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Incidence of symptomatic compressive peripheral neuropathy after shoulder replacement

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Abstract
Background The incidence of post-operative compressive peripheral neuropathy (CPN) after shoulder arthroplasty is not known. We hypothesized that the likelihood following shoulder arthroplasty would be higher compared to a non-operative cohort.
Methods Retrospective study compared the incidence of symptomatic CPN after shoulder replacement to a 1:1 age- and gender-matched non-operative control group with shoulder arthritis. Six hundred six consecutive shoulder replacements from a regional shoulder arthroplasty registry were analyzed. This included 319 primary total shoulder arthroplasties (TSR), 168 hemiarthroplasties (HA), 31 humeral resurfacings (HHR), 71 reverse arthroplasties (RTSA), and 17 revision arthroplasties. Diagnosis of post-operative CPN was obtained by documented clinical examination by a physician consistent with CPN based on patient complaints, positive nerve study results, and/or nerve decompression. Age, gender, body mass index, diabetes status, thyroid abnormalities, operative side, and anesthesiology (ASA) score were examined.
Results The surgery group had 15 cases (2.5 %) of post-operative CPN (ten carpal tunnel syndrome, five cubital tunnel syndrome). This included seven TSR, six HA, one revision TSR, and one RTSA. Diagnoses included ten osteoarthritis, four rotator cuff arthropathies, and one chondrolysis. Control group had eight cases (1.3 %) of CPN (seven carpal tunnel syndrome, one cubital tunnel syndrome). In univariate analysis, age, gender, body mass index, ASA score, operative side, thyroid status, and diabetes were not predictors of post-operative CPN. CPN incidence between surgical and control groups was not statistically significant.
Conclusion The 1-year incidence rate of new onset clinical post-operative CPN symptoms was 2.5 %. There was no significant difference of CPN rates between surgical and non-operative groups.

Keywords Compression neuropathy · Shoulder replacement · Carpal tunnel syndrome · Cubital tunnel syndrome

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Introduction

Shoulder replacement procedures including total anatomic shoulder arthroplasty, hemiarthroplasty, and reverse shoulder arthroplasty have become increasingly more common [10]. The procedure involves intraoperative manipulation of the shoulder, elbow, and wrist joint that may place nerves on stretch, followed by immobilization and post-operative

rehabilitation of the extremity. Subsequently, some patients may develop new symptoms of carpal tunnel syndrome or cubital tunnel syndrome following shoulder arthroplasty. Surgeons treating upper extremity conditions need to be mindful of progressive symptoms in these patients.

The overall incidence of new post-operative compressive peripheral neuropathy (CPN) symptoms after shoulder arthroplasty is not known. We hypothesized that the incidence of post-operative clinically significant CPN is higher after shoulder replacement surgery compared to an age- and gender-matched non-operative patient population diagnosed with shoulder arthritis.

Materials and Methods

A retrospective cohort study using prospectively collected data from a shoulder arthroplasty registry (SAR) was conducted. The data collection procedures, quality control, and participation of the SAR have been previously published [18]. In brief, the SAR collects patient, surgical, implant, surgeon, and hospital factors for all patients undergoing shoulder arthroplasty procedures using both a paper form and electronic data extraction from electronic medical records (EMR), as well as administrative claim files. All atraumatic TSA, reverse arthroplasties (RTSA), and hemiarthroplasties (HA) procedures performed between January 1, 2007 and December 31, 2010 in the two largest geographical regions (Southern California and Northern California) that participate in the registry were included in this analysis.

This study compared the incidence of symptomatic CPN within 1 year after shoulder arthroplasty to a 1:1 age- and gender-matched non-operative control group with shoulder arthritis. Between 2007 and 2010, 2,971 shoulder replacements were recorded in the registry. Seventeen of the study group cases had less than 1 year of follow-up due to mortality or loss of medical insurance coverage and were therefore excluded. Inclusion criteria included all atraumatic patients with primary diagnosis of osteoarthritis and/or rotator cuff arthropathy. Exclusion criteria included prior preoperative ipsilateral non-arthroplasty upper extremity surgery, fracture of affected limb, prior preoperative diagnosis of cervical radiculopathy or stroke (CVA), prior preoperative electromyography, and/or nerve conduction study (EMG/NCS) documenting symptomatic ipsilateral CPN before diagnosis of shoulder arthritis (control group) or replacement surgery (study group), or intraoperative brachial plexus neuropathies. Six hundred six shoulder arthroplasties qualified for inclusion in the study and were matched with 606 patients in the control group. The study group included 319 primary total shoulder arthroplasties (TSR), 168 primary HA, 31 primary HHR, 71 reverse RTSA, and 17 revision arthroplasties.

CPN diagnoses were captured through ICD-9 diagnostic codes 354.0, 354.1 (carpal tunnel syndrome), 354.2 (cubital tunnel syndrome), 354.9, 356.9 (peripheral neuropathy), 354.9 (peripheral nerve disorder), and 355.9 (peripheral nerve entrapment), which were inputted at the time of the clinic visit by the treating physician (primary care physician or orthopedic surgeon). Diagnosis of post-operative CPN was made if the patient had a positive EMG/NCS result for new onset of post-operative symptoms or was diagnosed clinically and subsequently underwent conservative or surgical treatment. All patient charts were reviewed and validated by an orthopedic surgeon for accuracy of data.

Patient age, gender, body mass index, diabetes status, thyroid abnormalities, EMG/NCS results, operative side, and anesthesiology (ASA) score were evaluated as possible risk factors for CPN in patients having shoulder replacement.

Descriptive statistics were employed. Chi-squared tests and Fisher's exact test compared proportions of CPN between the matched groups. A univariate logistic regression model was employed to evaluate risk factors for CPN in the shoulder replacement group. Data were analyzed using SAS (version 9.2, SAS Institute, Cary, NC, USA); alpha=0.05 was used; and all tests were two-sided.

Results

Out of the 606 patients in the surgery group, there were 15 cases (2.5 %) of post-operative CPN (ten carpal tunnel syndrome, five cubital tunnel syndrome). This included seven primary TSR, one revision TSR, six primary HA, and one primary RTSA (see Table 1). Diagnoses included ten osteoarthritis, four rotator cuff arthropathies, and one chondrolysis. Of the five cubital tunnel syndrome patients, three were treated with surgery and two were treated with bracing. Of the ten carpal tunnel syndrome patients, seven were treated with bracing and three were treated with surgery.

Nine (2.0 %) additional cases of intraoperative brachial plexopathy nerve injury diagnosed immediately post-operative and directly attributed to the shoulder replacement procedure were excluded. These included four mixed brachial plexopathies, two combined radial and ulnar motor neuropathies, one radial nerve injury (sensory and motor), and two musculocutaneous neuropraxias. These patients were excluded because the main focus of the study was CPN involving only the cubital tunnel or carpal tunnel.

The non-operative control group has eight cases (1.3 %) of CPN (seven carpal tunnels, one cubital tunnel).

The control group had a higher prevalence of diabetes with 182 cases (30.0 %) of 606, versus the study group, 137 cases (22.6 %), $p=0.003$. The study group had a higher prevalence of thyroid abnormalities, 111 cases (18.3 %) of 606, whereas the control group had 93 cases (15.4 %), $p=0.17$. The

Table 1 Summary of post-shoulder arthroplasty CPN patients

Age (years)	Shoulder surgery	Diabetes (Y/N)	Thyroid disease (Y/N)	Weeks to CPN diagnosis	CPN diagnosis	Treatment
80	Hemiarthroplasty			10	Carpal tunnel	Brace
70	Hemiarthroplasty	Y	Y	24	Carpal tunnel	Brace
79	Revision TSR			3	Carpal tunnel	Surgery
66	Hemiarthroplasty		Y	12	Carpal tunnel	Surgery
67	Hemiarthroplasty			28	Carpal tunnel	Brace
61	Hemiarthroplasty	Y		4	Carpal tunnel	Brace
76	Reverse shoulder replacement			24	Carpal tunnel	Surgery
72	Total shoulder replacement			6	Cubital tunnel syndrome	Surgery
70	Total shoulder replacement	Y		8	Carpal tunnel	Brace
64	Total shoulder replacement	Y		4	Cubital tunnel syndrome	Surgery
76	Total shoulder replacement			2	Cubital tunnel syndrome	Surgery
38	Total shoulder replacement			12	Cubital tunnel syndrome	Brace
68	Total shoulder replacement	Y		2	Carpal tunnel	Brace
67	Total shoulder replacement			24	Carpal tunnel	Brace
74	Hemiarthroplasty			8	Cubital tunnel syndrome	Brace

difference in incidence of CPN between the groups was not statistically significant (p=0.37), even after controlling for either thyroid condition (p=0.37) or diabetes (p=0.40).

Post-operative patients with CPN reported symptoms beginning at an average of 11.4 weeks (range 2–28 weeks) after shoulder arthroplasty. When CPN cases were separated out between carpal tunnel syndrome and cubital tunnel syndrome diagnoses, there was no statistically significant differences between the control and surgical groups.

When evaluating the surgical group cases only for possible risk factors of CPN, in univariate analysis, we did not find age (p=0.75), gender (p=0.80), body mass index (p=0.71), ASA score (p=0.54), operative side (p=0.23), thyroid status (p=0.88), and diabetes status (p=0.84) to be associated with this event.

Discussion

While past studies have analyzed the incidence of intraoperative nerve injuries during shoulder replacement, very few studies have evaluated the incidence of new onset post-operative compressive neuropathies [5, 12, 15, 21, 22]. The reported incidence of CPN in the general population varies in the literature due to regional differences. Prior studies report confirmed carpal tunnel syndrome incidence rates ranging from 0.4 to 2.3 cases per 100 person-years [4, 17, 23]. The annual incidence of cubital tunnel syndrome has been reported to be up to 25 cases per 100,000 person-years [14].

Our study found a low incidence of post-operative CPN symptoms after shoulder replacement (2.5 %). There were no clinically relevant differences in the development of CPN symptoms between post-shoulder arthroplasty and non-operative shoulder arthritis patient groups within 1 year after surgery.

There is most likely a complex interaction between multiple factors which can lead to symptomatic compressive peripheral neuropathies after open shoulder surgery, ranging from preoperative to intraoperative to post-operative variables. Multiple predisposing CPN factors in the non-operated general patient setting include diabetes, thyroid abnormalities, alcohol use, age, gender, smoking, occupation, and repetitive upper extremity use [19]. Intra-operative factors which may affect post-operative CPN incidence include surgical duration, interscalene block, and limb positioning [2, 8]. Post-operative sling use, cryocuff temperature changes, limb swelling, and manipulation during physical therapy may also contribute to the development of neuropathy symptoms. Sling and repetitive range-of-motion rehabilitation can increase intraneural pressures distally. Further investigations into these modifiable factors are needed.

Ladermann et al. evaluated the subclinical prevalence of peripheral compressive neurologic abnormalities after anatomic and reverse shoulder replacement using preoperative and post-operative electromyographic evaluation [11]. The

authors found subclinical worsening of prior preoperative CPN in 3 of 19 RSA patients but no new onset of acute clinically relevant post-operative CPN (carpal tunnel or cubital tunnel) lesions in their small patient cohort. They recommended that patients should be informed that preoperative neurologic symptoms could become worse following total or reverse shoulder arthroplasty. Our study sought to identify only newly symptomatic patients after the surgical procedure. We did not obtain nerve studies of all patients prior to surgery to exclude those with subclinical CPN. Instead, we excluded any patients with a prior preoperative diagnosis of CPN by a physician or documented clinical symptoms consistent with CPN at the preoperative visit. Therefore, the number of patients in our study who could develop CPN symptoms post-operatively may be underestimated. However, we controlled for the effect of the surgical course by comparing the post-operative incidence with a non-operative control group with a similar demographic profile. It is possible that there was a cohort of patients who had transient subclinical CPN symptoms which were not reported to the surgeon and were not accounted for in our study.

As discussed earlier, demographic factors including age, gender, and body mass index [1, 3, 6, 11, 13, 20] have all been proposed as risk factors for carpal tunnel syndrome and cubital tunnel syndrome in the general population. The incidence of CPN appears to increase with age [16, 19]. We did not find such an association in our study group although due to the nature of the shoulder arthritis diagnosis and surgical procedure, our studied patient group ages were in a much narrower, older, age range.

While compressive neuropathies can be associated with multiple medical conditions, diabetes has often been proposed as a risk factor for CPN in the general population [3, 8, 13, 19]. Microvascular injury or changes in perineural metabolism may make the affected nerves more susceptible to injury [7]. The role of the degree of glucose control, i.e., hemoglobin A1c levels, despite having a diabetic condition was not studied and may contribute to development of CPN symptoms.

Limitations of this study include heterogeneous intraoperative limb positioning and post-operative rehabilitation protocols due to the multiple surgeons who participate in the institutional registry. We believe that the effect of a large patient volume with a diverse surgeon group allows reasonable comparisons to be drawn. While the study did not examine effects of regional anesthesia such as interscalene block, we excluded proximal based plexus/nerve lesions because the study focus was on distal compressive neuropathies. The low number of CPN outcomes limited our statistical analysis to univariate analysis or controlling for one potential confounder at most; however, no factor was significantly associated with outcomes on a univariate basis. With much larger numbers, a more comprehensive analysis to adjust for multiple factors in the same model may be performed. We were unable to control for occupation or repetitive activities for each patient group. While this may be a factor contributing to CPN symptoms, the majority of our patients were above 60 years of age and more likely to be retired and sedentary than a younger cohort [9].

In conclusion, there was a low 2.5 % incidence of clinically relevant CPN symptoms after open shoulder arthroplasty surgery. This was not significantly different from a gender- and age-matched non-operative control group.

Conflict of Interest Edward H. Yian declares that he has no conflict of interest.
Mark Dillon declares that he has no conflict of interest.
Jeff Sodl declares that he has no conflict of interest.
Emil Dionysian declares that he has no conflict of interest.
Ronald Navarro declares that he has no conflict of interest.
Anshuman Singh declares that he has no conflict of interest.

Statement of Human and Animal Rights This is a retrospective study. This article does not contain any studies with human or animal test subjects performed by any of the authors.

Statement of Informed Consent Study approval was obtained from the institutional review board and because of the study's design, individual written informed consent was deemed not necessary.

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