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Associations Between Prior COVID-19 Infection and Venous Thromboembolism Following Common Plastic Surgery Operations

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SUMMARY

Introduction: SARS-CoV-2 (COVID-19) infection has been described as a cause of systemic hypercoagulability and a risk factor for the development of venous thromboembolism (VTE). While some multi-specialty studies have proposed a link between COVID-19 and postoperative thrombosis, other, single-specialty studies have found no such association. We utilized a large, national database to determine whether prior COVID-19 infection was associated with the incidence of VTE following common plastic surgery operations.

Methods: The Merative™ MarketScan® Research Databases were used to identify female patients who underwent index abdominal panniculectomy, breast reduction, autologous breast reconstruction or implant-based breast reconstruction procedures between 2020 and 2021. International Classification of Disease, tenth edition (ICD-10) codes were used to identify patients who were diagnosed with COVID-19 preoperatively and those who experienced a VTE in the 90 days postoperatively. Propensity score matching and multivariable logistic regression were used to determine any independent association between COVID-19 and postoperative VTE.

Results: 24,228 patients met inclusion criteria. Mean age at time of surgery was 44 years. 6.0% carried a preoperative COVID-19 diagnosis, and postoperative VTE occurred in 1.3%. In a propensity-score-matched analysis of 2,754 patients, COVID-19 did not significantly correlate with incidence of postoperative VTE ($p = 0.463$). Compared to a matched pre-pandemic cohort

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(14,151 patients), the incidence of VTE did not increase following any of the four studied procedures during the COVID-19 pandemic.

Conclusion: This analysis of a national insurance claims database provides evidence against a link between resolved COVID-19 infection and VTE within 90 days of four common plastic surgery operations.

Keywords

COVID-19; SARS-CoV-2; plastic surgery; venous thromboembolism

INTRODUCTION

As the world emerges from the SARS-CoV-2 (COVID-19) pandemic, questions remain about how a history of infection might predispose patients to subsequent poor health outcomes, including complications of surgery. The literature has linked a number of secondary disorders – myocarditis, persistent arrhythmia, chronic pulmonary disease, permanent kidney fibrosis, depression, anxiety – to long-COVID or prior COVID-19 infection.[1–4] COVID-19 has also been identified as a cause of systemic hypercoagulability and a risk factor for the development of venous thromboembolism (VTE), a common complication of surgery that has become the target of quality improvement efforts in many fields, including plastic surgery.

The exact pathogenesis of hypercoagulability in COVID-19 is not well understood, but may be caused by direct endothelial injury, microvascular inflammation, decreased fibrinolysis, blood hyperviscosity, thrombophilia, or a combination thereof.[5–8] While COVID-19 has been strongly implicated in the incidence of VTE among patients in the intensive care unit (ICU), and, to a lesser extent, those on the non-ICU wards, comparatively little is known about how COVID-19 infection affects the risk of perioperative thrombosis.[9–11] Relative to medical patients, surgical patients are exposed to a different set of risk factors for VTE including immobility, vascular injury, wounds, systemic inflammation, and acute blood loss, and therefore, warrant more targeted investigation. Yet, the literature remains sparse and conflicted on how a recent or remote history of COVID-19 infection might impact the rate of deep vein thrombosis (DVT) or pulmonary embolism (PE) in the postoperative period.[12–17]

VTE is one of the most devastating complications that can occur following a plastic surgery operation. An estimated 33,000 plastic surgery patients develop postoperative VTE annually, with the incidence varying widely by procedure type.[18] Post-bariatric patients undergoing abdominal body-contouring procedures are particularly prone to VTE, with rates reported as high as 6.6% when abdominoplasty is combined with another procedure.[19–22] Though VTE is rarer following breast surgery, 25% of plastic surgeons who perform autologous breast reconstruction report personally diagnosing one of their patients with a postoperative PE.[23] In general, rates of postoperative VTE are estimated at approximately 2% following the riskiest plastic surgery operations – like abdominoplasty or autologous breast reconstruction – to about 0.2% after breast reduction.[22,24–30] Crucially, PE is the leading cause of in-hospital mortality, and both PE and DVT frequently lead to debilitating sequelae in the form of post-thrombotic syndrome, pulmonary hypertension, and right heart failure.[31]

Recent studies estimate that 42% to 94% of the United States adult population has been infected by the SARS-CoV-2 virus.[32,33] Given this near-ubiquity, it will soon be impossible for surgeons in any field to avoid operating on patients with a history of COVID-19 infection. With the link between COVID-19 and VTE well-established in the medical literature, it is critical for surgeons in every specialty to understand how prior infection affects the risk of thrombosis following one of their procedures. In this study, we utilized the Merative™ MarketScan® Research Databases, a family of large, national insurance claims datasets, to determine whether prior COVID-19 infection should be considered a risk factor for VTE following four common plastic surgery operations. We hypothesized that a recent history of COVID-19 would confer a significant increase in the thromboembolic risk following any of these procedures.

METHODS

Data Source and Study Cohort

We used the Merative™ MarketScan® Research Databases to conduct a retrospective analysis of patients who underwent four index plastic surgery procedures during the COVID-19 pandemic to assess the effect of preoperative SARS-CoV-2 infection on the incidence of postoperative VTE.[34] The Merative™ MarketScan® Research Databases is a family of large, national commercial insurance datasets that contains inpatient, outpatient, and pharmaceutical claims data involving 183 million unique patients dating back to 1995. Female patients who underwent an abdominal panniculectomy, breast reduction, index autologous breast reconstruction, or index implant-based breast reconstruction procedure between January 1, 2020 and December 31, 2021 were identified using Current Procedural Terminology (CPT) codes (Supp. Table 1). International Classification of Disease, Ninth and Tenth edition (ICD-9 and -10), codes were used to identify patients who were diagnosed with COVID-19 prior to the index surgery and patients who experienced a VTE during the 90 days after surgery (Supp. Table 2). Patients who underwent multiple instances of the included procedures were excluded, as were patients who underwent additional procedures requiring anesthesia within 90 days of the index surgery (Supp. Table 1).

The Stanford Center for Population Health Sciences hosts the Merative™ MarketScan® Research Databases and covers any studies using their deidentified datasets under an umbrella institutional review board (IRB) application. As our study does not involve human subject research, individual IRB approval was not required. Per requirements stipulated by the Stanford Center for Population Health Sciences, cells of n < 11 were not reported.

Diagnosis and Prescription Claims

Insurance claims data were used to identify the year in which the index procedure was performed, patient age at the time of surgery, comorbidities, preoperative VTE risk factors, and fills of estrogenic hormone medications in the two weeks preceding the index surgery. History of vaccination or partial vaccination (i.e., having received at least one round of immunization) against COVID-19 and preoperative COVID-19 diagnoses were also extracted. Records of commonly used forms of VTE chemoprophylaxis (i.e., subcutaneous unfractionated or low-molecular weight heparin) within the two days following the index procedure were considered as evidence of postoperative VTE prophylaxis. Comorbidities were assessed and reported with the Elixhauser comorbidity index, using ICD-10 codes. The Elixhauser index is a set of 38 comorbidity indicators, updated for use with the ICD-10 coding system, that has been widely validated to describe comorbidity burden and predict in-hospital mortality and 30-day hospital readmission.[35,36] Of the Elixhauser comorbidities, hypertension, coagulopathy, obesity (BMI ≥ 30 kg/m^2), peripheral vascular disease, diabetes, and chronic pulmonary disease were parsed and considered independently. Linked pharmaceutical claims data were used to identify medications and filled prescriptions.

Outcomes, Covariables, and Statistical Analysis

Development of postoperative VTE within 90 days of the index operation was the primary outcome of this study.

Propensity score matching was utilized to determine the independent influence of preoperative COVID-19 diagnosis on the odds of developing postoperative VTE. Individual propensity scores were calculated through logistic regression modeling on a number of relevant covariates (see Table 2). Patients who were not diagnosed with COVID-19 preoperatively were matched 1:1 using nearest-neighbor selection without replacement against patients who did have a preoperative COVID-19 diagnosis using the generated propensity scores. Pairs were matched exactly on procedure type. The maximum caliper distance was set at 0.1. Standardized mean differences (SMDs) were compared after matching. Within this matched cohort, logistic regression modeling was used to calculate an odds ratio for the association between postoperative VTE and preoperative COVID-19 diagnosis.

Given potential for inconsistent diagnosis and reporting of COVID-19 during 2020 and 2021, we generated a second propensity-matched model that matched the cohort of patients who underwent surgery during 2020 and 2021 with patients who underwent the same procedures in 2018 and 2019, before the pandemic. Patients who underwent surgery in both 2018–2019 and 2020–2021 were excluded. Individual propensity scores were calculated using the same methodology as above (see Table 5). Patients who underwent the index surgery in 2018 or 2019 were matched with patients who underwent surgery in 2020 or 2021 using 1:1 nearest-neighbor selection without replacement through the generated propensity scores. Pairs were matched exactly on procedure type; maximum caliper distance was set at 0.1. SMDs were compared after matching. To compare these matched cohorts, we calculated rates of postoperative VTE per 1,000 patients in 2018–2019 and 2020–2021 for each index procedure; we compared rates between the two time periods using chi-squared tests. Additionally, logistic regression modeling performed on the matched patients generated an odds ratio for experiencing postoperative VTE attributable to undergoing surgery in 2020 or 2021 (versus in 2018 or 2019).

Shapiro-Wilk testing was used to determine whether continuous variables were normally distributed. Chi-squared, propensity-score-matched logistic regression, and multivariate logistic regression tests were used for statistical analysis. P values of < 0.05 were considered statistically significant. All analyses were completed using Stata, version 17 (StataCorp

LLC, College Station, TX, USA). Some figures were generated using Microsoft Excel (2023).

RESULTS

Among the 24,228 patients who met inclusion criteria, 305 (1.3%) experienced a postoperative VTE event within 90 days of the index surgery (Figure 1). Average (± SD) age at the time of surgery was 44.1 (± 12.5) years, and a similar proportion of operations were performed in 2020 and 2021 (49.6% and 50.4%, respectively). The most common operation was breast reduction (47.5%), followed by implant-based breast reconstruction (42.5%), panniculectomy (6.6%), and autologous breast reconstruction (3.4%). Comorbidity levels were moderate; 42.3% of patients had Elixhauser comorbidity index scores of four or higher. The most common preoperative VTE risk factors were obesity (41.9%), hypertension (32.8%), chronic pulmonary disease (22.5%), and diabetes (11.4%). Almost half of patients (46.9%) were vaccinated or partially vaccinated against COVID-19 at the time of surgery. 6.0% of patients had a preoperative COVID-19 diagnosis on record, with the largest portion (4.1% of all patients) being diagnosed with COVID-19 more than 90 days prior to the index surgery. 1.1% of patients were prescribed postoperative VTE prophylaxis. These characteristics are displayed in Table 1.

Patients who had preoperative COVID-19 diagnoses were matched 1:1 with patients who did not have preoperative COVID-19 diagnoses across age, surgery year, procedure type (exact matching), Elixhauser comorbidity index categories, preoperative VTE risk factors, COVID-19 vaccination status, and receipt of postoperative VTE prophylaxis. Table 2 compares these covariate characteristics before and after propensity score matching and demonstrates acquired balance in these characteristics after matching. This propensity-matched cohort amounted to 2,754 patients (1,377 patients without a preoperative COVID-19 diagnosis, and 1,377 patients with a preoperative COVID-19 diagnosis). Within the matched cohort, VTE occurred in 26 patients (1.9%) without a COVID-19 diagnosis and 21 patients (1.5%) with a prior COVID-19 diagnosis. Following the effective matching illustrated in Figure 2, logistic regression was used to calculate the effect of preoperative COVID-19 diagnosis on the average odds of developing postoperative VTE (Table 3). In this model, preoperative COVID-19 diagnosis was not independently associated with postoperative VTE within the 90 days following surgery ($p = 0.463$).

Table 4 describes independent associations between certain patient characteristics and odds of postoperative VTE among the entire (unmatched) 2020 – 2021 cohort. We used a multivariable logistic regression model in which index procedure type was considered a random effect given its baseline risk variation. Given multiple testing, a Bonferroni adjustment was applied to all *P* values. Older age ($p < 0.001$), history of VTE (OR 11.455; $p < 0.001$), coagulopathy (OR 3.792; $p < 0.001$), history of peripheral vascular disease (OR 2.306; $p < 0.001$), chronic pulmonary disease (OR 1.754; $p < 0.001$), and varicose veins (OR 2.450; $p < 0.001$) elevated the odds of postoperative VTE. As in the propensity-score-matched model, preoperative COVID-19 diagnosis was not significantly associated with postoperative VTE, irrespective of the recency of COVID-19 diagnosis ($p > 0.999$).

Post-hoc power calculation revealed a power of 92.4% for detecting an association between COVID-19 diagnosis and postoperative VTE.

Next, we compared the 2020 – 2021 cohort against a pre-pandemic cohort from 2018 – 2019 by propensity score matching along VTE-relevant variables: age, index procedure type (exact matching), Elixhauser comorbidity index scores, preoperative thrombotic risk factors, and postoperative VTE prophylaxis (Table 5). This propensity-matched analysis included 28,302 patients (14,151 patients who underwent the index procedure in 2018 or 2019 and 14,151 patients from 2020 or 2021). Following matching, demonstrated in Figure 3, we conducted a multivariable logistic regression to compare these cohorts. In this analysis, undergoing surgery in 2020 – 2021 (as opposed to 2018 – 2019) did not significantly impact odds of postoperative VTE ($p = 0.575$) (Table 6).

Figure 4 compares the rates of postoperative VTE per 1,000 patients in 2018 – 2019 versus 2020 – 2021 following propensity score matching, stratified by procedure. Rates of VTE were highest overall after abdominal panniculectomy (27.5 and 23.4 per 1,000 patients in 2018–2019 and 2020–2021, respectively), followed by autologous breast reconstruction (20.3 and 16.2 per 1,000 patients in 2018– 2019 and 2020–2021, respectively), implant-based breast reconstruction (14.6 and 14.5 per 1,000 patients in 2018–2019 and 2020–2021, respectively), and breast reduction (12.1 and 8.4 per 1,000 patients in 2018–2019 and 2020–2021, respectively). The incidence of VTE after breast reduction fell significantly from 2018 – 2019 to 2020–2021 ($p = 0.004$); otherwise, there were no significant changes in rates of VTE between the pre- and post-pandemic cohorts.

DISCUSSION

Contrary to our hypothesis, that prior COVID-19 infection would increase the risk of postoperative VTE, we found no independent association between a history of COVID-19 and the occurrence of DVT or PE within 90 days of any of the four operations we studied. We also found no relationship between the recency of COVID-19 diagnosis and the odds of thrombosis. Moreover, we identified no significant increase in the incidence of postoperative VTE among the 2020 – 2021 cohort compared to the pre-pandemic 2018 – 2019 group across any of the included procedures. In fact, we found that the incidence of thrombosis following breast reduction fell significantly—an encouraging finding that could imply improved adoption of thromboprophylactic measures like early postoperative mobilization, or more risk-averse patient selection during the pandemic. By comparing pre-pandemic and post-pandemic rates of postoperative VTE, we hoped to eliminate the potential for confounding as a result of underreporting or underdiagnosis of COVID-19 within the 2020 – 2021 cohort, including asymptomatic SARS-CoV-2 infections.

Two large studies conducted in 2022 found significant associations between recent COVID-19 diagnosis and VTE following a diverse group of procedures encompassing multiple surgical specialties.[12,13] Single-specialty studies, however, have been less resolute on the risk conferred by a recent history of COVID-19. The orthopedic surgery literature is most robust in this subcategory and argues against an increased risk of VTE following total joint arthroplasty, elective spine surgery, or joint arthroscopy among patients who have recovered from COVID-19.[14–17] Given that perioperative risk of VTE is affected by a host of variables including patient comorbidity, surgical complexity, anesthesia duration, postoperative immobilization, and thromboprophylaxis regimen, specialty-specific analyses are likely to be most prescriptive for individual surgeons.

Plastic surgery's diversity of procedures, heterogeneous patient population, and inconsistent use of thromboprophylaxis make estimating perioperative VTE risk particularly challenging. While body contouring patients, for instance, are more likely to have high body mass index (BMI), hypertension, diabetes and pulmonary disease, autologous breast reconstruction patients are more often affected by malignancy, hormone therapy, and long surgical durations. The plastic surgery literature is replete with diverse and continuously evolving recommendations on postoperative VTE prevention. Partly as a result, plastic surgeons are inconsistent in their use of postoperative thromboprophylaxis, despite the fact that VTE is one of the most dangerous complications that occurs in the field. With this study, we hoped to provide specific guidance to plastic surgeons on how previous SARS-CoV-2 infection might impact the risk of postoperative thrombosis in their patients.

To this end, we chose to focus on four index plastic surgery operations that are common, are reimbursed by most payers (and therefore reported in insurance claims data), and that represent the VTE risk factors most frequently encountered in plastic surgery. Abdominal panniculectomy is associated with a relatively high incidence of VTE (up to 2.1% in other large studies; 2.4% in our analysis) and captures the thromboembolic risk conferred by high BMI, manifestations of metabolic syndrome (e.g., hypertension, hyperglycemia), post-bariatric physiology, and prolonged postoperative immobility.[22,24–26] Conversely, breast reduction carries a low risk for VTE (0.22% in one large study; 0.8% in our study) but is one of the most commonly performed operations in plastic surgery.[30] Breast reconstruction patients are an important cohort in this conversation given the thromboembolic risk conferred by malignancy and cancer therapy; some studies estimate the incidence of VTE among autologous reconstruction patients to be as high as 2.2%; we derived an incidence of 1.7% in our analysis.[27–29] We did not include procedures that are typically performed following trauma, as the urgency of surgery is often dictated by the injury. We also excluded non-reimbursed cosmetic operations given the nature of MarketScan® as an insurance claims database.

After controlling for potential confounders through propensity score matching, our regression analysis echoed findings from the orthopedic surgery literature in which a prior COVID-19 diagnosis has not been associated with the development of postoperative VTE. In explaining why these results run counter to the multi-specialty reports previously mentioned, we theorize that differences in patient morbidity and clinical context have a major effect on the extent to which COVID-19 impacts thromboembolic risk. While those multi-specialty studies included a wide range of thoracic, abdominal oncologic, and open vascular operations, the studied plastic and orthopedic surgery procedures are confined to elective operations not involving traumatic injuries, intra-thoracic or intra-abdominal dissection, or severely comorbid patients. It follows, then, that although thrombosis can occur after any operation, COVID-19 infection is probably a relatively minor contributing factor and only rises to clinical significance in patients who are already at higher risk for

VTE. We conclude that a history of resolved COVID-19 infection likely does not increase the risk of VTE among patients undergoing body contouring or breast procedures with a plastic surgeon.

Limitations

This study has some important limitations. While the MarketScan® family of databases has been studied and referenced in more than 1,000 publications over the past 25 years, all large database studies are limited by the quality of data that is provided at each level. In this case, the consistency and completeness of COVID-19 diagnosis data is difficult to assess. Almost certainly, a large percentage of asymptomatic or mildly symptomatic patients with COVID-19 went unrecorded by ICD-10 diagnosis and were misclassified in our study. This flaw, however, is not unique to our work, and there is evidence that mild COVID-19 has little to no effect on VTE risk in other contexts.[37,38] Moreover, our use of 2018 – 2019 pre-pandemic data as a control group should further bolster confidence in our 2020 – 2021 findings.

The autologous breast reconstruction cohort was small compared to our entire study population, reflecting the relative rarity of that operation, and potentially limiting the generalizability of our findings to those patients. Additionally, our analysis overlooked certain VTE-relevant factors that are not captured by MarketScan® such as operative duration, numeric BMI (though the diagnosis of obesity was included), specific surgical maneuvers (e.g., rectus plication), use of sequential compression devices, and timing of postoperative mobilization. This lack of resolution is common among large database studies and increases the risk of Type II error in this case. Because MarketScan® is a commercial payor claims database, it also excludes many Medicare and Medicaid beneficiaries, which may be limit the applicability of our findings to those populations.

Lastly, only female patients were included in our analysis. Of the four operations studied, breast reduction, implant-based reconstruction, and autologous breast reconstruction are performed almost exclusively in women. Panniculectomy represented only 6.6% of the entire cohort, and of those subjects, males would have represented less than 1% of the study population. Given that the omission of males from our study reflects reality – i.e., the vast majority of patients undergoing high-VTE-risk plastic surgery operations are women – we do not believe this decision detracts significantly from the importance or validity of our conclusions.

CONCLUSIONS

This analysis of a large, national insurance claims database provides evidence against a link between COVID-19 infection and VTE within 90 days of four common plastic surgery operations. To our knowledge, this study is the first to report large-scale original findings on the safety of plastic surgery in relation to COVID-19. At this time, there are no plastic surgery-specific guidelines on the timing of surgery relative to COVID-19 diagnosis; many plastic surgeons, therefore, refer to recommendations released jointly by the American Society of Anesthesiologists and Anesthesia Patient Safety Foundation, which indicate that elective surgery be delayed 4 weeks from the date of diagnosis for an asymptomatic patient and 6 weeks for a symptomatic, non-hospitalized patient.[39,40] In light of our analysis, these recommendations appear sound, and plastic surgeons should not further delay or avoid operating on patients who have recovered from COVID-19 for the purpose of reducing thromboembolic risk.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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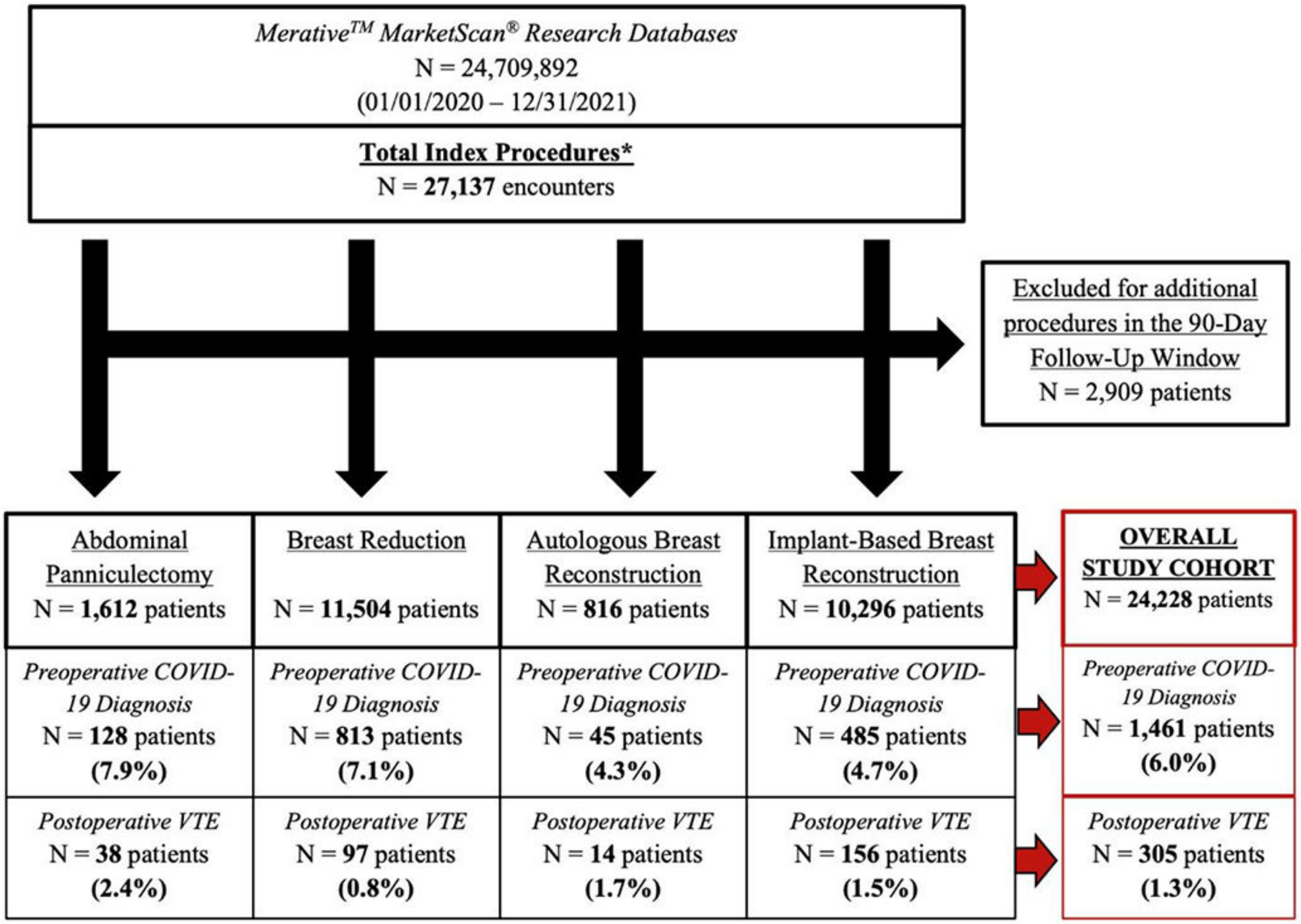

Figure 1.

Flow diagram of patients in the Merative™ MarketScan® Research Databases categorized by procedure type and postoperative VTE incidence. Patients were identified using relevant CPT and ICD-10 codes. *VTE*, venous thromboembolism.

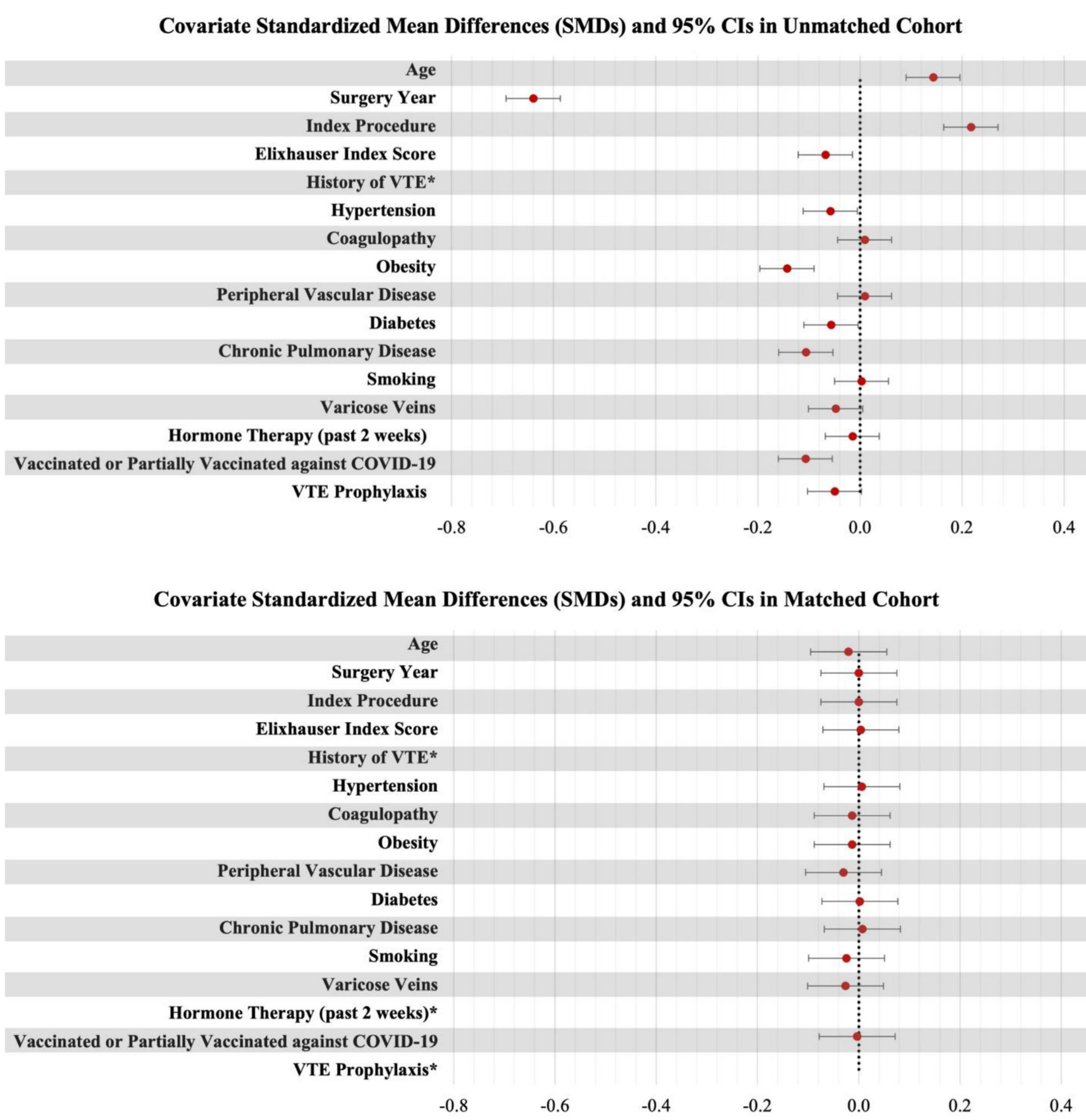

Figure 2.

Standardized mean differences (SMDs) and 95% confidence intervals (CIs) before (**A**) and after (**B**) propensity score matching was performed between subjects who did not have a preoperative COVID-19 diagnosis and subjects who did have a preoperative COVID-19 diagnosis (as displayed in Table 2). *Asterisks* indicate that results were unable to be reported due to cell sizes 11 or fewer. *VTE*, venous thromboembolism.

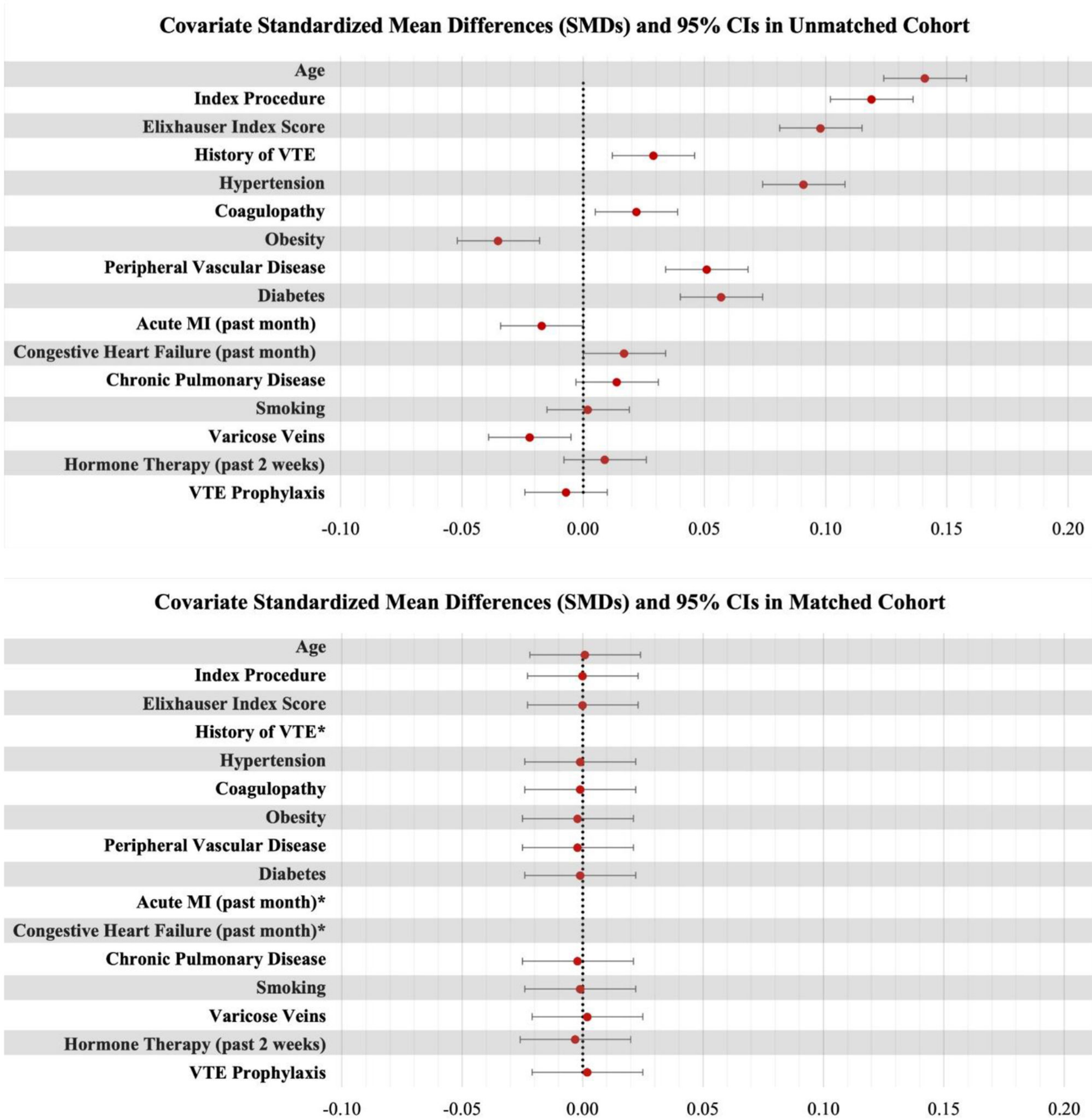

Figure 3.

Standardized mean differences (SMDs) and 95% confidence intervals (CIs) before (**A**) and after (**B**) propensity score matching was performed between subjects who underwent surgery in 2018 – 2019 and subjects who underwent surgery in 2020 – 2021 (as displayed in Table 5). *Asterisks* indicate that results were unable to be reported due to cell sizes 11 or fewer. *VTE*, venous thromboembolism; *MI*, myocardial infarction.

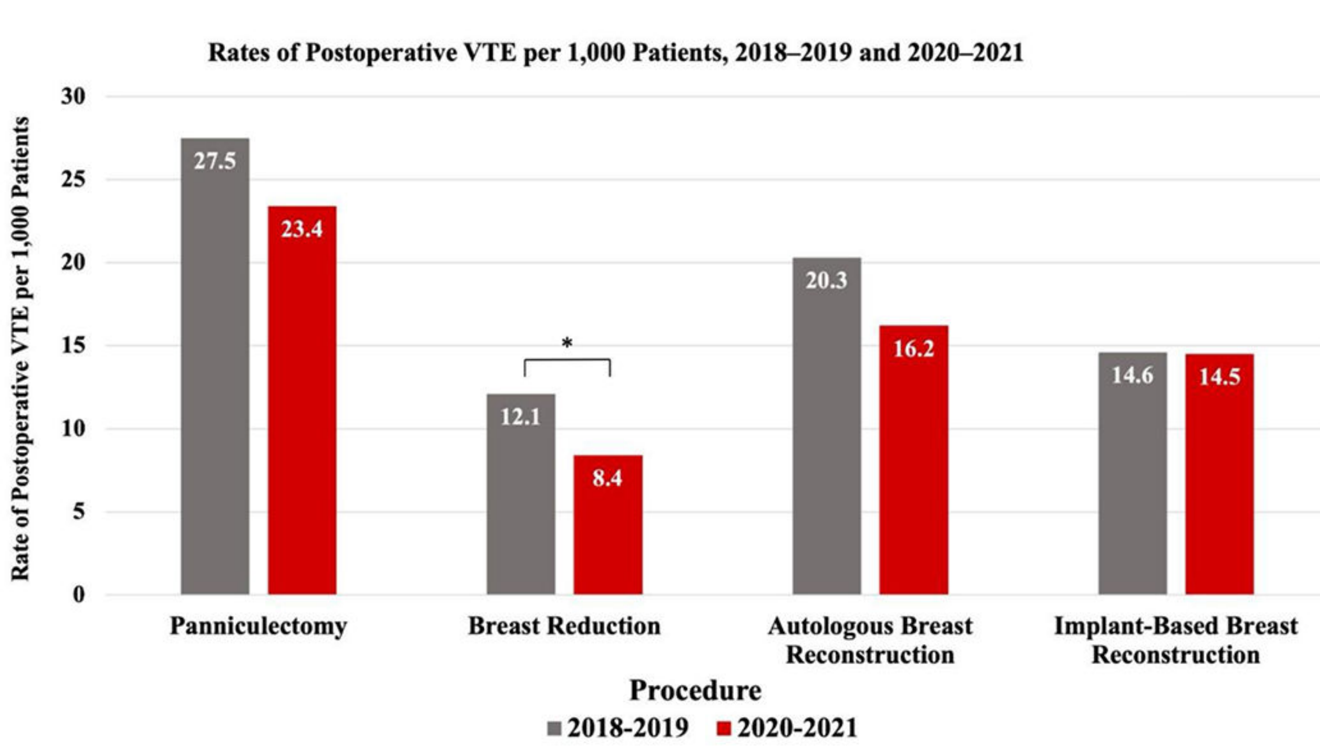

Figure 4.

Rates of VTE in the postoperative 90 days per 1,000 patients stratified by procedure type in the propensity score matched cohort comparing subjects from 2018 – 2019 versus 2020 – 2021 (n = 28,302). Patients were matched exactly on procedure type. Chi-squared testing was used to assess if rates of postoperative VTE were significantly different between the two time periods. *Asterisk* denotes statistically significant variation (p = 0.004). *VTE*, venous thromboembolism.

Table 1.
Overall Cohort Characteristics (N = 24,228).

SD, standard deviation; *VTE*, venous thromboembolism.

Characteristic	No. (%)
Age (years)	
18–35	6066 (25.0)
36–45	5685 (23.5)
46–55	7415 (30.6)
56+	5062 (20.9)
Age (years)	
Mean (±SD)	**44.1 (± 12.5)**
Year of Index Surgery	
2020	12014 (49.6)
2021	12214 (50.4)
Index Procedure	
Panniculectomy	1612 (6.6)
Breast Reduction	11504 (47.5)
Autologous Breast Reconstruction	816 (3.4)
Implant-Based Breast Reconstruction	10296 (42.5)
Elixhauser Comorbidity Index	
0 or 1	5834 (24.1)
2 or 3	8147 (33.6)
4+	10247 (42.3)
Preoperative Risk Factors	
History of VTE	65 (0.3)
Hypertension	7963 (32.8)
Coagulopathy	1138 (4.7)
Obesity	10141 (41.9)
Peripheral Vascular Disease	1119 (4.6)
Diabetes	2768 (11.4)
History of Acute Myocardial Infarction (past month)	19 (0.1)
History of Stroke (past month)	0 (0)
Congestive Heart Failure (past month)	18 (0.1)
Chronic Pulmonary Disease	5444 (22.5)
Smoking	1124 (4.6)
Varicose Veins	725 (3.0)
Hormone Therapy (past 2 weeks)	278 (1.2)
Vaccinated or Partially Vaccinated Against COVID-19	
No	12874 (53.1)
Yes	11354 (46.9)
COVID-19 Diagnosis [a]	
No	22767 (94.0)

Characteristic	No. (%)
Yes	1461 (6.0)
91+ Days Preop	*1003 (4.1)*
61–90 Days Preop	*173 (0.7)*
31–60 Days Preop	*178 (0.7)*
0–30 Days Preop	*207 (0.8)*
Postoperative VTE Chemoprophylaxis	
No	23952 (98.9)
Yes	276 (1.1)
Experienced Postoperative VTE	
No	23923 (98.7)
Yes	305 (1.3)

Table 2.

Propensity Score Matching, No COVID-19 versus COVID-19 Cohorts.

SMD, standardized mean difference; *SD*, standard deviation; *VTE*, venous thromboembolism; *MI*, myocardial infarction. Entries are frequency (percentage) unless otherwise specified. Statistically significant P values (< 0.05) in **bold**.

	Before Propensity Score Matching				After Propensity Score Matching			
Characteristic	**No COVID-19 Diagnosis (n = 22,767) No. (%)**	**COVID-19 Diagnosis (n =1,461) No. (%)**	**Absolute SMD**	**P Value**	**No COVID-19 Diagnosis (n = 1,377) No. (%)**	**COVID-19 Diagnosis (n = 1,377) No. (%)**	**Absolute SMD**	**P Value**
Age (years)								
Mean (± SD)	**44.2 (± 12.5)**	**42.4 (± 12.5)**	0.143	**<0.001**	**41.9 (± 13.3)**	**42.1 (± 12.6)**	0.020	0.906
Surgery Year								
2020	11724 (51.5)	290 (19.9)	0.640	**<0.001**	275 (20.0)	275 (20.0)	0.000	>0.999
2021	11043 (48.5)	1171 (80.1)			1102 (80.0)	1102 (80.0)		
Index Procedure								
Abdominal	1484 (6.5)	128 (8.8)	0.217	**<0.001**	102 (7.4)	102 (7.4)	0.000	>0.999
Panniculectomy	10691 (47.0)	813 (55.6)			792 (57.5)	792 (57.5)		
Breast Reduction	781 (3.4)	35 (2.4)			18 (1.3)	18 (1.3)		
Autologous Breast Reconstruction	9811 (43.1)	485 (33.2)			465 (33.8)	465 (33.8)		
Implant-Based Breast Reconstruction								
Elixhauser Index								
0 or 1	5505 (24.2)	329 (22.5)	0.068	**0.020**	323 (23.4)	326 (23.7)	0.004	0.990
2 or 3	7684 (33.8)	463 (31.7)			451 (32.8)	449 (32.6)		
4+	9578 (42.1)	669 (45.8)			603 (43.8)	602 (43.7)		
Preoperative Risk Factors								
History of VTE	–	N<11	–	–	N<11	N<11	–	–
Hypertension	7436 (32.7)	517 (35.4)	0.058	**0.032**	478 (34.7)	474 (34.4)	0.006	0.873
Coagulopathy	1072 (4.7)	66 (4.5)	0.009	0.738	38 (2.8)	41 (3.0)	0.013	0.732
Obesity	9433 (41.4)	708 (48.5)	0.143	**<0.001**	649 (47.1)	658 (47.8)	0.013	0.731
Peripheral Vascular Disease	1054 (4.6)	65 (4.5)	0.009	0.750	38 (2.8)	45 (3.3)	0.030	0.435
Diabetes	2576 (11.3)	192 (13.1)	0.057	**0.033**	170 (12.4)	169 (12.3)	0.002	0.954
History of Acute MI (past month)	–	N<11	–	–	N<11	N<11	–	–
History of Stroke (past month)	0 (0)	0 (0)	–	–	0 (0)	0 (0)	–	–
Congestive Heart Failure (past month)	–	N<11	–	–	N<11	N<11	–	–
Chronic Pulmonary Disease	5055 (22.2)	389 (26.6)	0.106	**<0.001**	357 (25.9)	353 (25.6)	0.007	0.862
Smoking	1057 (4.6)	67 (4.6)	0.003	0.920	43 (3.1)	49 (3.6)	0.024	0.525

Characteristic	Before Propensity Score Matching: No COVID-19 Diagnosis (n = 22,767) No. (%)	Before: COVID-19 Diagnosis (n =1,461) No. (%)	Before: Absolute SMD	Before: P Value	After Propensity Score Matching: No COVID-19 Diagnosis (n = 1,377) No. (%)	After: COVID-19 Diagnosis (n = 1,377) No. (%)	After: Absolute SMD	After: P Value
Varicose Veins	670 (2.9)	55 (3.8)	0.048	0.074	37 (2.7)	43 (3.1)	0.026	0.496
Hormone Therapy (past 2 weeks)	259 (1.1)	19 (1.3)	0.015	0.571	N<11	N<11	–	–
Vaccinated or Partially Vaccinated Against COVID-19								
No	12171 (53.5)	703 (48.1)	0.107	**<0.001**	657 (47.7)	655 (47.6)	0.003	0.939
Yes	10596 (46.5)	758 (51.9)			720 (52.3)	722 (52.4)		
Mean Time (days) From COVID-19 Diagnosis to Index Procedure								
Mean (± SD)	–	169.96 (± 131.78)		–	–	168.65 (± 131.26)	–	–
Postoperative VTE Chemoprophylaxis								
No	22515 (98.9)	1437 (98.4)	0.050	0.061	–	–	–	–
Yes	252 (1.1)	24 (1.6)			N<11	N<11		

Table 3:
Results of Logistic Regression Analysis after Matching.

VTE, venous thromboembolism.

Characteristic	Average OR of Postoperative VTE (95% CI)	P Value
COVID-19 Diagnosis	0.805 (0.451–1.437)	0.463

Table 4:

Multivariable Regression Analysis of the Entire Unmatched Cohort (N = 24,228).

VTE, venous thromboembolism. Statistically significant P values (< 0.05) in **bold**.

Characteristic	Average OR of Postoperative VTE (95% CI)	P Value[a]
Age (years)		
18–35	1	–
36–45	**3.971 (2.169–7.272)**	**<0.001**
46–55	**5.394 (3.010–9.669)**	**<0.001**
56+	**7.043 (3.898–12.726)**	**<0.001**
Year of Index Surgery		
2020	1	–
2021	0.991 (0.781–1.256)	>0.999
Preoperative Risk Factors		
History of VTE	**11.455 (5.483–23.934)**	**<0.001**
Hypertension	1.218 (0.942–1.574)	<0.999
Coagulopathy	**3.792 (2.808–5.121)**	**<0.001**
Obesity	1.296 (1.015–1.656)	0.563
Peripheral Vascular Disease	**2.306 (1.667–3.190)**	**<0.001**
Diabetes	1.335 (0.994–1.794)	0.827
History of Acute Myocardial Infarction (past month)	2.776 (0.357–21.590)	<0.999
History of Stroke (past month)	–	–
Congestive Heart Failure (past month)	–	–
Chronic Pulmonary Disease	**1.754 (1.377–2.234)**	**<0.001**
Smoking	1.119 (0.711–1.759)	>0.999
Varicose Veins	**2.450 (1.670–3.593)**	**<0.001**
Hormone Therapy (past 2 weeks)	–	–
Vaccinated or Partially Vaccinated Against COVID-19		
No	1	–
Yes	1.291 (1.020–1.633)	0.498
COVID-19 Diagnosis		
No	1	–
91+ Days Preop	1.426 (0.851–2.389)	>0.999
61–90 Days Preop	1.459 (0.434–4.906)	>0.999
31–60 Days Preop	1.616 (0.499–5.228)	>0.999
0–30 Days Preop	0.408 (0.056–2.954)	>0.999

[a] *P* values have been adjusted for multiple testing using the Bonferroni method.

Table 5: Propensity Score Matching, 2018 – 2019 versus 2020 – 2021 Cohorts.

SMD, standardized mean difference; *SD*, standard deviation; *VTE*, venous thromboembolism; *MI*, myocardial infarction. Entries are frequency (percentage) unless otherwise specified. Statistically significant P values (< 0.05) in **bold**.

	Before Propensity Score Matching				After Propensity Score Matching			
Characteristic	**Underwent the Index Procedure in 2018–2019 (n = 30,495) No. (%)**	**Underwent the Index Procedure in 2020–2021 (n = 22,582) No. (%)**	**Absolute SMD**	**P Value**	**Underwent the Index Procedure in 2018–2019 (n = 14,151) No. (%)**	**Underwent the Index Procedure in 2020–2021 (n = 14,151) No. (%)**	**Absolute SMD**	**P Value**
Age (years)								
Mean (± SD)	**45.4 (± 12.0)**	**43.7 (± 12.7)**	0.141	**<0.001**	**46.4 (± 11.2)**	**46.4 (± 11.2)**	0.001	0.947
Index Procedure								
Abdominal	1929 (6.3)	1580 (7.0)	0.119	<0.001	399 (2.8)	399 (2.8)	0.000	>0.999
Panniculectomy	13671 (44.8)	11387 (50.4)			6297 (44.5)	6297 (44.5)		
Breast Reduction	1083 (3.6)	680 (3.0)			262 (1.9)	262 (1.9)		
Autologous Breast Reconstruction	13812 (45.3)	8935 (39.6)			7193 (50.8)	7193 (50.8)		
Implant-Based Breast Reconstruction								
Elixhauser Index								
0 or 1	6787 (22.3)	5721 (25.3)	0.098	**<0.001**	3947 (27.9)	3947 (27.9)	0.000	>0.999
2 or 3	9953 (32.6)	7726 (34.2)			4624 (32.7)	4622 (32.7)		
4+	13755 (45.1)	9135 (40.5)			5580 (39.4)	5582 (39.5)		
Preoperative Risk Factors								
History of VTE	142 (0.5)	64 (0.3)	0.029	**0.001**	N<11	N<11	–	–
Hypertension	11126 (36.5)	7261 (32.2)	0.091	**<0.001**	4844 (34.2)	4848 (34.3)	0.001	0.960
Coagulopathy	1521 (5.0)	1019 (4.5)	0.022	**0.011**	290 (2.1)	293 (2.1)	0.001	0.900
Obesity	12297 (40.3)	9494 (42.0)	0.035	**<0.001**	4627 (32.7)	4639 (32.8)	0.002	0.879
Peripheral Vascular Disease	1639 (5.4)	964 (4.3)	0.051	**<0.001**	305 (2.2)	309 (2.2)	0.002	0.870
Diabetes	3965 (13.0)	2518 (11.2)	0.057	**<0.001**	1303 (9.2)	1307 (9.2)	0.001	0.935
History of Acute MI (past month)	12 (0.04)	18 (0.1)	0.017	0.053	0 (0)	0 (0)	–	–
History of Stroke (past month)	0 (0)	0 (0)	–	–	0 (0)	0(0)	–	–
Congestive Heart Failure (past month)	42 (0.1)	18 (0.1)	0.017	**0.049**	N<11	Nd 1	–	–

Characteristic	Before Propensity Score Matching: Underwent the Index Procedure in 2018–2019 (n = 30,495) No. (%)	Before Propensity Score Matching: Underwent the Index Procedure in 2020–2021 (n = 22,582) No. (%)	Before Propensity Score Matching: Absolute SMD	Before Propensity Score Matching: P Value	After Propensity Score Matching: Underwent the Index Procedure in 2018–2019 (n = 14,151) No. (%)	After Propensity Score Matching: Underwent the Index Procedure in 2020–2021 (n = 14,151) No. (%)	After Propensity Score Matching: Absolute SMD	After Propensity Score Matching: P Value
Chronic Pulmonary Disease	6930 (22.7)	4998 (22.1)	0.014	0.106	2341 (16.5)	2351 (16.6)	0.002	0.873
Smoking	1371 (4.5)	1004 (4.5)	0.002	0.784	201 (1.4)	203 (1.4)	0.001	0.920
Varicose Veins	774 (2.5)	654 (2.9)	0.022	**0.012**	78 (0.6)	76 (0.5)	0.002	0.872
Hormone Therapy (past 2 weeks)	390 (1.3)	267 (1.2)	0.009	0.320	26 (0.2)	28 (0.2)	0.003	0.785
Postoperative VTE Chemoprophylaxis								
No	30176 (98.9)	22330 (98.9)	0.007	0.440	14136 (99.9)	14137 (99.9)	0.002	0.853
Yes	319 (1.1)	252 (1.1)			15 (0.1)	14 (0.1)		

Table 6:

Results of Logistic Regression Analysis after Matching.

VTE, venous thromboembolism.

Characteristic	Average OR of Postoperative VTE (95% CI) *	P Value
Year of Index Procedure		
2018–2019	1	–
2020–2021	0.939 (0.754–1.170)	0.575