS

The present study was a comparative longitudinal retrospective study of 122 consecutive patients who had undergone post-bariatric abdominoplasty (Group A), 223 consecutive patients who had undergone bilateral reduction mammoplasty for breast hypertrophy (Group B), and 201 patients who had had a tissue loss with first intention healing (Group C) at the Division of Plastic Surgery of Modena University Hospital between 2007 and 2017. The patients were enrolled from the operation database of the clinic. The study was approved by the Ethics Committee of the Modena University Hospital (registration number 0006788/18).

Group A included bariatric patients who have excessive skin and/or pannus following significant weight loss, unchanged weight during the last year, BMI (body mass index) between 18 and 30, and age between 20 and 60 years.

Group B included patients with more than 500 g of breast tissue to be removed per breast or persistent symptoms (such as pain in the neck, shoulders, and upper back), directly attributed to macromastia and affecting daily activities for at least 1 year, and age between 20 and 60 years.

Group C included patients with a tissue loss (of traumatic origin for road traffic accidents, falls, violence, sport injuries and penetration such as stab wounds and bullets or for surgical removal of benign lesions) with first intention healing (with a surgical wound of 8–10 cm), and age between 20 and 60 years.

All patients who presented with collagen diseases or a history of cancer or prior surgical procedures or any comorbidity that could significantly alter skin biomechanics were excluded. For each patient, the IRI score[23–25] was calculated.

The IRI surgical patient risk index consists of scoring each operation by counting the number of risk factors present among the following 3:

1. A patient having an American Society of Anesthesiologists (ASA) preoperative assessment score of 3, 4, or 5[26,27] (Table 1);
2. An operation classified as either contaminated or dirty-infected[24] (Table 2);
3. An operation with duration of surgery more than T (minutes), where T depends on the operative procedure being performed (Table 3).

This risk index score ranges from 0 to 3 (Table 4). We recorded all cases of wound infection, which was defined as documented pus production, “infection,” or “abscess” of operative site within 30 days after surgery according to CDC’s criteria[25] (Table 5).

For each kind of surgical procedures (Group A, B, and C), we compared the percentage of SSI (as SSI rate and SSI ratio, Table 6) between 2 groups of patients: patients with 0 or 1 risk factor (IRI score 0 or 1), and patients with 2 or 3 risk factors (IRI score 2 or 3). The chi-square test

Table 1. ASA Physical Status Classification[26,27]

ASA Class	Definition	Definition
I	Normally healthy patient	Healthy, nonsmoking, no or minimal alcohol use
II	Patient with mild systemic disease	Mild diseases only without substantive functional limitations. Examples include (but not limited to): current smoker, social alcohol drinker, pregnancy, obesity (30 < BMI < 40), well-controlled DM/HTN, mild lung disease
III	Patient with severe systemic disease	Substantive functional limitations; 1 or more moderate-to-severe diseases. Examples include (but not limited to): poorly controlled DM or HTN, COPD, morbid obesity (BMI ≥ 40), active hepatitis, alcohol dependence or abuse, implanted pacemaker, moderate reduction of ejection fraction, ESRD undergoing regularly scheduled dialysis, premature infant PCA < 60 weeks, history (>3 months) of MI, CVA, TIA, or CAD/stents
IV	Patient with an incapacitating systemic disease that is a constant threat to life	Old traumatic wounds with retained devitalized tissue and those wounds including (but not limited to): recent (<3 months) MI, CVA, TIA, or CAD/stents, ongoing cardiac ischemia or severe valve dysfunction, severe reduction of ejection fraction, sepsis, DIC, ARD, or ESRD not undergoing regularly scheduled dialysis involve existing clinical infection or perforated viscera. This definition suggests that organisms causing postoperative infection are present in operative field before operation
V	Moribund patient who is not expected to survive for 24 h with or without operation	Examples include (but not limited to): ruptured abdominal/thoracic aneurysm, massive trauma, intracranial bleed with mass effect, ischemic bowel in the face of significant cardiac pathology, or multiple organ/system dysfunction

For IRI calculation, 1 point is given to the patient if ASA preoperative assessment is ASA III, ASA IV, or ASA V.

Table 2. Wound Classification[24]

Class	Definition
I. Clean	Uninfected operative wounds in which no inflammation is encountered and 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 nonpenetrating (blunt) trauma should be included in this category if they meet criteria.
II. Clean - contaminated	Operative wounds in which respiratory, alimentary, genital, or urinary tracts are entered under controlled conditions and without unusual contamination. Specifically, operations involving biliary tract, appendix, vagina, and oropharynx are included in this category, provided no evidence of infection or major break in technique is encountered.
III. Contaminated	Open, fresh, accidental wounds. In addition, operations with major breaks in sterile technique (eg, open cardiac massage) or gross spillage from gastrointestinal tract, and incisions in which acute, nonpurulent inflammation is encountered are included in this category.
IV. Dirty or infected	Old traumatic wounds with retained devitalized tissue and those wounds that involve existing clinical infection or perforated viscera. This definition suggests that organisms causing postoperative infection are present in operative field before operation.

For IRI calculation, 1 point is given to the patient if wound class is III (contaminated) or IV (dirty or infected).

Table 3. Distribution of Surgery Duration for 3 Different Operative Procedures

Type of Surgical Procedure	No. Operation	T 75th Percentile
Abdominoplasty	122	195 min
Reductive mastoplasty	223	235 min
Tissue loss with first intention healing	201	60 min

The 75th percentile of each distribution was identified and used as cut point "T" (in minutes), for distinguishing between operations of short and long duration. Here, T (75th percentile) of our operation is shown. For IRI calculation, 1 point is given to the patient if the duration of surgery is longer than T (75th percentile).

Table 4. IRI Score of Patients

	Criteria
IRI score 0	The patient has none of the following criteria: 1. ASA preoperative assessment is ASA III, ASA IV, or ASA V 2. Wound class is III (contaminated) or IV (dirty or infected) 3. Duration of surgery is longer than 75th percentile
IRI score 1	The patient has 1 of the following criteria: 1. ASA preoperative assessment is ASA III, ASA IV, or ASA V 2. Wound class is III (contaminated) or IV (dirty or infected) 3. Duration of surgery is longer than 75th percentile
IRI score 2	The patient has 2 of the following criteria: 1. ASA preoperative assessment is ASA III, ASA IV, or ASA V 2. Wound class is III (contaminated) or IV (dirty or infected) 3. Duration of surgery is longer than 75th percentile
IRI score 3	The patient has all of the 3 following criteria: 1. ASA preoperative assessment is ASA III, ASA IV, or ASA V 2. Wound class is III (contaminated) or IV (dirty or infected) 3. Duration of surgery is longer than 75th percentile

(χ^2) was used to compare the 2 groups. $P < 0.05$ was considered statistically significant.

RESULTS

In group A, we identified 101 patients with 0 or 1 risk factors (IRI score 0–1), 11 patients with 2 or 3 risk factors (IRI score 2–3) and 10 patients with unidentified (NA) risk factors (unknown IRI score). Among patients with IRI score 0–1 (101 patients), 3 patients developed an SSI, with an SSI Rate of 1.4% and an SSI Ratio of 2.97%, whereas among patients with IRI score 2–3 (11 patients), 3 patients developed an SSI with an SSI rate of 12.93% and an SSI ratio of 27.27%. SSI Ratio and SSI Rate are higher in patients with IRI 2–3, with a statistically significant difference, respectively χ^2 amount 87918 ($P = 0.003026$) and 10,8896 ($P = 0.000967$) (see Table 7).

Table 5. Summary of CDC Definition[25] of SSI

Superficial incisional SSI	Infection involves only skin or subcutaneous tissue, and the patient has at least 1 of the following: a. Purulent drainage (culture documentation not required) b. Organisms isolated from fluid/tissue of superficial incision c. At least 1 of the following signs of infection: pain or tenderness; localized swelling; redness; or heat d. Diagnosis of superficial incisional SSI by the surgeon or attending physician
Deep incisional SSI	Infection involves deep soft tissues of the incision (eg, fascial and muscle layers) and the patient has at least 1 of the following: a. Purulent drainage from the deep incision b. Fascial dehiscence or fascia is deliberately separated by the surgeon due to signs of inflammation c. An abscess or other evidence of infection involving the deep incision is found on direct examination, during invasive procedure, or by histopathologic examination or imaging test d. Diagnosis of a deep incisional SSI by a surgeon or attending physician.

In group B, we identified 201 patients with 0 or 1 risk factors (IRI score 0–1), 11 patients with 2 or 3 risk factors (IRI score 2–3) and 11 patients with unidentified (NA) risk factors (unknown IRI score). Among patients with IRI score 0–1 (201 patients), 6 patients developed SSI with an SSI rate of 1.568% and an SSI ratio of 2.99%, whereas among patients with IRI score 2–3 (11 patients), 2 developed SSI with an SSI rate of 10.87% and an SSI ratio

Table 6. Calculation of 2 Main Indicators for Each Type of Surgical Procedure: SSI Ratio and SSI Rate

SSI Ratio	$\frac{\text{SSIs}}{\text{Number of operations}} \times 100$
SSI Rate	$\frac{\text{SSIs}}{\text{Total amount of patient surveillance days}} \times 100$

Table 7. Results of Abdominoplasty Procedures

IRI Score	Abdominoplasty	SSI	Days Follow-up	SSI Ratio	SSI Rate
0–1	101	3	2143	2.970%	1.400%
2–3	11	3	232	27.273%	12.931%
NA	10	1	173	10.000%	5.780%
Total	122	7	2548	5.738%	2.747%

Note the increase in SSI ratio from 2.970% in IRI 0;1 to 27.273% in IRI 2;3 and the increase in SSI rate from 1.400% in IRI 0;1 to 12.931 % in IRI 2;3.

Table 8. Results of Reduction Mammoplasty Procedures

IRI Score	Reduction Mammoplasty	SSI	Days Follow-up	SSI Ratio	SSI Rate
0–1	201	6	3827	2.985%	1.568%
2–3	11	2	184	18.182%	10.870%
NA	11	0	167	0.000%	0.000%
Total	223	8	4178	3.587%	1.915%

Note the increase in SSI ratio from 2.985% in IRI 0–1 to 18.182 % in IRI 2–3 and the increase in SSI rate from 1.568% in IRI 0–1 to 10.870 % in IRI 2–3.

of 18.18%. SSI Ratio and SSI Rate are higher in patients with IRI 2–3 with a statistically significant difference, respectively χ^2 amount 5442 (P = 0.019658) and 7.5371 (P = 0.006044) (see Table 8).

In Group C, we identified 105 patients with 0 or 1 risk factors (IRI score 0–1), 78 patients with 2 or 3 risk factors (IRI score 2–3), and 18 patients with unidentified (ND) risk factors (unknown IRI score). Among patients with an IRI score of 0–1 (105 patients), 8 developed SSI, with an SSI rate of 4.29% and an SSI ratio of 7.62%, whereas among patients with an IRI score of 2–3 (78 patients), 24 developed SSI with an SSI rate of 21.22% and an SSI ratio of 30.77%. SSI Ratio and SSI Rate are higher in patients with IRI 2–3 with a statistically significant difference, respectively χ^2 amount 11.4508 (P = 0.000715) and 18.5897 (P = 0.000016) (See Table 9).

In all 3 groups, we found a difference of incidence of SSIs in patients with none or 1 risk factor (IRI 0–1) compared with patients with 2 or 3 risk factors (IRI 2–3), where an SSI is more apparent. IRI score is a significant predictor of SSI risk and performs well across a broad range of operative procedures.

DISCUSSION

Despite efforts made to improve the safety of surgical practices and decrease postoperative complications, SSIs remain a significant obstacle in health care.[28–30] Postoperative complications after plastic surgical

Table 9. Results of Tissue Loss Procedures with First Intention Healing

IRI Score	Tissue Loss with First Intention Healing	SSI	Days of Follow-up	SSI Ratio	SSI Rate
0–1	105	8	1863	7.619%	4.294%
2–3	78	24	1131	30.769%	21.220%
NA	18	0	127	0.000%	0.000%
Total	201	32	3121	15.920%	10.253%

Note the increase in SSI ratio from 7.619% in IRI 0–1 to 30769% in IRI 2–3, and the increase in SSI rate from 4294% in IRI 0–1 to 21.220 % in IRI 2–3.

procedures have been shown to have a negative impact on patient satisfaction.[31–34] Several algorithms described in the literature allow identifying patients at a high risk for post-surgical infections.[18–21]

For example, Kim et al[20,21] have used a large database to create a risk calculator for postoperative complications after immediate breast reconstruction by adding several known risk factors in a statistical model, which then calculates the risks for each individual patient of getting any of the numerous complications. This risk calculator is accessible on the internet for all clinicians.

These existing scores are procedure-specific and require an accurate record of several risk factors. This could be time-consuming for a plastic surgeon that performs different kind of surgical procedures during the day. We focused our attention on IRI score that is based on 3 parameters: ASA score, wound contamination classification, and operation duration. IRI score is extensively used in European surveillance system[25]; however, it is possible that practical application has never been taken into consideration in plastic surgery.

Our results suggest that IRI score is a significant risk score for plastic surgical postoperative infections. The IRI score is able to identify patients at high or low risk of postoperative infections even if it is based on only 3 factors (wound classification, ASA score, and duration of surgery) and it performs well across a broad range of operative procedures. In fact, the 3 groups of different surgical procedures (abdominoplasties, reduction mammoplasty, and tissue loss with surgical closure) show that patients with 0 or 1 risk factors (IRI score 0–1) have less of a chance to develop a SSI compared with patients with 2 or 3 risk factors (IRI 2–3).

For surgical wound infections, the traditional wound classification system, which stratifies each wound into 1 of 4 categories (clean, clean-contaminated, contaminated, and dirty-infected), has been recognized and recommended since 1964.[28–30,35] Limitations of this system of risk stratification are well recognized.[35] One of the major problems is its failure to account for intrinsic patient risk.

The American Society of Anesthesiologists Physical Status Classification System (ASA) ranks patients for risk of adverse events during a surgical procedure. It is an index designed to assess preoperatively the overall physical status of the patient, which ranges from 1, for an otherwise normally healthy patient to 5, for a patient not expected to survive the next 24 hours.[36–38] The ASA score is a critical component of the index, included in an attempt to measure intrinsic host susceptibility.[35]

This classification is used as a surrogate for the patient's underlying severity of illness and has been recommended for use in SSI and risk stratification.[35] ASA class can intuitively be appreciated as a tool in patient risk stratification because it inherently includes a large spectrum of patient comorbidities (such as hypertension, smoking, obesity, pulmonary diseases, alcohol abuse, and heart or liver deficiency), and therefore, advanced ASA class acts as a risk factor for postoperative adverse events.[39] For example, it includes risk factors such as age, diabetes, and obesity. A high ASA score is due to a combination of specific comorbidities. In patient demographics, old age had a significant correlation with higher ASA[39] such as diabetes and obesity that have been associated with a greater risk of SSIs as a result of tissue hypoperfusion and subsequently impaired immunological function.[14] ASA class assignment has been known to achieve 98% reliability across different anesthesiologists.[40]

We recognize timing of surgery as a third SSI risk factor for the correlation between exposure and contamination of surgical wounds. In the literature, duration of surgery is found to be a risk factor for postoperative complications such as wound infection and wound dehiscence in different plastic surgical procedures.[41–47] Of course, it is related to different patient characteristics (such as obesity) that have been found to be connected with both longer operation time and increased frequency of complications such as infections and wound dehiscence.[48]

The 75th percentile was widely found to have a discriminatory power. Extremely long duration of surgery may serve as a marker for the complexity of the individual case, some aspect of surgical technique, and for certain procedures, the possible diminished effects of antimicrobial prophylaxis.[35] In our opinion, the correlation between longer operation time and complications is due to procedure-related risk factors. For example, there can be a relationship between thick fat tissue layer and duration of surgery: in fact, dissection, hemostasis, and suture time is without doubt long-lasting. For these reasons, the duration of surgery should be kept to a minimum.[24]

There are concerns about all kind of surgical procedures in different fields, that wound class remains a moderately effective predictor of SSI risk. However, as a single predictor of SSI risk, the ASA score is at least as good as the traditional wound classification system. Considerable improvement is obtained in predicting SSI risk when all 3 risk factors are combined into the composite index.[35] Our results in plastic surgery are in agreement with the results of several other surgeries in which SSI increases from patients with none or one of the risk factors to patients with 2 or 3 of the risk factors present.[35] Within each category of the traditional wound classification system, SSI rates increase considerably with the number of risk factors present. Of the 122 patients with clean operative procedures, 101 patients had 0 or 1 of the risk factors, and 11 patients had both operation of long duration and an ASA score of 3, 4, or 5. The increase in SSI ratio from 2.97% to 27.27% infections per 100 clean operations highlighted that all clean wounds do not carry the same SSI risk. The same can be stated for breast reduction.

The risk of postoperative complications has been shown to be related to patient risk factors but also to the surgical method[49] and to some perioperative factors.[50] In fact, the surgical method itself is important because different methods can have different patterns of complications.[51–56]

The present study includes a large series of consecutive patients from a single center, with long-time follow-up by surgeons, and the same criteria were meticulously used to define and report medical information. A factor that can certainly affect the duration of surgery is the experience of the surgeon who performs the procedures. However, in our teaching center, the surgical skill is well-established (a resident, a consultant without extensive experience, and a consultant with extensive experience) so that all surgical procedures have been performed by one with similar experience. All surgical procedures are also well-established according to our resident training program, and the use of surgical devices and sutures is strictly adhered to.

IRI score has several advantages: general applicability within a broad range of operative procedure categories; simplicity of application because of being based on only three factors; easily available at the end of surgery when duration of surgery is recorded and the factors documented.

Nevertheless, limitations of this system of SSI risk stratification are easy to understand: IRI score cannot be applied to outpatients at surgical clinic, where usually there is not an anesthesiologist and the time of surgery is not recorded; it is not procedure-specific and it does not take into considerations important factors such as antibiotic prophylaxis in those procedures where it has been shown to be effective. Moreover, in our study we have not mentioned individual predictive factors such as drugs, smoking, hyperglycemia, diabetes, and blood transfusion, which are taken into consideration in several SSI score systems.[57–58] Nevertheless, we think that the ASA class includes a large spectrum of patient comorbidities and predictive factors of SSI, and therefore, advanced ASA class acts as a comprehensive risk factor. We conclude that patients scored as IRI 2–3 have a significantly higher SSI risk than patients scored as IRI 0–1. We observe this phenomenon in every operation category that we included in our study. We reasonably hypothesize to effect preventive strategy for risk reduction (such as negative pressure therapy application or prophylactic antibiotic therapy prevention) in IRI class 2–3 and obtain cost-effectiveness and results-effectiveness.

CONCLUSIONS

In this study, it was verified that higher IRI index assignments show a significant correlation with SSI. Our results suggest the utility of IRI score in refining the infection risk stratification profile and improving postoperative cares for those patients with IRI 2–3.

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