Hepatitis C infection and complication rates after total shoulder arthroplasty in United States veterans

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\textbf{Level of Evidence:} Level III; retrospective cohort Comparison using large database; treatment study

\begin{abstract}
Few studies have evaluated the effect of hepatitis C (HCV) on primary total shoulder arthroplasty (TSA). Our purpose was to determine if HCV infection is associated with increased complication rates after TSA in United States (US) veterans and, secondarily, to determine if preoperative HCV treatment with direct-acting antivirals (DAAs) affects postoperative complication rates.

\textbf{Methods:} US Department of Veterans Affairs (VA) data sets were used to retrospectively identify patients without HCV, patients with untreated HCV, and patients with HCV treated with DAAs who underwent TSA from 2014 to 2019. Medical and surgical complications were assessed using International Classification of Diseases codes. Complication rates between patients with HCV (treated and untreated) and patients without HCV and between HCV-treated patients and HCV-untreated patients were compared at 90 days and 1 year after surgery.

\textbf{Results:} We identified 5774 primary TSAs that were performed at VA hospitals between 2014 and 2019. A minority (9.5\%) of TSA patients had HCV, 23.4\% of whom were treated preoperatively with DAAs. On multivariate analysis, HCV patients had increased odds of 1-year medical complications (odds ratio, 1.39; 95\% confidence interval, 1.06\--1.81, \(P = .016\)), when compared with patients without HCV. No statistically significant difference in complication rates was observed between HCV-treated and HCV-untreated patients.

\textbf{Discussion:} US veterans with a history of HCV are at an increased risk of developing medical but not surgical complications within the first year after TSA. Larger studies are necessary to evaluate the effects of DAA treatment on complication rates.

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\end{abstract}
Medicare patients with HCV undergoing TSA were found to be at significantly higher risk for both medical and surgical complications. The purpose of our study was to determine if HCV infection is also associated with increased medical and surgical complication rates after TSA in US veterans. Secondarily, we sought to determine if preoperative HCV treatment with DAAs affected postoperative complication rates. We hypothesized that HCV patients would have higher rates of medical and surgical complications after TSA compared with patients without HCV. We further hypothesized that HCV patients who received preoperative DAA treatment would experience fewer postoperative medical and surgical complications after TSA compared with untreated HCV patients.

**Methods**

**TSA data set**

This study was performed after obtaining institutional review board approval. The VA Corporate Data Warehouse (CDW) was used to identify a cohort of patients who underwent TSA (both anatomic and reverse) at US Veterans Health Administration (VHA) hospitals between January 1, 2014 and September 30, 2019. This study interval was selected because the VHA embarked on a system-wide campaign to curatively treat all US veterans with HCV infection in 2014. Common Procedural Terminology (CPT) codes were used to identify patients who underwent primary total shoulder arthroplasty (23472). Since CPT codes do not differentiate between anatomic (ATSA) and reverse TSA (RTSA), International Classification of Diseases, Ninth and Tenth Revision (ICD-9 and ICD-10) codes were used to identify medical and surgical complications after TSA compared with patients without HCV. Patients treated with DAA-based therapies before TSA were excluded if they had no documentation of DAA treatment (daclatasvir, dasabuvir/ombitasvir/paritaprevir/ritonavir, elbasvir/grazoprevir, ledipasvir/sofosbuvir, ombitasvir/paritaprevir/ritonavir, simprevir, sofosbuvir, velpatasvir/sofosbuvir, velpatasvir/voxilaprevir). These treatments are not used for alternative diagnoses. Patients with negative laboratory tests for HCV who had no ICD codes for HCV and no HCV-specific treatment were classified as HCV-free. Patients without ICD codes for HCV and without HCV-specific treatment were excluded if they had no laboratory testing for HCV.

**Identifying HCV-treated and HCV-untreated patients**

Patients treated with DAA-based therapies before TSA were classified as “treated.” Patients treated with older therapies, including ribavirin and interferon, were excluded from the analysis due to lower overall cure rates (around 50%) and higher complication rates relative to DAA-based therapies, which have cure rates over 95%. An undetectable HCV viral load was not used to confirm successful treatment.

ICD-9 and ICD-10 codes were used to identify preoperative comorbidities and to calculate the Charlson Comorbidity Index (CCI) for each patient. A comorbid condition was considered present if it was recorded in the patient’s record during one inpatient or 2 outpatient encounters between January 1, 2014 and the date of surgery.

**Outcome ascertainment**

ICD codes were also used to identify medical and surgical complications within 90 days and 1 year after surgery (Table I) from inpatient and outpatient files in the VA CDW and from purchased care files (for care provided at a non-VA facility).

**Statistical analysis**

Analysis of variance, Fisher’s exact test, and chi-squared analyses were utilized to compare differences in demographics and complication rates at 90 days and at 1 year after surgery among patients without HCV, untreated HCV patients, and treated HCV patients. Multivariate logistic regression was performed to identify
odds ratios (ORs) of implant infection, any medical complication, and any surgical complication at 90 days and at 1 year. Comparisons were made between patients with (treated or untreated) HCV and patients without HCV, as well as between HCV treated and HCV untreated patients. In addition to HCV status, the regression analysis adjusted for all variables that were significantly different between groups, including age, gender, HIV status, hepatitis B virus infection, history of smoking, and CCI.

Results

We identified 5774 primary TSAs (1680 ATSA, 1367 RTSA, 2727 unspecified) that were performed at US VHA hospitals between 2014 and 2019 that met our inclusion and exclusion criteria. Of these, 548 patients (9.5% of all TSA) were identified to have been infected with HCV. One hundred twenty-eight patients, or 23.4% of patients with HCV, had their HCV treated preoperatively with DAA-based therapies (Table II). Patients with HCV were significantly younger (P < .001). The average age of patients without HCV was 67.3 ± 7.8 years, the average age of untreated HCV patients was 64.1 ± 5.8 years, and the average age of treated HCV patients was 64.0 ± 5.2 years. Patients with HCV had an increased rate of HIV infection (1.9% vs. 0.2%, P < .001), hepatitis B infection (1.1% vs. 0.2%, P < .001), and history of smoking (75.7% vs. 64.5%, P < .001) compared to patients without HCV. Additionally, patients with HCV had a significantly higher CCI than patients without HCV (P < .001). Patients with treated HCV had an increased rate of concomitant HIV infection (4.7% vs. 1.0%, P = .006), history of smoking (84.4% vs. 73.1%, P = .009), and significantly higher CCI (P < .001) than patients without untreated HCV. Interestingly, diabetes mellitus was significantly more common in patients without HCV compared to patients with HCV (0.7% vs. 0.0%, P = .05). At 1 year, patients with HCV had a higher rate of AKI (6.8% vs. 4.8%, P = .05), pneumonia (5.0% vs. 2.9%, P = .009), acute myocardial infarction (2.6% vs. 1.5%, P = .05), and sepsis (2.7% vs. 1.4%, P = .01) compared to patients without HCV. The rate of medical complications was not significantly different between treated and untreated HCV groups (14.0% vs. 16.4%, P = .51).

The complication rates for ATSA and RTSA are displayed in Tables IV and V, respectively. Among patients who underwent ATSA, those with HCV had a significantly higher rate of overall medical complications (16.8% vs. 9.1%, P = .001), AKI (8.4% vs. 3.8%, P = .006), pneumonia (5.4% vs. 1.7%, P = .001), and sepsis (3.0% vs. 0.7%, P = .002) compared to those without HCV. Only significantly higher rates of sepsis were observed for patients with HCV undergoing RTSA compared to those without HCV (4.3% vs. 1.7%, P = .05).

The most frequently coded surgical complications were mechanical in nature, accounting for 62.1% and 66.0% of the surgical complications at 90 days and 1 year. Among all TSAs, there were no significant differences in wound disruption, implant infection, or mechanical complications among the groups at 90 days and at 1 year. However, for the ATSA subgroup, patients with HCV had a significantly higher rate of mechanical complications than patients without HCV at 1 year (4.9% vs. 1.9%, P = .04). Although the ATSA HCV-treated cohort had no mechanical complications at 1 year, this was not significant compared to the untreated cohort (P = .27).

Multivariate logistic analysis was performed to evaluate the associations between HCV status and complication rates (Table VI). At 90 days, there was no difference in implant infection rates, any medical complication rate, or any surgical complication rate between patients with and without HCV. However, at 1 year, patients with HCV undergoing TSA or ATSA had a significantly increased odds of developing a medical complication compared to patients without HCV (TSA: OR = 1.39 [95% confidence interval: 1.06–1.81], P = .016; ATSA: OR = 2.02 [95% confidence interval: 1.27–3.21], P = .030). There was no difference in implant infection rates, medical complication rates, or surgical complication rates between patients in the HCV-treated and HCV-untreated cohorts.
Table II
Patient demographics.

|                          | Total shoulder arthroplasty | Anatomic total shoulder arthroplasty | Reverse total shoulder arthroplasty |
|--------------------------|-----------------------------|--------------------------------------|-----------------------------------|
|                          | Total no. of surgeries      | TSA without HCV                      | TSA with untreated HCV            | TSA with treated HCV              | Total no. of surgeries | RTSA without HCV                  | RTSA with untreated HCV | RTSA with treated HCV |
|                          | (n = 5774)                  | (n = 5226)                           | (n = 128)                         | (n = 1680)                        | (n = 1367)                  | (n = 1251)                         | (n = 87)                   | (n = 29)                |
| Age (yr)                 | 67.0 ± 7.7                  | 67.3 ± 7.8                           | 64.1 ± 5.8                        | 64.0 ± 5.2                        | 65.3 ± 7.8                  | 65.5 ± 8.0                        | 63.6 ± 5.6                 | 62.6 ± 5.7              | 68.6 ± 7.0              | 69.0 ± 7.1              | 64.1 ± 4.6              | 64.3 ± 5.0 | <.001 | .84 |
| Gender                   |                             |                                     |                                   |                                   |                             |                                     |                                      |                        |                        |                             |                        |                             |                        |                        |                      |
| Female                   | 322                         | 5.7%                                 | 4.0%                              | 3.9%                              | .09                         | 98                                 | 6.2%                         | 2.8%                   | 0.0%                    | 69                         | 5.2%                         | 4.6%                     | 0.0%                        | .41                        | .24                        |
| Male                     | 5452                        | 94.3%                                | 96.0%                             | 96.1%                             | 1582                        | 93.8%                             | 97.2%                         | 100.0%                 | .05                     | 1298                        | 94.8%                         | 95.4%                     | 100.0%                     |                             |                              |
| Year of surgery          |                             |                                     |                                   |                                   |                             |                                     |                                      |                        |                        |                             |                        |                             |                        |                        |                      |
| 2014                     | 898                         | 15.4%                                | 21.9%                             | 0.0%                              | .84                         | 445                                 | 26.0%                         | 36.4%                  | 0.0%                    | 292                         | 21.7%                         | 23.0%                     | .0%                        | .34                        | .06                        |
| 2015                     | 1109                        | 19.1%                                | 23.1%                             | 10.2%                             | 437                         | 25.9%                             | 28.7%                         | 16.7%                  | .84                     | 373                         | 27.3%                         | 27.6%                     | 27.6%                     |                          |                              |
| 2016                     | 1153                        | 20.0%                                | 19.5%                             | 21.1%                             | 256                         | 15.6%                             | 11.9%                         | 12.5%                  | .92                     | 188                         | 13.4%                         | 17.2%                     | 17.2%                     |                          |                              |
| 2017                     | 1109                        | 19.2%                                | 14.5%                             | 32.8%                             | 207                         | 12.8%                             | 6.3%                          | 16.7%                  | .83                     | 203                         | 14.5%                         | 14.9%                     | 27.6%                     |                          |                              |
| 2018                     | 1303                        | 22.7%                                | 18.3%                             | 32.8%                             | 40                          | 2.3%                              | 2.8%                          | 4.2%                   | .03                     | 49                          | 3.8%                         | 1.1%                      | .0%                       |                          |                              |
| 2019                     | 202                         | 3.6%                                 | 2.6%                              | 3.1%                              | 40                          | 2.3%                              | 2.8%                          | 4.2%                   | .03                     | 49                          | 3.8%                         | 1.1%                      | .0%                       |                          |                              |
| HIV                      | 22                          | .2%                                  | 1.0%                              | 4.7%                              | <.001                       | 8                                 | 0.3%                          | 0.7%                   | 12.5%                   | 5                           | .3%                          | 1.1%                      | .0%                       | .35                        | .56                        |
| Hepatitis B              | 14                          | .2%                                  | 1.4%                              | .0%                               | <.001                       | 6                                 | 0.2%                          | 2.1%                   | 0.0%                    | 2                           | .1%                          | 1.1%                      | .0%                       | .04                        | .56                        |
| Smoking                  | 3785                        | 64.3%                                | 73.1%                             | 84.4%                             | <.001                       | 1055                              | 61.5%                         | 74.8%                  | 75.0%                   | 942                         | 67.0%                         | 77.0%                     | 86.2%                     | .01                        | .29                        |
| Diabetes                 | 1567                        | 27.9%                                | 19.8%                             | 20.3%                             | <.001                       | 436                              | 26.6%                         | 20.3%                  | 16.7%                   | 410                         | 30.9%                         | 19.5%                     | 20.7%                     | .01                        | .89                        |
| BMI ≥ 40                 | 314                         | 5.5%                                 | 5.2%                              | 1.6%                              | .25                         | 110                                | 6.7%                          | 4.9%                   | 4.2%                    | 77                          | 5.9%                          | 3.4%                      | .0%                       | .14                        | .31                        |
| Charlson score           |                             |                                     |                                   |                                   |                             |                                     |                                      |                        |                        |                             |                        |                             |                        |                        |                      |
| 0                        | 2431                        | 43.6%                                | 33.3%                             | 7.8%                              | <.001                       | 744                                | 45.8%                         | 34.3%                  | 8.3%                    | 513                         | 39.0%                         | 26.4%                     | 6.9%                      | <.001                      | .05                        |
| 1-3                      | 2786                        | 47.0%                                | 56.9%                             | 71.1%                             | <.001                       | 811                                | 47.1%                         | 58.7%                  | 62.5%                   | 688                         | 48.9%                         | 63.2%                     | 72.4%                     |                          |                              |
| ≥ 4                      | 557                         | 9.4%                                 | 9.8%                              | 21.1%                             | 125                         | 7.1%                              | 7.0%                          | 29.2%                  | .05                     | 166                         | 12.1%                         | 10.3%                     | 20.7%                     |                          |                              |

TSA, total shoulder arthroplasty; HCV, hepatitis C virus; ATSA, anatomic total shoulder arthroplasty; RTSA, reverse total shoulder arthroplasty; HIV, human immunodeficiency virus; BMI, body mass index.

Bold denotes significance.
Associated with lower complication rates. Moreover, preoperative HCV treatment with a DAA was not associated with a signifi-
cantly higher 1-year rate of mechanical complications with HCV on univariate analysis, there was no other difference in sur-
cidal complications between patients with and without HCV.

Although a subgroup analysis of patients undergoing ATSA showed medical complications 1 year after TSA compared to those without. In this study, patients with HCV were found to have an increased risk of medical complications 1 year after total shoulder arthroplasty (TSA), anatomic total shoulder arthroplasty (ATSA), or reverse total shoulder arthroplasty (RTSA).

Discussion

Despite the high prevalence of HCV among US veterans, few studies have evaluated the effect of HCV on primary TSA. In this study, patients with HCV were found to have an increased risk of medical complications 1 year after TSA compared to those without. Although a subgroup analysis of patients undergoing ATSA showed a significantly higher 1-year rate of mechanical complications with HCV on univariate analysis, there was no other difference in surgical complications between patients with and without HCV. Moreover, preoperative HCV treatment with a DAA was not associated with lower complication rates.

This study demonstrated that patients with HCV were significantly more likely to develop AKI, pneumonia, acute myocardial infarction, and sepsis compared to controls. Furthermore, the incidence of major complications, such as myocardial infarction and sepsis, was not inconsequential as the overall risk was greater than 2.6% at 1 year. These findings extend those of a Medicare database study involving 22,968 TSA patients, which found a significantly increased systemic medical complication rate of 5.9% in patients with HCV compared to 4.6% in patients without HCV at 90-days.

The association between HCV infection status and the increased risk of medical complications has also been well documented in the hip and knee arthroplasty literature. Bendich et al reported that US veterans with HCV had higher rates of septic complications at 90 days and 1 year after hip and knee total joint arthroplasty (TJA) compared to those without HCV. Similarly using the National Inpatient Sample database, Issa et al found that when compared to matched controls, TJA patients with HCV had a 15% increased risk of a medical complication. Best et al used the National Hospital Discharge Survey to demonstrate that HCV patients had twice the odds of suffering a general medical complication compared to uninfected patients. The underlying reasons for increased medical complications among HCV patients may be related to extrahepatic manifestations of the disease. Prior studies have hypothesized that a combination of cryoglobulin small vessel vasculitis, impaired lymphoproliferation, and disrupted kidney and hematologic function may predispose HCV patients to the increased risk for several of the medical complications demonstrated in this study.

Although HCV infection was associated with an increased rate of medical complications, it was not associated with an increased rate of implant infection or surgical complications after TSA. On subgroup analysis, HCV patients undergoing ATSA had a significantly higher rate of mechanical complications compared to uninfected patients at

Table III

| No. of patients with complications | TSA without HCV (p = 5226) | TSA with untreated HCV (p = 420) | TSA with treated HCV (p = 128) | P value Patients with HCV vs. without HCV | P value Patients with untreated HCV vs. treated HCV |
|----------------------------------|----------------------------|---------------------------------|-------------------------------|------------------------------------------|------------------------------------------|
| 90-d medical complications       | 324 5.6%                  | 4.5%                            | 8.6%                          | .88                                      | .08                                      |
| Acute kidney injury              | 143 2.5%                  | 1.9%                            | 4.7%                          | .90                                      | .08                                      |
| Acute myocardial infarction      | 39 0.6%                   | 1.2%                            | 1.6%                          | .70                                      | .74                                      |
| Cerebrovascular accident         | 15 0.3%                   | 0.2%                            | 0.0%                          | .71                                      | .58                                      |
| Deep vein thrombosis             | 27 0.5%                   | 0.2%                            | 0.0%                          | .30                                      | .58                                      |
| Pneumonia                        | 65 1.1%                   | 1.4%                            | 0.8%                          | .72                                      | .57                                      |
| Pulmonary embolism               | 40 0.7%                   | 0.2%                            | 0.8%                          | .33                                      | .37                                      |
| Sepsis                           | 32 0.6%                   | 0.2%                            | 1.6%                          | .98                                      | .08                                      |
| Urinary tract infection          | 37 0.7%                   | 0.0%                            | 0.0%                          | .05                                      | N/A                                      |
| 90-d surgical complications      | 211 3.6%                  | 4.3%                            | 3.9%                          | .48                                      | .85                                      |
| Wound disruption                 | 25 0.4%                   | 0.2%                            | 1.6%                          | .67                                      | .08                                      |
| Implant infection                | 77 1.3%                   | 1.9%                            | 1.6%                          | .29                                      | .80                                      |
| Mechanical complication          | 131 2.2%                  | 3.3%                            | 3.3%                          | .44                                      | .12                                      |
| 1-yr medical complications       | 644 10.8%                 | 14.0%                           | 16.4%                         | .007                                     | .51                                      |
| Acute kidney injury              | 290 4.8%                  | 6.2%                            | 8.6%                          | .05                                      | .34                                      |
| Acute myocardial infarction      | 90 1.5%                   | 2.9%                            | 1.6%                          | .05                                      | .42                                      |
| Cerebrovascular accident         | 46 0.7%                   | 1.2%                            | 1.6%                          | .18                                      | .74                                      |
| Deep vein thrombosis             | 41 0.7%                   | 0.7%                            | 0.8%                          | .95                                      | .94                                      |
| Pneumonia                        | 178 2.9%                  | 4.8%                            | 5.5%                          | .009                                     | .75                                      |
| Pulmonary embolism               | 66 1.2%                   | 0.5%                            | 1.6%                          | .17                                      | .68                                      |
| Sepsis                           | 88 1.4%                   | 3.1%                            | 1.6%                          | .01                                      | .35                                      |
| Urinary tract infection          | 44 0.8%                   | 0.5%                            | 0.0%                          | .26                                      | .43                                      |
| 1-yr surgical complications      | 350 5.9%                  | 7.6%                            | 7.0%                          | .14                                      | .82                                      |
| Wound disruption                 | 41 0.7%                   | 0.2%                            | 1.6%                          | .63                                      | .08                                      |
| Implant infection                | 128 2.2%                  | 3.1%                            | 1.6%                          | .38                                      | .35                                      |
| Mechanical complication          | 231 3.9%                  | 5.7%                            | 3.9%                          | .10                                      | .42                                      |

TSA, total shoulder arthroplasty; HCV, hepatitis C virus.

Bold denotes significance.

Figure 2 Medical and surgical complication rates in patients with and without HCV 1 year after total shoulder arthroplasty (TSA), anatomic total shoulder arthroplasty (ATSA), or reverse total shoulder arthroplasty (RTSA).
1 year. These findings differ from those of a prior national database study, which showed not only increased of mechanical complications, such as dislocation, but also increased rates of infection, revision surgery, stiffness, and fracture among HCV patients undergoing TSA. These discrepancies may be due to significant differences between our cohorts, such as increased percentage of female patients, prevalence of diabetes, and a larger sample size in the previous study. Our results are also in contrast to the overall trends in the hip and knee arthroplasty literature, in which HCV patients have found no significant differences in surgical complications, including prosthetic joint infection, mechanical complications, and postoperative bleeding, compared with matched controls. Many of these studies utilized national databases with much larger sample sizes, which compared with matched controls. Many of these studies utilized national databases with much larger sample sizes, which may suggest that our study may have been underpowered to detect a significant difference in surgical complications.

To the best of our knowledge, this is the first study to examine the effects of preoperative HCV treatment with DAA on rates of common medical and surgical complications after TSA. Patients who had undergone HCV treatment preoperatively had a 1.5% and 1.8% lower rate of implant infection and mechanical complication, respectively, compared to untreated patients 1 year after TSA. The rates of implant infection and mechanical complication were also similar in TSA patients without HCV and those with treated HCV. Although these differences did not reach statistical significance, the differences were in the expected direction, and the magnitude of these differences was similar to the results of prior studies evaluating the effect of HCV treatment in hip and knee arthroplasty. Bendich et al showed that preoperative DAA treatment was associated with significantly reduced rates of 1-year implant infectious and mechanical complications (1.8% and 0.8% reductions, respectively), compared to untreated patients. The trend toward decreased infection and mechanical complication rate after DAA treatment may be related to the improvement in multisystem function associated with sustained virologic response. Prior studies evaluating the effects of DAA therapy have demonstrated a decreased rate incidence of mixed cryoglobulinemia, lymphoproliferative disorders, diabetes, and cardiovascular disease after treatment. Despite the benefits in treating hepatic and extrahepatic manifestations, there is currently insufficient evidence to recommend preoperative DAA treatment in HCV patients undergoing TSA. However, future studies are warranted on this topic.

Interestingly, our results also demonstrated higher rates of AKI in HCV patients who received treatment preoperatively compared to untreated patients. Although DAAs have a relatively safe adverse effect profile, Brown et al reported that nearly 20% of patients treated with DAA had AKI during DAA therapy. Furthermore, prior studies have found no significant difference in renal function between untreated and treated HCV patients, suggesting that viral eradication may not be associated with improvement in renal disease progression. This stresses the importance of monitoring renal function in patients with high HCV prevalence, who recently received DAA therapy.

Another important finding in this study is the 9.5% prevalence of HCV in US veterans undergoing TSA in the past 5 years. This rate is much higher than the national prevalence of 1.3% and the 2014 US veteran prevalence of 6.1%. Furthermore, there was a decrease in the prevalence of HCV infected veterans undergoing TSA from 11.4% in 2014 to 6.5% in 2018. Recently, Shapiro et al reported a decrease in overall virologic prevalence from 53.1% in 2012 to 30.3% in 2019 among HCV patients undergoing total hip and knee arthroplasty at a single California VA medical center. The current study utilized a nationwide database, which may account for the difference in the rates of treated HCV patients. Nonetheless, their study underscores that the rates of HCV treatment among US veterans is lagging nationally.

Although this study utilized a large national database of a single population of patients with high HCV prevalence, it is not without limitations, including its retrospective nature. In addition, like other studies that analyze a VA patient cohort, there is a patient demographic bias that underrepresents female patients and young

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Table IV

| ATSA complication rates at 90 d and 1 yr. | ATSA without HCV (n = 1680) | ATSA with untreated HCV (n = 143) | ATSA with treated HCV (n = 24) | P value Patients with HCV vs. untreated HCV |
| No. of patients with complications | | | | |
| 90-d medical complications | 76 | .46% | 3.5% | 8.3% | .83 | .27 |
| 90-d surgical complications | 26 | 1.6% | 1.4% | .0% | .70 | .56 |
| Acute myocardial infarction | 13 | .7% | 1.4% | .0% | .51 | .56 |
| Deep vein thrombosis | 3 | .2% | .0% | .0% | .56 | N/A |
| Pneumonia | 7 | .5% | .0% | .0% | .56 | N/A |
| Pulmonary embolism | 14 | .9% | .0% | 4.2% | .73 | .01 |
| Sepsis | 10 | .6% | .7% | .0% | .59 | .68 |
| Urinary tract infection | 3 | .1% | .0% | 4.2% | .18 | .01 |
| 90-d surgical complications | 36 | 2.2% | 1.4% | .0% | .37 | .56 |
| Wound disruption | 4 | .3% | .0% | .0% | .51 | N/A |
| Implant infection | 20 | 1.3% | .7% | .0% | .46 | .68 |
| Mechanical complication | 15 | .0% | .7% | .0% | .67 | .68 |
| 1-yr medical complications | 165 | 9.1% | 17.5% | 12.5% | .001 | 55 |
| 1-yr surgical complications | 72 | 3.8% | 9.1% | 4.2% | .006 | 42 |
| Acute kidney injury | 31 | 1.7% | 3.5% | .0% | .25 | .35 |
| Cerebrovascular accident | 15 | .8% | 1.4% | 4.2% | .19 | .34 |
| Deep vein thrombosis | 12 | .7% | .7% | .0% | .85 | .68 |
| Pneumonia | 34 | 1.7% | 4.9% | 8.3% | .001 | .49 |
| Pulmonary embolism | 19 | 1.2% | .7% | .0% | .49 | .68 |
| Sepsis | 15 | .7% | 2.8% | 4.2% | .002 | .72 |
| Urinary tract infection | 19 | 1.2% | .7% | .0% | .49 | .68 |
| 1-yr surgical complications | 66 | 3.8% | 6.3% | .0% | .31 | .21 |
| Wound infection | 7 | .5% | .0% | .0% | .38 | N/A |
| Implant infection | 31 | 1.9% | 2.1% | .0% | .96 | .47 |
| Mechanical complication | 35 | 1.9% | 4.9% | .0% | .04 | .27 |

ATSA, anatomic total shoulder arthroplasty; HCV, hepatitis C virus.

Bold denotes significance.
Table V
RTSA complication rates at 90 d and 1 yr.

| Complication                          | No. of patients with complications (n = 1367) | RTSA without HCV (n = 1251) | RTSA with untreated HCV (n = 87) | RTSA with treated HCV (n = 29) | P value Patients with HCV vs without HCV | P value Patients with untreated HCV vs. treated HCV |
|---------------------------------------|---------------------------------------------|-----------------------------|---------------------------------|--------------------------------|------------------------------------------|-----------------------------------------------|
| 90-d medical complications            |                                             |                             |                                 |                                | .03                                      | .41                                           |
| Acute kidney injury                   | 43                                          | 3.4%                        | 1.1%                            | .0%                            | .14                                      | .56                                           |
| Acute myocardial infarction           | 8                                           | .6%                         | .0%                             | .0%                            | .39                                      | N/A                                           |
| Cerebrovascular accident              | 6                                           | .4%                         | 1.1%                            | .0%                            | .47                                      | .56                                           |
| Deep vein thrombosis                  | 12                                          | 1.0%                        | .0%                             | .0%                            | .29                                      | N/A                                           |
| Pneumonia                             | 15                                          | 1.2%                        | .0%                             | .0%                            | .24                                      | N/A                                           |
| Pulmonary embolism                    | 12                                          | 1.0%                        | .0%                             | .0%                            | .29                                      | N/A                                           |
| Sepsis                                | 10                                          | .8%                         | .0%                             | .0%                            | .33                                      | N/A                                           |
| Urinary tract infection               | 11                                          | .9%                         | .0%                             | .0%                            | .31                                      | N/A                                           |
| 90-d surgical complications           | 64                                          | 4.6%                        | 8.0%                            | .0%                            | .47                                      | .12                                           |
| Wound disruption                      | 4                                           | .3%                         | .0%                             | .0%                            | .54                                      | N/A                                           |
| Implant infection                     | 17                                          | 1.2%                        | 2.3%                            | .0%                            | .63                                      | .41                                           |
| Mechanical complication               | 49                                          | 3.4%                        | 8.0%                            | .0%                            | .14                                      | .12                                           |
| 1-yr medical complications            | 179                                         | 13.3%                       | 11.5%                           | 6.9%                           | .36                                      | .48                                           |
| Acute kidney injury                   | 83                                          | 6.4%                        | 3.4%                            | .0%                            | .10                                      | .31                                           |
| Acute myocardial infarction           | 22                                          | 1.7%                        | 1.1%                            | .0%                            | .50                                      | .56                                           |
| Cerebrovascular accident              | 15                                          | 1.0%                        | 1.1%                            | 3.4%                           | .50                                      | .41                                           |
| Deep vein thrombosis                  | 14                                          | 1.1%                        | .0%                             | .0%                            | .25                                      | N/A                                           |
| Pneumonia                             | 50                                          | 3.6%                        | 4.6%                            | 3.4%                           | .70                                      | .79                                           |
| Pulmonary embolism                    | 16                                          | 1.2%                        | 1.1%                            | .0%                            | .75                                      | .56                                           |
| Sepsis                                | 26                                          | 1.7%                        | 5.7%                            | .0%                            | .05                                      | N/A                                           |
| Urinary tract infection               | 12                                          | 1.0%                        | .0%                             | .0%                            | .29                                      | N/A                                           |
| 1-yr surgical complications           | 103                                         | 7.4%                        | 11.5%                           | 3.4%                           | .41                                      | .20                                           |
| Wound disruption                      | 8                                           | .6%                         | .0%                             | .0%                            | .39                                      | N/A                                           |
| Implant infection                     | 36                                          | 2.5%                        | 5.7%                            | .0%                            | .24                                      | N/A                                           |
| Mechanical complication               | 73                                          | 5.2%                        | 8.0%                            | 3.4%                           | .44                                      | .40                                           |

RTSA, reverse total shoulder arthroplasty; HCV, hepatitis C virus. Bold denotes significance.

Table VI
Multivariate analysis of TSA, ATSA, and RTSA complications at 90 d and 1 yr.

| Complication                          | HCV infection vs. no HCV infection | HCV untreated vs. HCV treated |
|---------------------------------------|----------------------------------|------------------------------|
|                                       | OR (95% CI)                      | P value                      | OR (95% CI)                      | P value |
| TSA 90 d                              |                                  |                              |                               |
| Implant infection                     | 1.25 (0.63-2.48)                 | .533                         | 1.11 (0.23-5.31)                | .895    |
| Any medical complication              | 0.96 (0.64-1.43)                 | .825                         | .74 (0.38-1.44)                 | .376    |
| Any surgical complication             | 1.09 (0.69, 1.71)                | .707                         | .98 (0.38-2.52)                 | .960    |
| TSA 1 yr                              |                                  |                              |                               |
| Implant infection                     | 1.18 (0.68-2.06)                 | .559                         | 1.72 (0.38-7.80)                | .481    |
| Any medical complication              | 1.39 (1.06-1.81)                 | .016                         | .81 (0.49-1.34)                 | .397    |
| Any surgical complication             | 1.16 (0.82-1.64)                 | .399                         | .92 (0.45-1.88)                 | .820    |
| ATSA 90 d                              |                                  |                              |                               |
| Implant infection                     | .36 (0.05-2.74)                  | .322                         | N/A                           | N/A    |
| Any medical complication              | .88 (0.39-2.01)                  | .768                         | .80 (0.12-5.24)                 | .812    |
| Any surgical complication             | .45 (0.11-1.91)                  | .277                         | N/A                           | N/A    |
| ATSA 1 yr                              |                                  |                              |                               |
| Implant infection                     | .84 (0.25-2.84)                  | .778                         | N/A                           | N/A    |
| Any medical complication              | 2.02 (1.27-3.21)                 | .003                         | 1.83 (0.35-9.57)                | .472    |
| Any surgical complication             | 1.26 (0.60-2.64)                 | .545                         | N/A                           | N/A    |
| RTSA 90 d                              |                                  |                              |                               |
| Implant infection                     | 1.19 (0.26-5.5)                  | .827                         | N/A                           | N/A    |
| Any medical complication              | .25 (0.06-1.05)                  | .059                         | N/A                           | N/A    |
| Any surgical complication             | 1.27 (0.54-2.95)                 | .584                         | N/A                           | N/A    |
| RTSA 1 yr                              |                                  |                              |                               |
| Implant infection                     | 1.48 (0.54-4.06)                 | .444                         | 2.45 (0.56-10.70)               | .234    |
| Any medical complication              | .76 (0.40-1.46)                  | .416                         | 2.36 (0.31-17.93)               | .407    |
| Any surgical complication             | 1.20 (0.60-2.37)                 | .610                         | 2.37 (0.70-8.09)                | .168    |

TSA, total shoulder arthroplasty; ATSA, anatomic total shoulder arthroplasty; RTSA, reverse total shoulder arthroplasty; HCV, hepatitis C virus; OR, odds ratio; CI, confidence interval. Bold denotes significance.

*Reference group is patients without HCV.

Reference group is patients with treated HCV.
patients, limiting the generalizability of the findings. Second, HCV status and complications were identified using ICD-9 and ICD-10 codes, which may be inaccurate. However, prior studies evaluating the coding accuracy of ICD-9 codes in the VHA system showed a positive predictive value of 93% and negative predictive value of 92% in correctly identifying HCV status. We also cannot rule out potential cases of misclassification in which HCV patients were treated with DAA therapy that was not documented in the medical record. Another limitation is the relatively small sample size of HCV-treated and HCV-un-treated patients. This study was likely underpowered to detect a difference in surgical complications as previously reported by larger database studies using the National Inpatient Sample. A post hoc power analysis showed that 19,623 patients would be needed to demonstrate a significant difference in implant infection rates between patients with and without HCV. Next, this study did not divide HCV patients into those with and without cirrhosis. It has been previously shown that cirrhosis is an independent risk factor for increased postoperative complications after TSA. However, this study investigated only patients who received arthroplasty, and patients who were ill due to cirrhosis may not have been TSA candidates. Furthermore, we did not include transfusion rates or revision rates, which are all factors that have been reported to be elevated in HCV TSA cohorts. Finally, we did not prove cure with DAA-based treatments of HCV. We did not view this as necessary as recent therapies have generated cure rates over 95%.

Conclusion

In summary, 9.5% of patients undergoing TSA in the US VHA system from 2014 to 2019 had HCV infection. Patients with HCV are at an increased risk of medical complications, including AKI, acute myocardial infarction, pneumonia, and sepsis, 1 year after TSA compared to uninfected patients. The overall risk for these complications is not inconsequential and surgeons should discuss this risk with patients and maintain vigilance for cardiovascular and infectious signs postoperatively. There was no significant difference in surgical complication rates between patients with and without HCV at 90 days and 1 year. At this time, there is insufficient evidence to recommend preoperative DAA treatment in HCV patients undergoing TSA to decrease medical or surgical complications, although there are other benefits of HCV treatment. Larger studies are needed in the future to evaluate the effect of HCV treatment on outcomes in TSA.

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