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Intraoperative complications during revision shoulder arthroplasty: a study using the National Joint Registry dataset

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Abstract

Background: The surgical options for revision shoulder arthroplasty and the number of procedures performed are increasing. However, little is known about the risk factors for intraoperative complications associated with this complex surgery.

Methods: The National Joint Registry (NJR) is a surgeon reported database recording information on major joint replacements including revision shoulder arthroplasty. Using multivariable binary logistic regression modelling, we analyzed 1445 revision shoulder arthroplasties reported to the NJR between April 2012 and 2015.

Results: The risk of developing a complication during revision surgery was greater than primary arthroplasty (5% versus 2.5%). An intraoperative fracture was the most common complication occurring in 50 (3.5%) cases. Nerve injuries were recorded for two (0.1%) patients and vascular injuries for one (0.1%) patient. The incidence of intraoperative fractures was higher in females than males (relative risk = 3.25; $p = 0.005$). Periprosthetic fracture as an indication for revision carried the highest risk for any complication (relative risk = 3.00, $p = 0.06$).

Conclusions: This is the largest registry study to date investigating the incidence and risk factors for intraoperative complications during revision shoulder arthroplasty. Females have over three times the risk of intraoperative fractures compared to males. This study will help inform surgeons to accurately counsel patients.

Keywords

complication, fracture, National Joint Registry, neurovascular injury, revision, shoulder arthroplasty

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Introduction

There has been an increase in primary and revision shoulder arthroplasties since the National Joint Registry of England, Wales, Northern Ireland and the Isle of Man (NJR) started collecting data in 2012 and it is widely anticipated that this is likely to continue.[1–4] Intraoperative complications during shoulder arthroplasty are rarely reported in the literature. A previous registry study has found that during primary arthroplasty, intraoperative complications are identified at a rate of 2.6% (1.7% fracture and 0.9% 'other' complications).[1] Case series have shown a complication rate of up to 11%.[5,6] Intraoperative complications during revision shoulder arthroplasty have been reported to occur in up to 30% of cases.[7,8] The incidence of intraoperative fractures is reported to be up to 16%; and the true incidence of vascular and nerve injuries is unknown.[9,10] Existing studies report the results of small sample sizes,[9,10] and therefore may not be generalizable. The true incidence of intraoperative complications and their risk factors remains poorly understood, posing difficulties for patients and surgeons to make fully informed decisions on treatment.

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In April 2012, the NJR began collecting data on shoulder arthroplasty. It has captured 1445 revision arthroplasties in 3 years, making it the second largest registry and the only one to capture data on intraoperative complications.[3,11–13]

The primary aim of the present study is to define the incidence for intraoperative complications reported by the NJR for revision shoulder arthroplasty. The secondary aim is to identify what patient and surgical factors increase the risk of intraoperative complications in revision shoulder arthroplasty.

Methods

An application was made to the NJR for data on all revision shoulder arthroplasties between 1 April 2012 and 31 March 2015. Intraoperative complications were the primary outcome being investigated. The complications that the minimum data set allows surgeons to record are shaft penetration, fracture humerus, fracture glenoid, nerve injury, vascular injury and 'other'. Humerus fracture was recorded 35/1445 (2.4%) times, glenoid fracture was recorded 14/1445 (1.0%) times and shaft penetration was recorded 5/1445 (0.3%) times. Nerve injuries were recorded 2/1445 (0.1%) times, vascular injuries were recorded 1/1445 (0.1%) times and 'other' intraoperative complications were recorded 19/1445 (1.3%) times. Because the event rate (incidence of complications) was low, complications were pooled in to two groups prior to further statistical analysis. This was performed so that adequate numbers would be available within the regression models. The three fracture complications (shaft penetration, fracture humerus, fracture glenoid) were combined into one larger 'fracture' group. Neurological, vascular injuries and 'other' injuries were similarly pooled in a second group.

The risk factors investigated by the multivariable analyses were taken from the NJR shoulder revision minimum dataset. Variables included within the models were age, sex, American Society of Anesthesiologists (ASA) grade,[14] indication for revision, operation type, surgical approach and details of any intraoperative complications. The risk factors that were not analyzed were component fixation method and rotator cuff condition. These variable were omitted because they were closely related to the operation type, and could therefore confound the results. The lead grade of surgeon was also not analyzed because very few operations had a lead surgeon who was not a consultant.

The NJR minimum data set allows multiple indications for revision surgery to be recorded. Surgeons may select one or multiple revision indications when completing the minimum dataset. Variations in recording the indication for arthroplasty on the NJR minimum data set most likely represent different interpretations of the questionnaire. For example, some surgeons recorded infection as the indication and others recorded infection and conversion of hemiarthroplasty to a total shoulder replacement. To limit the number of indications to a manageable level, a primary indication was therefore selected using the hierarchy outlined in Table 1.

Table 1. Revision indication priority.

Priority	Indication for revision
1	Infection
2	Periprosthetic fracture
3	Cuff insufficiency
4	Aseptic loosening
5	Instability
6	Hemiarthroplasty to total shoulder replacement
7	Other

The categories of ASA grade were converted from 1 to 5 to two groups; one included patients with an ASA grade of 1 or 2 ($n = 1034$); the other included patients with an ASA grade of 3, 4 or 5 ($n = 411$). All of the indications for revision were analyzed separately except 'total shoulder replacement to hemiarthroplasty', which was a very small group ($n = 18$) and so was combined with 'other' ($n = 327$). Surgical approach was summarized as deltopectoral ($n = 1075$) or other ($n = 370$) because over three-quarters of revisions were performed through a deltopectoral approach.

For the statistical analysis, age was converted to a categorical variable using the ranges less than 55 years, 55 years to 64.9 years, 65 years to 74.9 years and more than 75 years. These boundaries mirror those used within standard NJR reporting.

Statistical analysis

Statistical analyses were performed using SPSS, version 20.0 (IBM, New York USA). The unadjusted rates for all complications and intraoperative fractures were calculated for each of the recorded variables. Binary logistic regression models were constructed to assess associations between the risk factors and the incidence of intraoperative fracture or the incidence of any intraoperative complication. Univariable models were constructed to examine the influence of each risk factor upon the complication groups in isolation. This formed the unadjusted analysis. To enable meaningful

comparison between the risk factors, multivariable analyses was used to adjust for variation in patient and surgical characteristics. These were performed using all variables as simultaneous predictors for the outcomes under investigation.

Further analyses were performed using ANOVA for continuous variables and chi-squared or Fishers Test for categorical variables. For ANOVA testing, a Bonferroni post-hoc analysis was carried out to minimixe the risk of type one error.

$p < 0.05$ was considered statistically significant. The results of the univariable (unadjusted) and multivariable (adjusted) analyses were used when reporting statistical significance.

Results

In total, 1445 revision shoulder arthroplasties were identified. The mean patient age was 68 years (range 19.7 years to 92.8 years). There were 518 arthroplasties in males and 927 in females. The total number of complications was 72 (5%), with 50 intraoperative fractures (3.5%). Nerve injuries were recorded for two (0.1%) patients and vascular injuries were recorded for one (0.1%) patient. Table 2 shows the frequency of intraoperative complications.

The indication for revision was infection for 182 (13%) operations, periprosthetic fracture for 57 (4%) operations, cuff insufficiency for 334 (23%) operations, instability for 151 (10%) operations, aseptic loosening for 160 (11%) operations, 'hemi to total shoulder replacement' for 334 (23%) operations and other for 227 (16%) operations. There were 741 (51%) revisions to a reverse arthroplasty, 408 (28%) revisions to a conventional total shoulder replacement, 128 (9%) revisions to a stemmed hemiarthroplasty and 67 (5%) revisions to a resurfacing hemiarthroplasty. The operation type was not recorded for 101 (7%) operations. The deltopectoral approach was used in 1075 (74%) cases and another approach was used 370 (26%) times.

The univariate and multivariable analyses of intraoperative fractures found females were at a significantly higher risk than males with a relative risk (RR) of 3.55 ($p = 0.002$) and 3.25 ($p = 0.005$), respectively. ASA grade, patient age, surgical approach, indication and operation type were not associated with an increased incidence of intraoperative fractures.

The incidence of any complication on an unadjusted univariate analysis was significantly higher for females (RR = 1.86, $p = 0.03$) (Table 3) and for patients undergoing revision for a periprosthetic fracture (RR = 3.05, $p = 0.04$) (Table 4). Considering the small pick-up of complications, the multivariable analysis did not find any statistically significant risk factors for any intraoperative complications.

Discussion

The present study is the largest report of registry data of revision shoulder arthroplasties to date and shows that revision arthroplasty has an incidence of intraoperative complications of 5%. This is significantly greater than that observed with primary shoulder arthroplasty, which had an incidence of intraoperative complications of 2.6% reported by another NJR registry data study ($p < 0.01$ revision versus primary complications).[1] The incidence of intraoperative fractures during revision arthroplasty is 3.5%. This is also over double the incidence in primary arthroplasty, which is 1.7%.[1]

Previous studies have reported the incidence of intraoperative fractures during revision shoulder arthroplasty to be between 7.5% and 16%; this is over double the incidence reported in the present study.[9,15] The high incidence of intraoperative fractures reported in other studies may be a result of variations in reporting because they include minor and inconsequential fractures confined to the metaphysis, which we consider that surgeons are unlikely to report to the NJR. The self-reported nature of the registry data whereby individual surgeons decides whether a fracture is significant or not makes it likely that it has captured only serious, clinically significant fractures.

The risk of intraoperative fractures for females is over three times that for males (RR = 3.25, $p = 0.005$). Our analysis did not find that patient age, ASA grade, indication for revision or surgical approach were risk factors for intraoperative fractures. Because of the rarity of intraoperative fractures, registry data are prone to type 2 errors and we may have potentially failed to identify some genuine risk factors. However, because the NJR contains a very large number of revision procedures, the chances of missing a significant increase in relative risk should be small.

It has previously been suggested that intraoperative fractures often occur when explanting the existing component.[9,16–18] The explant stem geometry, fixation method and length may have a greater influence on the incidence of fractures than the risk factors that we have investigated. There could also be other risk factors that influence the incidence of fractures that we have not investigated. For example, the findings may be confounded by surgical team, brand, type and configuration of arthroplasty. We have, however, investigated all of the risk factors that are commonly considered to be likely to influence the incidence of intraoperative fractures.

There has been a recent increase in the use of modular platform systems, which have the theoretical advantage of enabling revision surgery without removing the existing stem. Small studies have shown that this can make revision surgery less complicated and can reduce

Table 2. Rates of complications dependent upon patient and surgical demographics.

All categories	Count	Any complication (%)	Fracture complication (%)
n	1445	72 (5.0%)	50 (3.5%)
Age group			
<55 years	182	6 (3.3%)	4 (2.2%)
55 years to 64.9 years	287	11 (3.8%)	6 (2.1%)
65 years to 74.9 years	539	31 (5.8%)	21 (3.9%)
>75 years	437	24 (5.5%)	19 (4.3%)
Sex			
Male	518	17 (3.3%)	7 (1.4%)
Female	927	55 (5.9%)	43 (4.6%)
ASA grade			
ASA 1/2	1034	48 (4.6%)	34 (3.3%)
ASA 3/4/5	411	24 (5.8%)	16 (3.9%)
Indication for revision			
Infection	182	8 (4.4%)	7 (3.8%)
Periprosthetic fracture	57	7 (12.3%)	3 (5.3%)
Cuff insufficiency	334	15 (4.5%)	12 (3.6%)
Instability	151	5 (3.3%)	2 (1.3%)
Aseptic loosening	160	9 (5.6%)	5 (3.1%)
Hemiarthroplasty to total shoulder replacement	334	18 (5.4%)	14 (4.2%)
Other	227	10 (4.4%)	7 (3.1%)
Operation type			
Total shoulder replacement	408	18 (4.4%)	11 (2.7%)
Resurfacing hemiarthroplasty	67	3 (4.5%)	1 (1.5%)
Reverse total shoulder replacement	741	38 (5.1%)	27 (3.6%)
Stemmed hemiarthroplasty	128	7 (5.5%)	7 (5.5%)
Unknown	101	6 (5.9%)	4 (4.0%)
Surgical approach			
Deltopectoral	1075	54 (5.0%)	38 (3.5%)
Other	370	18 (4.9%)	12 (3.2%)

ASA, American Society of Anesthesiologists; CI, confidence interval.

Table 3. All Complications (univariable and multivariable binary logistic regression).

	Univariable unadjusted analysis		Multivariable adjusted analysis	
	Odds ratio (95% CI)	*p* value	Odds ratio (95% CI)	*p* value
Age group				
< 55 years	Reference		Reference	
55 years to 64.9 years	1.16 (0.43 to 3.22)	0.76	1.11 (0.40 to 3.09)	0.84
65 years to 74.9 years	1.79 (0.73 to 4.36)	0.20	1.63 (0.66 to 4.04)	0.29
> 75 years	1.71 (0.69 to 4.24)	0.25	1.40 (0.54 to 3.58)	0.49
Sex				
Male	Reference		Reference	
Female	1.86 (1.07 to 3.24)	0.03	1.70 (0.96 to 3.00)	0.07
ASA grade				
ASA 1/2	Reference		Reference	
ASA 3/4/5	1.27 (0.77 to 2.11)	0.35	1.20 (0.71 to 2.01)	0.50
Indication for revision				
Infection	Reference		Reference	
Periprosthetic fracture	3.05 (1.05 to 8.81)	0.04	3.00 (0.96 to 9.39)	0.06
Cuff insufficiency	1.02 (0.43 to 2.46)	0.96	1.00 (0.38 to 2.62)	1.00
Instability	0.75 (0.24 to 2.33)	0.61	0.80 (0.24 to 2.64)	0.71
Aseptic loosening	1.30 (0.49 to 3.44)	0.60	1.29 (0.46 to 3.60)	0.63
Hemiarthroplasty to total shoulder replacement	1.24 (0.53 to 2.91)	0.62	1.35 (0.52 to 3.51)	0.54
Other	1.00 (0.89 to 2.59)	1.00	1.10 (0.39 to 3.06)	0.86
Operation type				
Total shoulder replacement	Reference		Reference	
Resurfacing hemiarthroplasty	1.02 (0.29 to 3.55)	0.98	0.96 (0.27 to 3.38)	0.95
Reverse total shoulder replacement	1.17 (0.66 to 2.08)	0.59	1.18 (0.64 to 2.20)	0.59
Stemmed hemiarthroplasty	1.25 (0.51 to 3.07)	0.62	1.16 (0.46 to 2.91)	0.76
Unknown	1.37 (0.53 to 3.54)	0.52	1.83 (0.55 to 6.16)	0.33
Surgical approach				
Deltopectoral	Reference		Reference	
Other	0.97 (0.56 to 1.67)	0.90	0.81 (0.42 to 1.56)	0.52

ASA, American Society of Anesthesiologists; CI, confidence interval.

Table 4. Intraoperative fractures.

	Univariable Unadjusted analysis		Multivariable Adjusted analysis	
	Odds ratio (95% CI)	p value	Odds ratio (95% CI)	p value
Age group				
< 55 years	Reference		Reference	
55 years to 64.9 years	0.95 (0.26 to 3.41)	0.94	0.86 (0.24 to 3.12)	0.82
65 years to 74.9 years	1.80 (0.61 to 5.33)	0.29	1.56 (0.52 to 4.69)	0.43
> 75 years	2.02 (0.69 to 6.03)	0.21	1.53 (0.50 to 4.71)	0.46
Sex				
Male	Reference		Reference	
Female	3.55 (1.59 to 7.95)	0.002	3.25 (1.43 to 7.39)	0.005
ASA grade				
ASA 1/2	Reference		Reference	
ASA 3/4/5	1.19 (0.65 to 2.18)	0.57	1.10 (0.59 to 2.04)	0.77
Indication for revision				
Infection	Reference		Reference	
Periprosthetic fracture	1.39 (0.35 to 5.56)	0.64	1.07 (0.24 to 4.64)	0.93
Cuff insufficiency	0.93 (0.36 to 2.41)	0.88	0.78 (0.27 to 2.23)	0.64
Instability	0.34 (0.07 to 1.64)	0.18	0.33 (0.06 to 1.71)	0.19
Aseptic loosening	0.81 (0.25 to 2.59)	0.72	0.71 (0.21 to 2.43)	0.59
Hemiarthroplasty to total shoulder replacement	1.09 (0.43 to 2.76)	0.85	1.13 (0.40 to 3.10)	0.82
Other	0.80 (0.27 to 2.31)	0.67	0.81 (0.25 to 2.56)	0.73
Operation type				
Total shoulder replacement	Reference		Reference	
Resurfacing hemiarthroplasty	0.55 (0.07 to 4.31)	0.57	0.48 (0.06 to 3.83)	0.49
Reverse total shoulder replacement	1.37 (0.67 to 2.78)	0.39	1.37 (0.64 to 2.94)	0.42
Stemmed hemiarthroplasty	2.09 (0.79 to 5.50)	0.14	2.04 (0.75 to 5.52)	0.16
Unknown	1.49 (0.46 to 4.78)	0.50	1.83 (0.55 to 6.16)	0.46
Surgical approach				
Deltopectoral	Reference		Reference	
Other	0.92 (0.47 to 1.77)	0.79	0.80 (0.36 to 1.78)	0.58

ASA, American Society of Anesthesiologists; CI, confidence interval.

operative time.[17,19] However, whether they reduce the risk of intraoperative fractures should be investigated in future studies.

When the incidence of any complication was analyzed, no statistically significant risk factors were identified. This may be because the 'any complication' analysis included a mixture of different complications including nerve injuries, vascular injuries, fractures and other complications, which may have different risk factors. A larger sample would enable these complications to be analyzed separately. A larger sample could be achieved by pooling data with other shoulder registries; however, no other registry currently collects data on intraoperative complications in the same format. Pooling data from other registries to analyze a larger sample is therefore unrealistic at the present time.

The most common approach used was the deltopectoral approach. This is often used for revision surgery because it is extensile and poses less risk to the axillary nerve, which is often surrounded by adhesions. A previous registry study of primary arthroplasty reported that the deltopectoral approach has a higher incidence of complications than deltoid splitting approaches.[1] Our analysis found no association between the incidence of complications and the surgical approach used.

The most common indications for revision from the registry data were rotator cuff insufficiency and revision from a hemiarthroplasty to a conventional total shoulder replacement. Taken together, these made up almost half of all revisions. A peri-prosthetic fracture was the least common indication for surgery and was carried out 57 (4%) times. The indication for surgery was not found to be a risk factor for intraoperative complications. However, the incidence of intraoperative complications during revision for a peri-prosthetic fracture almost reached statistical significance (RR = 3.00, $p = 0.06$). We consider revisions for a periprosthetic fracture to be high-risk operations and suggest that they should only be undertaken by surgeons experienced in revision arthroplasty.

Nerve injuries are very disabling and, although most resolve spontaneously, some will be permanent.[20–22] Only two (0.1%) nerve injuries were identified despite the reported incidence of nerve injuries being up to 25%.[20] The large difference between these figures shows that surgeons find it difficult to identify nerve injures intraoperatively. Because most nerve injuries are often neurapraxias from retraction or arm positioning, it may not be possible to identify these intraoperatively. Precautions should be taken to prevent nerve injuries during all revision arthroplasties. In high-risk operations or operations where a nerve injury would be catastrophic such as when the contralateral limb is nonfunctional, surgeons may consider using intraoperative nerve monitoring using neurophysiology. This is, however, technically demanding, which limits its use, and the benefits remain unproven.[21]

Vascular injuries were very uncommon and occurred once (0.1%) in the registry. This is likely to represent the true incidence because most intraoperative vascular injuries will be identified at the time of surgery. The very rare occurrence of vascular injuries is reassuring; however, their rare occurrence means that most surgeons will not be experienced in their management.

Limitations

The NJR records details from the voluntary reporting of shoulder arthroplasties in England, Wales, Northern Ireland and the Isle of Man. This means that the data do not comprise a complete consecutive series, which may introduce bias.

This is a study of complications identified intraoperatively and does not include intraoperative complications that are identified postoperatively. The documented incidence of intraoperative nerve injuries in the NJR is much lower than the overall reported postoperative incidence,[20] which is likely to be a result of difficulties in reliably identifying nerve injuries intraoperatively.[23] It is also likely that some fractures were not identified intraoperatively, although this is considered to be uncommon. We consider it very unlikely that significant vascular injuries are not identified intraoperatively.

Conclusions

This is the largest study of registry data to date investigating the incidence and risk factors for intraoperative complications during revision shoulder arthroplasty. Females have over three times the risk of intraoperative fractures compared to males. If surgeon outcome data are published, our results suggest that the incidence of intraoperative fractures in males and females should be reported separately. Other variables that are commonly considered as risk factors were not found to significantly increase the risk of intraoperative complications. The findings of the present study should enable surgeons to counsel patients appropriately during the consent process.

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The data used in this paper is freely available on request and does not require ethical approval.

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