



UNIVERSITY OF GOTHENBURG

Blood loss and duration of surgery are independent risk factors for complications after breast reconstruction

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ABSTRACT

Background: Complications after breast reconstructive surgery are common, and they can be caused by a wide range of factors. The aim of the present study was to identify independent perioperative risk factors for postoperative complications after breast reconstruction.

Methods: A retrospective study of 623 consecutive breast cancer patients who had undergone deep inferior epigastric perforator (DIEP) flap, latissimus dorsi (LD) flap, lateral thoracodorsal flap (LTDF), or tissue expander with secondary implant (EXP) was performed. Data on demography, perioperative parameters, and complications were collected. Logistic regression models adjusted to the reconstruction method and to confounding demographic factors were used for statistical analysis.

Results: Increased blood loss for each 10-ml step, increased in the risk for overall early complications ($p=0.017$), early seroma ($p=0.037$), early resurgery ($p=0.010$), late local overall complications ($p=0.024$) and late fat necrosis ($p=0.031$). Longer duration of surgery for each 10-minute step, increased the risk of overall early complications ($p=0.019$), but in the univariate model, there was an increased risk for nine different types of complications ($p=0.004-0.029$). There was no association between the experience of the surgeon performing the procedure and the frequency of complications.

Conclusions: Duration of surgery and blood loss during surgery are independent risk factors for postoperative complications, and should be minimised. Further research is needed to establish the association between the experience of the surgeon and the occurrence of complications.

Key words: breast cancer, breast reconstruction, postoperative complications, perioperative factor, duration of surgery, blood loss during surgery

INTRODUCTION

Complications after breast reconstruction are common,[1-6] and they can affect patients' emotional well-being and satisfaction.[5, 7, 8] Many patients suffer complications that could possibly be avoided.

The risk of complications has been shown to be related to several factors.[9-11] Firstly, the surgical method itself is important, because different methods have different patterns of complications.[12] Secondly, the risk is also associated with certain patient characteristics, such as age, smoking, overweight and adjuvant cancer therapy.[2, 6, 12-17] Thirdly, some perioperative factors have also been shown to be associated with postoperative complications.[18]

Previous studies on the effects of different perioperative factors on postoperative complications have shown inconsistent results. Prolonged operation time has been found to be a risk factor for loss of tissue expander,[19, 20] and other complications, such as fat necrosis, skin necrosis and infection.[21, 22] Woerdeman et al. analysed six patient-related and nine procedure-related characteristics as potential risk factors for complications in a prospective study on immediate reconstruction, and found the experience of the surgeon and weight of the specimen to have an association with postoperative complications.[23] Fischer and co-workers have used the National Surgical Quality Improvement Program (NSQIP) database to associate many patient-related and perioperative risk factors with outcome after breast reconstruction.[24-26] Kim et al. have taken it one step further and used the 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 numerous complications. This risk calculator is accessible on the Internet for all clinicians.[27, 28]

On the other hand, several studies have failed to show any relationship between the duration of surgery and hematoma [29] or other postoperative complications such as wound complications, flap failure, thromboembolism or respiratory complications.[9, 10, 30] There is a correlation between obesity and both longer operation time and increased frequency of complications such as infections, thromboembolism and wound dehiscence.[26]

The relationship between perioperative blood transfusion and complications has been studied and a strong correlation has been found, but the perioperative blood loss was not directly reported.[25, 31, 32] Other studies have failed to show any correlation between the degree of blood loss and several different patient characteristics.[21]

The aim of the present study was to identify independent perioperative risk factors for postoperative complications after breast reconstruction.

MATERIALS AND METHODS

The present study was a retrospective study of 623 consecutive patients with a history of breast cancer, who had had delayed breast reconstruction at the Department of Plastic Surgery, Sahlgrenska University Hospital, Gothenburg, Sweden, between 2003 and 2009. The patients were enrolled from the operation database of the clinic (Operätt; C&S Healthcare Software AB, Mölndal, Sweden). The inclusion criteria were first-time delayed reconstruction with (1) deep inferior epigastric perforator (DIEP) flap [33], (2) latissimus dorsi (LD) flap [34], (3) lateral thoracodorsal flap

(LTDF) with silicone implant[35] or (4) tissue expander with a secondary silicone implant (EXP).[36] The primary (expander) and secondary (implant) procedures were both registered separately and compiled in the EXP group. Existing data on at least 30 days of follow-up time were required. Patients who were lost to follow-up were excluded. Data were collected from the chart filing systems (Melior [Siemens Healthcare, Upplands Väsby, Sweden] and Operätt) from the patient's first referral to the last follow-up visit.

The demographic parameters registered are seen in Table I.

The registered pharmaceuticals used were on-going adjuvant hormone therapy, acetylsalicylic acid, corticosteroids, thyroid supplements and anticoagulants. The concurrent morbidities registered were diabetes, hypothyroidism, cardiovascular disease, history of thromboembolism, coagulopathy, and rheumatic disease, neurologic disease, kidney disease, liver disease, or lung disease.

The perioperative parameters registered are shown in Table II.

The experience of the surgeon was divided into consultants with > 5 years' experience of breast reconstructions, consultants with < 5 years' experience of breast reconstructions, or residents. The duration of surgery was measured from the first incision to the last stitch, and blood loss during surgery was measured by volume of blood in the suction system and the weight of gauzes used.

The registered postoperative complications are shown in Table III. They were divided into early complications (≤ 30 days after surgery) and late complications (> 30 days after surgery). Overall local complications were also subdivided into skin necrosis, fat necrosis, hematoma, seroma and wound rupture. The late postoperative complications registered were the same as the early complications, but in addition, occurrence of scars in need of treatment, late resurgery and cosmetic corrections were registered.

The data were processed in a secure FileMaker database (Filemaker Inc., Santa Clara, CA, USA).

Statistics

Logistic regression was used to study the association between the independent possible risk factors and the dependent outcome parameters (the postoperative complications). Because the reconstruction methods varied significantly regarding the duration of surgery, blood loss during surgery and the incidence of postoperative complications, all models were statistically adjusted for the reconstructive method. This means that the reconstructive method itself was not a factor that biases the results of the statistical analysis. To establish whether the experience of the surgeon, the duration of the surgery or perioperative blood loss had an independent effect on the outcome factors, a multivariate logistic regression, with adjustment for patient demographic parameters acting as confounding factors, was performed. This means that all demographic factors that acted as confounding factors were statistically adjusted for, and they do not bias the results of the statistical analysis. Relationships between independent variables (i.e., possible risk factors) and dependent (outcome) variables are presented with odds ratio (OR), 95% confidence interval (CI) and p-value (p). Values of $p < 0.05$ were considered statistically significant. Statistical analysis was performed with SPSS 23 (IBM Corp., Armonk, NY, USA). The study was approved by the Gothenburg Ethical Committee (No. 043-08).

RESULTS

Experience of the surgeon performing the procedure as an independent risk factor for complications.

No association was seen between the identity or experience of the surgeon and any of the registered postoperative complications.

Blood loss as an independent risk factor for complications

Table IV shows the association between the amount of blood loss and the risks for postoperative complications. The univariate model shows a clear association between increased blood loss in 10-ml steps and increased risk for numerous early and late complications. The multivariate model, adjusted for the reconstructive method and for all demographic factors acting as confounding factors, shows that for each 10-ml step of blood loss during the procedure, the risk increased for overall early complications (OR 1.019 / CI 1.003–1.036 / $p = 0.017$), early seroma (OR 1.016 / CI 1.004–1.032 / $p = 0.037$), early resurgery for complications (OR 1.019 / CI 1.004–1.037 / $p = 0.010$), late overall complications (OR 1.019 / CI 1.003–1.036 / $p = 0.024$) and late fat necrosis (OR 1.023 / CI 1.002 – 1.044 / $p = 0.031$).

This means, for example, that the risk for encountering any early complication increases by 1.9% for each 10-ml of blood loss during the surgical procedure (Figure 1). As a result, significant blood loss during a procedure can explain why there is a substantial increase in the risk for an early overall complication.

Duration of surgery as an independent risk factor for complications

Table V shows the association between the duration of surgery and the risks for postoperative complications. The univariate model shows a clear association between increased duration of surgery in 10-minute steps and increased risk for numerous early and late complications. The multivariate model, adjusted for reconstructive method and all demographic factors acting as confounding factors, shows that for each 10-minute step of duration of surgery, the risk increased for overall early complications (OR 1.052 / CI 1.008 – 1.097 / p=0.019). This means that the risk for encountering any early complication increases by 5.2% for each 10 minutes in the duration of surgery (Figure 2). As a result, a long duration of surgery can explain a substantial increase of the risk for any early complication.

DISCUSSION

Breast reconstructions are an important part of the treatment after breast cancer and have been shown to reduce the psychosocial morbidity and to increase quality of life.[37-40] Postoperative complications after breast reconstructions have also been shown to have a negative effect on patient satisfaction.[7, 41-43] The aim of the present study was to identify independent perioperative risk factors for postoperative complications after breast reconstructive surgery. To be able to isolate the registered perioperative factors (the surgeon, the duration of surgery and the blood loss during surgery), a statistical adjustment was carried out, both for the reconstructive method (e.g., DIEP takes longer time, and increased blood loss compared to the EXP group) and the demographic factors acting as confounding factors, in the model. This means

that the results are not explained by various demographic factors, or by the reconstructive method.

The most important finding of the present study was that both duration of surgery and perioperative blood loss were significant independent risk factors for several postoperative complications.

The results are in agreement with the results of several other studies in which prolonged duration of surgery was found to be a risk factor for tissue expander loss,[19, 20] wound infection,[44] or other postoperative complications such as wound dehiscence and flap failure.[22, 45-47] However, several other studies in the field of plastic surgery have failed to detect such a relationship.[48-50]

Lymperopoulos et al. found a high correlation between the duration of surgery and several postoperative complications, such as fat necrosis, infection and partial flap failure, but failed to identify a correlation between patient characteristics, or blood loss and complications.[21]

Another study showed a clear relationship between the need for blood transfusion and complications, but there was no significant correlation between blood loss and various patient characteristics.[31] However, in the present study, there was a clear relationship between blood loss and complications. In the multivariate model, where all patient-related factors were adjusted for statistically, the association remained strong, so the results can be interpreted as a real association without the possibility of confounding factors being the true reason for the results. Consequently, our results indicate that the duration of surgery should be kept to a minimum, and that meticulous surgical technique to minimise blood loss is also important. In the hands of skilled surgeons, meticulous hemostasis is not consistent with markedly increased duration of surgery.

The National Surgical Quality Improvement Program (NSQIP) database has been extensively used to associate many patient-related and perioperative factors to outcome after breast reconstruction. The strength of the database is the huge number of patients used for the statistical analyses, but it is impossible to examine potential biases in the reporting, there are gaps in the data collecting,[28] and many of the reported outcome measures are assessed by trained nurses.[51] The present study includes a large series of consecutive patients from a single centre, with long-time follow-up by surgeons, and the same criteria were meticulously used to define and report all complications. The accurate methodology of the present study, when giving the entire complication picture where all of the reconstructive methods are evaluated with the same standards of definitions for each complication, and its large material is one of the main strengths of the study, despite the absence of the possibility to grade the complications.

A factor that can certainly affect both the duration of surgery and the degree of blood loss during surgery is the experience of the surgeon who performs the procedure. It is well established that the experience of the surgeon is associated with a low frequency of complications.[52-55] However, in the present study, no correlation was seen between the experiences of the 8 surgeons (resident, consultant without extensive experience, consultant with extensive experience). There could be several explanations for these results. Firstly, the accurate methodology of registering all postoperative occurrences as complications give no room for grading the severity of each complication. More experienced surgeons may have had complications of a milder degree than less experienced surgeons. Secondly, more experienced surgeons may have operated on patients for whom the preconditions for successful results were harder. Thirdly, there is a certain bias in the distribution of the cases between the

surgeons, in which only two of them carried out all of the microsurgical reconstructions besides the other methods, but the others only performed the non-microsurgical reconstructions. Furthermore, in the present study, no attempt is carried out to evaluate if there were differences in the cosmetic results between more and less experienced surgeons.

Through examination of the four methods of breast reconstructive surgery, the present study has highlighted the importance of blood loss during surgery and duration of surgery as independent risk factors for postoperative complications. However, to obtain a more complete overview of possible risk factors that affect postoperative complications, patient-related factors, concurrent diseases and adjuvant cancer treatment should also be analysed.

CONCLUSION

Duration of surgery and blood loss during surgery were found to be important independent risk factors for postoperative complications, and should be kept to a minimum. Further research is needed to establish the association between the experience of the surgeon and the occurrence of complications.

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References

FIGURE LEGENDS AND TABLES

Table I: Demographic data collected

Table II: Perioperative data collected

Table III: Postoperative complications and follow-up data collected

Table IV: Blood loss as a risk factor for early and late postoperative complications.

Table V: Duration of surgery as a risk factor for early and late postoperative complications.

Figure 1: Diagrams explaining further the results of the multivariate statistical model for perioperative blood loss and early complications. For each 10-ml step of blood loss, the predicted probability for early overall complications, early seroma and early resurgery increased for all four methods.

Figure 2: Diagram explaining further the results of the multivariate statistical model for duration of surgery and early overall complications. For each 10-minute step of the duration, the predicted probability for any early overall complication increased for all four methods.

Table I

Demographic data
Age
BMI
Smoking
Radiotherapy
Chemotherapy
Pharmaceuticals used
Concurrent morbidity
Follow-up time

Table II

Perioperative data
Identity of surgeon
Experience of surgeon
Duration of surgery
Blood loss during surgery

Table III

Postoperative complications	
Early (≤ 30 days)	Overall complications
	Signs of infection
	Administration of antibiotics
	Overall local complications
	Resurgery for complications
Late (> 30 days)	Same as early complications
	Scars in need of treatment
	Late resurgery/cosmetic corrections

Table IV

Blood loss (10-ml steps)	Univariate model		Adjusted for confounding factors*	
	Odds ratio (95 % CI)	p- value	Odds ratio (95 % CI)	p- value
Early complications				
Overall complications (n=192)	1.022 (1.013-1.030)	<0.001	1.019 (1.003-1.036)	0.017
Signs of infection (n=80)	1.008 (1.000-1.016)	0.040	1.008 (0.997-1.019)	0.157
Antibiotics administration (n=104)	1.008 (1.000-1.016)	0.040	1.004 (0.995-1.014)	0.374
Local overall complications (n=107)	1.010 (1.002-1.018)	0.018	1.002 (0.992-1.012)	0.715
- Fat necrosis (n=26)	1.025 (1.012-1.038)	<0.001	1.013 (0.997-1.029)	0.125
- Skin necrosis (n=41)	1.010 (1.001-1.018)	0.032	1.004 (0.991-1.017)	0.565
- Hematoma (n=26)	1.005 (0.996-1.015)	0.277	1.007 (0.988-1.026)	0.484
- Seroma (n=40)	1.010 (1.001-1.020)	0.024	1.016 (1.004-1.032)	0.037
- Wound rupture (n=9)	1.007 (0.994-1.020)	0.302	n.a.**	
Resurgery for complications (n=76)	1.023 (1.014-1.033)	<0.001	1.019 (1.004-1.037)	0.010
Late complications				
Overall complications (n=336)	1.002 (0.995-1.008)	0.567	1.006 (0.995-1.016)	0.320
Signs of infection (n=57)	1.006 (0.998-1.014)	0.115	1.004 (0.993-1.015)	0.473
Antibiotics administration (n=63)	1.005 (0.997-1.013)	0.213	1.004 (0.993-1.015)	0.502
Local overall complications (n=35)	1.016 (1.004-1.027)	0.007	1.019 (1.003-1.036)	0.024
-Fat necrosis (n=19)	1.018 (1.004-1.031)	0.011	1.023 (1.002-1.044)	0.031
-Skin necrosis (n=8)	1.007 (0.994-1.020)	0.306	n.a.**	
-Hematoma (n=2)	0.994 (0.898-1.100)	0.905	n.a.**	
-Wound rupture (n=9)	1.006 (0.991-1.021)	0.434	n.a.**	
-Seroma (n=4)	0.993 (0.944-1.046)	0.802	n.a.**	
Scars in need of treatment (n=24)	1.005 (0.995-1.015)	0.339	0.982 (0.949-1.017)	0.305
Resurgery/Cosmetic corrections(n=301)	1.001 (0.995-1.007)	0.793	1.006 (0.996-1.017)	0.251
*Multivariate regression adjusted for demographic factors acting as confounding factors: age, BMI, smoking, diabetes, glucocorticoids, adjuvant hormone therapy, radiotherapy, chemotherapy and reconstruction method.				
**Due to low occurrence frequency, early wound rupture, late hematoma, late skin necrosis, late wound rupture, and late seroma were not applicable for multivariate analysis.				

Table V

Duration of surgery (10-min steps)	Univariate models		Adjusted for confounding factors*	
	Odds ratio (95 % CI)	p- value	Odds ratio (95 % CI)	p-value
Early complications				
Overall complications (n=192)	1.040 (1.026-1.056)	<0.001	1.052 (1.008-1.097)	0.019
Signs of infection (n=80)	1.020 (1.002-1.038)	0.027	1.050 (0.990-1.114)	0.107
Antibiotic administration (n=104)	1.030 (1.014-1.047)	<0.001	1.019 (0.967-1.074)	0.477
Local overall complications (n=107)	1.042 (1.026-1.059)	<0.001	1.018 (0.967-1.071)	0.504
- Fat necrosis (n=26)	1.085 (1.057-1.114)	<0.001	1.038 (0.962-1.121)	0.338
- Skin necrosis (n=41)	1.059 (1.037-1.081)	<0.001	1.048 (0.982-1.117)	0.156
- Hematoma (n=26)	1.011 (0.981-1.042)	0.483	0.913 (0.814-1.025)	0.125
- Seroma (n=40)	1.014 (0.990-1.039)	0.252	1.049 (0.954-1.152)	0.324
- Wound rupture (n=9)	1.035 (0.993-1.078)	0.102	n.a.**	
Resurgery for complications (n=76)	1.041 (1.024-1.059)	<0.001	1.008 (0.954-1.066)	0.771
Late complications				
Overall complications (n=336)	0.994 (0.981-1.007)	0.357	0.994 (0.952-1.039)	0.799
Signs of infection (n=57)	1.012 (0.991-1.033)	0.269	1.026 (0.958-	0.463
Antibiotic administration (n=63)	1.014 (0.994-1.034)	0.173	1.036 (0.968-	0.304
Local overall complications (n=35)	1.036 (1.013-1.059)	0.002	1.008 (0.937-	0.823
- Fat necrosis (n=19)	1.043 (1.014-1.073)	0.003	1.015 (0.928-	0.742
- Skin necrosis (n=8)	1.053 (1.012-1.095)	0.010	n.a.**	
- Hematoma (n=2)	0.733 (0.463-1.162)	0.187	n.a.**	
- Wound rupture (n=9)	0.971 (0.868-1.085)	0.601	n.a.**	
Seroma (n=4)	1.007 (0.955-1.060)	0.808	n.a.**	
Scars in need of treatment (n=24)	1.000 (0.993 – 1.072)	0.999	n.a.**	
Resurgery / cosmetic corrections (n=301)	0.993 (0.961 –	0.680	0.991 (0.956 –	0.610

*Multivariate regression adjusted for demographic factors acting as confounding factors: age, BMI, smoking, diabetes, glucocorticoids, adjuvant hormonal therapy, chemotherapy, radiotherapy and reconstruction method.

**Due to low occurrence frequency, early wound rupture, late skin necrosis, late hematoma, late wound rupture and late seroma were not applicable for multivariate analysis.