End-stage renal disease patients have comparable results to renal transplant patients after shoulder arthroplasty

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Background: End-stage renal disease (ESRD) and renal transplant (RT) patients are known to have more perioperative and postoperative complications after arthroplasty surgeries when compared to patients without. We hypothesize that RT patients undergoing shoulder arthroplasty (SA) have fewer systemic and surgical complications when compared to ESRD patients undergoing SA.

Methods: This was a retrospective review from the PearlDiver Patient Record Database. International Classification of Diseases and Current Procedural Terminology codes were used to identify patients who had undergone primary total and reverse shoulder arthroplasty, respectively, and subsequent surgical revisions. Unadjusted univariate analysis of patient demographics, Charlson Cormorbidty Index, and surgical complications at 90 days, 1 year, and 2 years after was performed using chi-squared testing. Multivariate logistic regression analyses were subsequently performed for systemic complications and prosthesis outcomes at all time points.

Results: Of 1191 patients with ESRD or previous RT and who underwent either total shoulder arthroplasty or reverse total shoulder arthroplasty, 1042 (87.5%) had ESRD and 149 (12.5%) had a previous RT. ESRD SA patients were more likely to have hypertension, liver disease, coronary artery disease, and hypothyroidism. Interestingly no statistical significance was found in multivariate analysis for systemic complications at 90 days, nor for surgical complications at the 90-day, 1-year, or 2-year mark between ESRD and RT cohorts.

Conclusion: SAs have comparable outcomes in ESRD and RT patients. The differing conclusions among studies might be partially accounted for by the demographic differences and comorbidities between these 2 patient populations. Providers should continue to provide appropriate counseling concerning risks, benefits, and timing of SA for these patients.

Because of the aging population, it is estimated that up to one-third of people older than 60 years suffer from glenohumeral arthritis.[35] Depending on glenoid bone stock and rotator cuff functionality, there are different options for shoulder arthroplasty (SA) for patients who have failed conservative management. Anatomic total shoulder arthroplasty is indicated for patients with an intact rotator cuff and sufficient glenoid bone, while those who have physically demanding lives or poor glenoid bone stock can benefit from a hemiarthroplasty.[11-14,16,18,29] Reverse SA are indicated in patients with rotator cuff deficiency.[20] SA is also reliable options for improving function, relieving pain, and treating fractures and cuff arthropathies in patients when conservative management has failed.[8,19,21,28,33,46] Although SA procedure volume has exponentially increased over the last 2 decades, postoperative complications still occur in almost 10% of patients.[5]

Renal transplant (RT) and end-stage renal disease (ESRD) patients have a documented increased risk of complications following arthroplasty surgeries.[6,9,10,22,24,25,28,30,32,34,37,40,43-45,47,49] ESRD patients have a 10 times increased risk of death, 4-fold increased risk of infections following total hip arthroplasty (THA) and total knee arthroplasty (TKA) surgeries.[10,36] RT gives patients with ESRD improvement in renal function leading to lower mortality rates and better quality of life when compared to patients with ESRD.[4,12] However, because both RT and renal disease patients have concomitant chronic conditions and are chronically

Table I
Baseline patient characteristics.

	ESRD n = 1042 (82.5%)	RT n = 149 (17.5%)	P value
Age			
<40	4 (0.38)	3 (2.01)	.063
40-49	11 (1.06)	3 (2.01)	**.013**
50-59	94 (9.02)	26 (17.45)	**.002**
60-69	282 (27.06)	63 (42.28)	**<.001**
70-79	547 (52.5)	52 (34.9)	**<.001**
≥80	87 (8.35)	1 (0.67)	**.001**
Gender			
Male	436 (41.84)	79 (53.02)	**.01**
Female	606 (58.16)	70 (46.98)	**.01**
Charlson Comorbidity Index			
0	18 (1.73)	3 (2.01)	.12
1	16 (1.54)	4 (2.68)	.496
2	61 (5.85)	18 (12.08)	**.007**
3	129 (12.38)	16 (10.74)	.66
4	140 (13.44)	19 (12.75)	.92
≥5	678 (65.07)	86 (57.72)	.097

ESRD, end-stage renal disease; *RT*, renal transplant.
The significance of the bold is that it indicates statistical significance based on P value <.05.

Table II
Baseline patient comorbidities.

	ESRD N (%)	RT N (%)	P value
DM	545 (52.3)	66 (44.3)	.082
HTN	902 (86.56)	117 (78.52)	**.013**
Liver disease	77 (7.39)	21 (14.09)	**.009**
Obesity	291 (27.93)	31 (20.81)	.083
Weight loss	69 (6.62)	12 (8.05)	.635
Hypothyroidism	273 (26.2)	21 (14.09)	**.002**
CVD	154 (14.78)	13 (8.72)	.062
MI	98 (9.40)	11 (7.28)	.516
CAD	342 (32.82)	35 (23.49)	**.028**
CHF	67 (6.43)	16 (10.74)	.078
PVD	215 (20.63)	23 (15.44)	.169
Pulmonary heart disease	100 (9.6)	13 (8.72)	.849
Ischemic heart disease	75 (7.2)	5 (3.36)	.115
Valvular disease	194 (18.62)	13 (8.72)	**.004**
Arrhythmias	319 (30.61)	40 (26.85)	.4
Coagulopathy	89 (8.54)	16 (10.74)	.465
Deficiency anemia	213 (20.44)	22 (14.77)	.129
Asthma	127 (12.19)	13 (8.72)	.275
Solid tumor	105 (10.08)	16 (10.74)	.916
Cancer	115 (11.04)	19 (12.75)	.63
Metastatic cancer	25 (2.4)	2 (1.34)	.606
RA	35 (3.36)	10 (6.71)	.075
Tobacco use	60 (5.76)	11 (7.38)	.55
Alcohol use	33 (3.17)	4 (2.68)	.948
Drug abuse	63 (6.05)	8 (5.37)	.888
Depression	266 (25.53)	29 (19.46)	.132
Dementia	40 (3.84)	3 (2.01)	.378

HTN, hypertension; *CHF*, congestive heart failure; *CAD*, coronary artery disease; *PVD*, peripheral vascular disease; *CVD*, cardiovascular disease; *DM*, diabetes mellitus; *RA*, rheumatoid arthritis; *MI*, myocardial infarction; *ESRD*, end-stage renal disease; *RT*, renal transplant.
The significance of the bold is that it indicates statistical significance based on P value <.05.

immunosuppressed, they are prone to postoperative complications following arthroplasty surgeries. Such complications include deep venous thrombosis (DVT), periprosthetic joint infections (PJIs), aseptic loosening (AL), wound complications, and periprosthetic fractures (PPFs).[2,6,9,22,28,30,35,49] The majority of such studies focus on patients undergoing TKA and THA surgery, respectively, few however have investigated SA. In addition, there have been no studies comparing SA postoperative risks between ESRD and RT patients. As long-term survival for RT and ESRD patients continues to increase, more of these patients will require arthroplasty surgeries in the future.[39,40] It is vital to have an understanding of postoperative complication profiles for these 2 patients groups so that they can be informed of the risks and benefits of proceeding with SA. Furthermore, the findings in this study may allow for guidance on whether or not patients with ESRD who are RT candidates requiring SA should proceed with SA before or after transplant. The purpose of this study was to determine and compare the demographics and postoperative medical and surgical complications between RT and ESRD patients receiving SA. We hypothesize that ESRD patients will have more postoperative complications when compared to RT patients.

Methods

This retrospective study used the PearlDiver Patient Record Database (PearlDiver [www.pearldiver.inc], Fort Wayne, IN, USA), a commercially available repository of 41 billion Health Insurance Portability and Accountability Act of 1996-compliant patient records. Specifically, the "MUExtr" dataset within PearlDiver was used, which is comprised of medical records for privately insured, Medicare, and Medicaid patients across the United States who have undergone upper extremity procedures. International Classification of Diseases, 10th revision diagnosis (ICD-10) and Current Procedural Terminology procedure codes were used to identify all adult patients who underwent primary total shoulder arthroplasty (TSA) and reverse TSA for arthritis or cuff arthropathy from 2015-2019. ICD-10 and Current Procedural Terminology codes were used to include both primary TSA and reverse TSA cases into patients who had concurrent ESRD and patients who had undergone previous RT. Patients with a history of fracture, revisions, or infections were excluded. All collected data were deidentified and exempt from institutional review board requirements.

The primary study outcomes evaluated included medical complications at 90 days and surgical complications at 90 days, 1 year, and 2 years post-SA. Systemic complications included cardiac arrest, DVT, pneumonia, pulmonary embolism, urinary tract infection (UTI), sepsis, reintubation, wound disruption, hematoma, and need for transfusion. Surgical complications included PPF, PJI, stiffness, instability, and AL.

All data analysis was performed using the R statistical software package (Vienna, Austria) integrated within PearlDiver. Patient demographics, comorbidities (defined as diagnoses occurring within 1 year of index SA), and hospital factor data were compared between patient groups using Welch's 2-sample t-test for continuous variables and the chi-square test for categorical variables. Categorical variables are displayed as frequency and percentage of the cohort, while continuous variables are shown as means with standard error. Multivariable logistic regression was performed for systemic complications and prosthesis outcomes of interest while controlling for age, gender, Charlson Comorbidity Index (CCI), diabetes mellitus, and all other comorbidities found to be significantly different in the univariate analysis (Tables I and II). Significance was determined with a 2-tailed P value of .05.

Results

A total of 1191 patients with ESRD or RT undergoing SA were identified during the study period. There were 1042 (87.5%) patients with ESRD and 149 (12.5%) patients with a previous RT.

Table III
Systemic complications at 90 days.

	ESRD	RT	OR (95% CI)	P value
	N (%)	N (%)		
Cardiac arrest	2 (0.19)	0 (0)	NA	NA
DVT	15 (1.44)	3 (2.013)	1.33 (0.36-4.85)	.671
Pneumonia	43 (4.13)	3 (2.013)	1.72 (0.78-3.76)	.176
Transfusion	20 (1.92)	1 (0.67)	0.34 (0.02-1.7)	.297
PE	1 (0.096)	(0)	NA	NA
UTI	83 (7.97)	2 (1.34)	0.95 (0.43-1.9)	.9
Sepsis	27 (2.59)	3 (2.013)	0.85 (0.2-2.52)	.792
Reintubation	5 (0.48)	0 (0)	NA	NA
Disruption of wound	8 (0.77)	1 (0.67)	0.65 (0.03-3.71)	.686
Hematoma	2 (0.19)	0 (0)	NA	NA

DVT, deep vein thrombosis; *PE*, pulmonary embolism; *UTI*, urinary tract infection; *ESRD*, end-stage renal disease; *RT*, renal transplant; *OR*, odds ratio; *CI*, confidence interval.

Table IV
Surgical complications at 90 days.

	ESRD	RT	OR (95% CI)	P value
	N (%)	N (%)		
PPFX	29 (2.78)	1 (0.67)	0.3 (0.02-1.48)	.244
PJI	3 (0.29)	1 (0.67)	7.31 (0.19-2.38)	.228
Stiffness	98 (9.4)	14 (9.4)	1.01 (0.53-1.81)	.97
Instability	37 (3.55)	3 (2.01)	0.53 (0.13-1.53)	.304
Aseptic loosening	0	0	N/A	N/A

PPFX, periprosthetic fracture; *PJI*, prosthetic joint infection; *ESRD*, end-stage renal disease; *RT*, renal transplant; *OR*, odds ratio; *CI*, confidence interval.

Table V
Surgical complications at 1 year.

	ESRD	RT	OR (95% CI)	P value
	N (%)	N (%)		
PPFX	40 (3.84)	3 (2.01)	0.5 (0.12-1.42)	.255
PJI	5 (0.48)	1 (0.67)	1.73 (0.08-16.6)	.661
Stiffness	123 (11.8)	18 (12.1)	1.08 (0.61-1.83)	.79
Instability	58 (5.57)	6 (4.03)	0.56 (0.19-1.32)	.23
Aseptic loosening	0 (0)	0	N/A	N/A

PPFX, periprosthetic fracture; *PJI*, prosthetic joint infection; *ESRD*, end-stage renal disease; *RT*, renal transplant; *OR*, odds ratio; *CI*, confidence interval.

Table VI
Surgical complications at 2 years.

	ESRD	RT	OR (95% CI)	P value
	N (%)	N (%)		
PPFX	51 (4.89)	4 (2.69)	0.53 (0.16-1.33)	.228
PJI	6 (0.58)	1 (0.67)	1.06 (0.05-7.74)	.96
Stiffness	137 (13.15)	19 (12.75)	0.97 (0.55-1.61)	.902
Instability	66 (6.33)	6 (4.03)	0.48 (0.16-1.13)	.131
Aseptic loosening	1 (0.1)	0	N/A	N/A

PPFX, periprosthetic fracture; *PJI*, prosthetic joint infection; *ESRD*, end-stage renal disease; *RT*, renal transplant; *OR*, odds ratio; *CI*, confidence interval.

Patient characteristics

Male patients made up a larger proportion of the RT cohort (53%) than the ESRD cohort (41.8%) (P = .01) (Table I). Overall, RT patients were younger than ESRD patients (aged 65 vs. 70.9 years, P < .001). Patients aged 40-49 (2.01% vs. 1.06%, P = .01), 50-59 (17.45% vs. 9.02%, P = .002), and 60-69 years (42.28% vs. 27.06%, P < .001) made up a larger proportion of the RT cohort than the ESRD cohort (Table I). Patients aged 70-79 years (52.5% vs. 34.9%, P < .001) and 80+ years (8.35% vs. 0.67%, P = .001) made up a larger proportion of the ESRD cohort than the RT cohort (Table I). Patients with 2 CCIs accounted for a larger proportion of the RT cohort (12.08%) than the ESRD cohort (5.85%) (P = .007) (Table I).

Baseline medical comorbidities

ESRD patients were more likely to have hypertension (86.56% vs. 78.52%, P = .012), coronary artery disease (32.82% vs. 23.49%, P = .028), hypothyroidism (26.2% vs. 14.09%, P = .002), and valvular disease (18.62% vs. 8.72%, P = .004) within 1 year of index SA compared to RT patients. RT patients were more likely to have liver disease within 1 year of index SA compared to ESRD patients (14.09% vs. 7.39%, P = .009) (Table II).

Systemic and surgical complications

After controlling for age, gender, CCI, diabetes mellitus, and other index comorbidities identified as significantly different in univariate analysis, there was no significant difference in systemic complications (cardiac arrest, DVT, pneumonia, transfusion, pulmonary embolism, UTI, sepsis, reintubation, disruption of wound, hematoma) at 90 days between the ESRD and RT cohorts (Table III). There was also no significant difference in surgical complications (PPF, PJI, stiffness, instability, AL) at 90 days (Table IV), 1 year (Table V), or 2 years (Table VI) between ESRD and RT cohorts.

Discussion

With medical advances and increased success of maintenance treatment for ESRD and RT, there will continue to be a rise in the number of these patients undergoing SA.[7,12] THA and TKA have been studied extensively, comparing results between both the RT and ESRD patient population.[9,17,25,26,28,31,34-36] Li et al's meta-analysis of 10 studies and 6904 patients showed that RT patients had a lower risk of mortality, revision surgeries, and PJIs compared to ESRD patients when undergoing THA or TKA.[26] Chou et al's[7] meta-analysis which included 22 studies and 9384 patients undergoing THA or TKA showed a slightly increased mortality rate, surgical site complication, and PJI, however all without a significant trend, when comparing ESRD patients to RT patients. Lieu et al's[27] study looked at THA in 128 ESRD and 406 RT patients and showed that ESRD patients had twice the infection rates, higher rates of mortality, AL, and hip dislocations. Lieberman et al[25] looked at 30 patients and found that ESRD patients had poor results and an infection rate of 19%; however, there was no analysis done to indicate a significant trend. Shrader et al[41] showed that in patients undergoing THA, RT patients had higher cumulative rates of revisions and complications when compared to ESRD patients. This is most likely secondary to them having only 37 patients.

Currently, there are no studies available comparing medical complications between RT patients receiving SA and ESRD patients receiving SA. However, there are a few studies that studied SA in ESRD and RT separately. Schwartz et al[40] showed that ESRD patients had an increased risk of developing UTIs, DVT, C. diff infections, strokes, and myocardial infarctions in the postoperative period after SA when compared to patients without ESRD. These patients have an immunocompromised status, a decreased renal clearance, and electrolyte abnormalities, all of which increase their risk of developing postoperative complications.[3,28,40] In our study, there was no significant difference between the ESRD and RT patient cohorts and systemic complications at the 30-day mark. Schwartz et al[40] also found an increased risk of transfusions in

ESRD patients which they attribute to platelet dysfunction secondary to uremia.[23] We did not find an increased risk of transfusion when comparing ESRD and RT patients in our study. Because of their immunocompromised states and poor wound healing abilities, both ESRD and RT patients are also at an increased risk of surgical complications compared to patients with normal renal function.[15,28,40] Hatta et al[15] found an increased risk of PPF in solid-organ transplantation patients, without a significant difference in PJI or shoulder functional outcomes scorers. They hypothesized that the use of corticosteroids post-transplant, metabolic bone disease, and altered vitamin D metabolism all play a role in the risk of PPF.[1] However, their study only had 25 post-transplant patients. There was no increased risk of PPF or PJI among our cohort of 150 RT patients when compared to ESRD patients undergoing SA. Given that ESRD patients require hemodialysis with repeated vascular access, some studies have shown that these patients have higher rates of bacteremia, increasing their risk of PJI.[3,42] When compared to RT patients in our study, there was no increased risk of PJI in ESRD patients.

Our regression analysis did not show a significant trend favoring RT over ESRD patients with regards to stiffness, instability, AL, or PJI or fractures. It is difficult to delineate the variation found in our study compared to other studies. One of the main reasons is the difficulty in matching demographic characteristics of ESRD and RT patients.[34] Generally, RT patients are known to be younger and healthier than ESRD patients.[9,12,34] As such, could the poorer results among ESRD patients be confounded by their demographic characteristics of having more comorbidities and being generally older than RT patients? This may be the case because the above-mentioned studies that concluded more complications among ESRD patients in arthroplasty procedures did not allude to any attempts at decreasing confounding factors of these demographic characteristics (ie, through their regression model).[13,34,36,38] Only Chou et al[7] mentioned performing multiregression analysis, which yielded no significant trends. In the future, studies should focus on matching these 2 patient cohorts to decrease any confounding bias. Some authors have recommended that patients with ESRD should wait for kidney transplantation before receiving arthroplasty surgery.[22,48] The data presented here should act as a reference for surgeons and physicians in counseling both ESRD and RT patients regarding risks and benefits for undergoing SA. In addition to metabolic bone disease, both RT and ESRD are at higher risk of osteonecrosis of the humeral secondary to their chronic immunosuppression through steroids.[36] Providers should also consider holding these drugs prior to proceeding with SA procedures because of the increased risk of PJI in these patient populations.

There are limitations to this study. First, the study was a large database study and individualized patient information was not available, such as operative time, cement use, antibiotic use, types of implants, and perioperative imaging. One of these is whether a patient received an reverse TSA or TSA. Perhaps the revisions or infections only occurred in one versus the other. Another limitation is the length of follow-up. Given the life span of implants, a longer period of follow-up is required to observe any other postoperative changes/complications. Because ICD-9 and ICD-10 coding practices are not standardized, there is the risk of coding errors. Specifically, prior to 2010, all TSAs and reverse TSAs share the same procedure code.

Conclusion

Our present study is one of the largest comparing postoperative complications among RT and ESRD patients undergoing SA. Although previous studies have demonstrated difference between RT and ESRD patients, these differences may be the result of confounding of different comorbidities. There was no significant difference among rates of surgical and medical complications postoperatively between RT and ESRD patients. Although there is a known increased rate of complications among RT and ESRD patients individually, we did not find increased postoperative risks when comparing the 2 populations. When counseling RT and ESRD patients undergoing SA surgery, providers should still discuss the increased risk of postoperative complication in both these populations.

Disclaimers:

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