Factors impacting arthroscopic rotator cuff repair operational throughput time at an ambulatory care center

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Abstract

Identifying patient factors influencing operational throughput time is becoming more imperative due to an increasing focus on value and cost savings in healthcare. The primary objective of this study was to determine patient factors influencing throughput time for primary rotator cuff repairs. Demographic information, medical history and operative reports of 318 patients from one ambulatory care center were retrospectively reviewed. Operating room set up, incision to closure and recovery room time were collected from anesthesia records. Univariate analysis was performed for both continuous and categorical variables. A stepwise, multivariable regression analysis was performed to determine factors associated with operating room time (incision to closure) and recovery room time. Of the 318 patients, the mean age was 54.4 ± 10.0 and 197 (61%) were male. Male patients had a significantly longer OR time than females (115.5 *vs*. 100.8 minutes; $P<0.001$) Furthermore, patients set up in the beach chair position had a significantly longer OR time than patients positioned lateral decubitus (115.8 *vs*. 89.6 mins, $P<0.0001$). Number of tendons involved, and inclusion of distal clavicle excision, biceps tenodesis and labral debridement also added significant OR time. Type and number of support staff present also significantly affected OR time. Recovery room time was significantly longer patients who had surgery in the beach chair position (+9.61 minutes) and for those who had a cardiac-related medical comorbidity (+11.7 minutes). Our study found that patients positioned in a beach chair spent significantly more time in the operating and recovery rooms. While ease of set up has been a stated advantage of beach chair position, we found the per-
ceived ease of set up does not result in more efficient OR throughput.

Introduction

The current state of our healthcare system poses challenges secondary to decreasing reimbursements and increasing costs.[1-4] The operating room (OR) is often a place where a concerted effort is employed to identify areas for cost savings. Various methods have been proposed to maximize OR efficiency, including dedicated OR teams, tools to better predict procedure time, generalized staff education, patient specific instrumentation, physical space redesign, and throughput analysis.[5-14] For orthopedic procedures, patient positioning may also impact OR throughput and subsequently improve OR efficiency. Patient positioning has also been shown to be related to differences in post-operative complication rates. Arthroscopic and open shoulder surgery can be performed in either the lateral decubitus or beach-chair position. The orthopedic community utilizes both positioning techniques, with benefits and challenges to each with regard to visualization, access and surgical risks.[15-22] However, no study has directly compared differences between lateral decubitus (LD) and beach chair (BC) positioning complication rates or operative throughput times in shoulder arthroscopy.

The purposes of this study are to i) determine factors associated with operative throughput time for arthroscopic rotator cuff repair ii) determine whether throughput times differ based on patient positioning (LD *vs*. BC) and iii) assess whether differences in intraoperative and perioperative complications exist based on patient positioning (LD *vs*. BC).

Materials and Methods

All patients undergoing primary arthroscopic rotator cuff repair at one ambulatory care surgery center over a two-year period were retrospectively identified. Patients who underwent primary open, revision open and revision arthroscopic rotator cuff repairs were excluded from this study. All medical records were reviewed and pertinent data was extracted including patient demographics, co-morbidities, preoperative shoulder MRI findings, intra-operative findings, surgical procedures performed, intra-operative complications, number of OR staff present, perioperative complications and readmissions. ASA physical status

classification system was calculated for each patient to assess the relative health status preoperatively. All patients were also called by nursing staff 24 hours postoperatively and all patient-responses were recorded for dichotomous (Yes/No) responses to patient satisfaction, nausea/vomiting and pain control. Temporal data was extracted from the anesthesia records and included metrics of operating and recovery room times, specifically surgical start time, induction, incision, surgical end, transit time from the operating room to recovery room and time in recovery room. All rotator cuff repair surgeries were performed by one of five surgeons. All surgeries

ies were performed by the attending surgeon with or without the assistance of a fellow, resident and/or physician assistant.

Overall summary statistics were calculated in terms of means and standard deviations for continuous variables, and frequencies and percentages were calculated for discrete variables. For the various outcomes that were analyzed, independent samples t-tests were performed for continuous data and Mann-Whitney U non-parametric tests were used to evaluate continuous variables that were not normally distributed. Chi-square and Fisher's exact tests were used for evaluations of categorical variables.

Patient characteristics that were found to be to be independently associated with the outcome of interest were included as candidates for inclusion in a multivariable linear regression model with operating room time and acute complications used as dependent variables. Using a forward stepwise procedure, characteristics that failed to achieve a P-value of 0.10 or below were removed from the final model. A P-value of 0.10 was chosen as the critical threshold for retention in the final model because of the exploratory nature of the analyses. Characteristics that achieved a p-value of 0.05 or below were considered statistically significant factors. All analyses were performed using SPSS version 22.0 (IBM Corp., Armonk, NY).

Results

Of the 318 patients, mean age was 54.4±10.01 (range: 19-79 years) and 197 (61.9%) were male (Table 1). The majority of our patients were white 276 (87.1%) and non-Hispanic 291 (97.7%). The population was generally healthy with 67.2% who (n=213) were never smokers, 61.9% (n=193) with a body mass index (BMI) less than 30 and most had an ASA status of 1 or 2 (47.6%; 44.1%).

Based on univariate analysis which compared OR time (incision to closure) between groups, males were in the OR significantly longer than females (115.51 minutes *vs*. 100.79 minutes, P<0.001, Table 2). No other patient demographics were found to significantly impact OR time. In terms of intraoperative variables, patients positioned in the lateral decubitus position were found to have significantly shorter operative time than patients in the beach chair position (89.59 minutes *versus* 115.75 minutes, P<0.0001, Table 3). Additionally, increased number of tendon involvement (P<0.0001), distal clavicle excision (P<0.0001) and biceps tenodesis or tenotomy (P<0.0001)

were all significantly associated with longer OR times. Interestingly, type of support staff assisting in the room significantly impacted OR time (P=0.002), but not the number of support staff (P=0.529). Physician assistants (101.30±37.06 minutes) and PGY3-PGY5 residents (106.59±35.51 minutes) were found to have reduced OR times compared to PGY1-PGY2 residents (119.39±37.78 minutes) and fellows (118.5±38.68).

In our regression analysis using operative time in minutes from incision to surgery end as the dependent variable (Table 4), male patients had significantly longer OR time (9.25 minutes longer, P=0.02).

Table 1. Demographic factors and overall throughput time.

	Mean ± SD
Age	54.41±10.01
Height	67.28±5.30
Weight	187.71±39.94
BMI	28.97±5.10
Number of allergies	0.84±1.38
Number of medications	3.49±3.23
Set up time (min)*	24.82±6.93
Operative time (min)**	109.91±38.30
Time in Recovery Room (min)***	97.50±34.39

*Induction to incision; *incision to surgery end; ***recovery room to discharge.

Table 2. Association between patient demographics and surgery time.

	N (%)	Mean±SD, OR time	P-value
Sex			0.001
Female	121 (38.1)	100.79±3 9.27	
Male	197 (61.9)	115.51±36.68	
Laterality			0.310
Left	108 (35.0)	113.07±39.12	
Right	201 (65.0)	108.38±38.41	
Race			0.486
Asian	7 (2.2)	113.86±35.06	
Native Hawaiian/Pacific Islander	1 (0.3)	64.00±0.00	
Black	13 (4.1)	113.00±29.96	
White	276 (87.1)	110.81±38.46	
Unknown	20 (6.3)	98.70±41.71	
Ethnicity			0.902
Not Hispanic	291 (97.7)	110.80±38.06	
Hispanic	7 (2.3)	109.00±35.27	
BMI categories			0.763
Normal	71 (22.8)	110.34±36.39	
Overweight	122 (39.1)	108.89±36.31	
Obese	119 (38.1)	112.52±41.54	
Smoking status			0.753
Never Smoker	213 (67.2)	109.14±38.29	
Former Smoker	72 (22.7)	110.89±37.22	
Current Every Day Smoker	32 (10.1)	114.41±41.19	
Cardiac Status*			0.092
No	179 (57.9)	107.38±36.30	
Yes	130 (42.1)	114.85±41.13	
ASA			0.601
1	150 (47.6)	108.97±38.41	
2	139 (44.1)	109.80±39.30	
3	26 (8.3)	117.19±34.47	
Number of previous surgeries (non-shoulder)			0.108
0	85 (26.9)	106.86±33.06	
1	94 (29.7)	118.74±40.45	
2	63 (19.9)	109.46±40.49	
3	37 (11.7)	106.73±38.01	
4 or more	37 (11.7)	101.68±36.91	
Number of previous surgeries shoulder)			0.392
0	263 (83.0)	110.15±38.93	
1	48 (15.1)	110.96±35.60	
2	5 (1.6)	110.60±19.26	
3	1 (0.3)	44.00±0.00	

*Includes high blood pressure, high cholesterol, previous MI, heart murmur.

Also, beach-chair positioned patients had significantly longer operating room time compared to lateral decubitus patients (25.08 minutes, P<0.0001). Other factors that were associated with significantly longer OR time included increasing number of tendons involved (15.66 minutes, P<0.0001), distal clavicle excision (17.49 minutes, P=0.0003) and biceps tenodesis (16.23 minutes, P<0.0001). Furthermore, for every increase in support staff, 11.11 minutes of OR time was added to the total OR time (P=0.003).

The mean preoperative set up time and recovery room time was also compared for all retrieved variables. A regression analysis for preoperative set up time was performed using the same methodology above, but no factors were found to be associated with a significantly longer set up time except for patients that had a concomitant distal clavicle excision performed (P=0.02, 95% CI: 0.29-4.22). A regression analysis for recovery room time was also performed and beach-chair position and cardiac comorbidity were found to be significant factors associated with longer time in the recovery room. The beach-chair position added 9.61 minutes to recovery time (P=0.04), while a cardiac history added 11.65 minutes (P=0.004).

Postoperative nausea/vomiting, patient satisfaction and acute postoperative complications were also recorded (Table 5). Overall postoperative nausea/vomiting was low (8.9%) as was the complication rate (7.3%). Most patients reported satisfaction with their operative experience 24 hours postoperatively (96.3%). A higher percentage of patients reported not having adequate pain control postoperatively (22.9%). When comparing these postoperative measures to patient positioning, none of these factors were significant.

Multivariable logistic regression models were then generated for complications and nausea/vomiting outcomes. Increased age (OR: 0.94, P=0.02) and BMI (OR: 0.88, P=0.02) were protective for acute complications while higher ASA score (OR: 5.98, P=0.0001) and concomitant biceps tenotomy (OR: 5.738, P=0.001) increased the odds of acute complications by nearly six times. When evaluating self-reported nausea/vomiting as a dependent variable, beach chair patients were nearly six times more likely to have nausea and vomiting (OR: 5.820) compared to LD patients, although this difference did not reach statistical significance (P=0.09). Male sex (OR: 0.364, P=0.03) was protective for reports of nausea and vomiting.

Table 3. Relationship between intraoperative factors and operating room time.

Operating room time	N (%)	Mean±SD, OR time	P-value
Tendon Involvement			0.000
Supraspinatus	299 (94.0)	110.61±38.93	
Infraspinatus	121 (38.1)	126.50±3 7.37	
Subscapularis	89 (28.0)	119.64±37.57	
Teres Minor	11 (3.5)	136.73±25.23	
Number of Tendons Involved			0.000
1	165 (51.9)	96.33±33.58	
2	104 (32.7)	121.78±38.36	
3	47 (14.8)	129.96±35.74	
4	2 (0.6)	141.50±57.28	
Lateral vs. Beach Chair			0.000
Lateral	71 (22.3)	89.59±24.76	
Beach Chair	247 (77.7)	115.75±39.53	
Labral Debridement			0.556
No	110 (35.7)	111.69±37.91	
Yes	198 (64.3)	108.99±38.84	
Subacromial Decompression			0.051
No	28 (8.8)	96.46±32.91	
Yes	289 (91.2)	111.25±38.65	
Distal Clavicle Excision			0.000
No	249 (78.8)	105.10±36.09	
Yes	67 (21.2)	127.60±41.72	
Biceps Status?			0.000
Biceps Tenodesis	138 (43.9)	121.99±37.95	
Biceps Tenotomy	56 (17.8)	115.20±41.00	
Biceps Normal	120 (38.2)	94.33±31.85	
Support staff present			0.002
P.A.	117 (32.9)	101.30±37.06	
Medical Student	2 (0.6)	99.50±31.82	
Resident- PGY1-PGY2	79 (22.2)	119.39±37.78	
Resident- PGY3-PGY5	54 (15.2)	106.59±35.51	
Fellow	104 (29.2)	118.50±38.68	
Number of support staff present			0.529
0	22 (6.9)	107.14±41.26	
1	237 (74.5)	108.74±38.09	
2	58 (18.2)	115.17±38.33	
3	1 (0.3)	144.00±0.00	

Table 4. Multivariable regression analysis with operative time in minutes (incision to surgery end) as dependent variable

Coefficients	Unstandardized coefficients		Standardized Coefficient Beta	t	P-value	95% CI for B	
	B	SE				Lower	Upper
(Constant)	15.61	10.93		1.43	0.1544	-5.91	37.13
Beach Chair (vs. Lateral)	25.08	4.75	0.27	5.28	0.0000	15.73	34.43
Male sex	9.25	3.96	0.12	2.34	0.0200	1.47	17.04
Distal Clavicle Excision	17.49	4.72	0.18	3.70	0.0003	8.19	26.78
Number of tendons involved	15.66	2.50	0.31	6.26	0.0000	10.73	20.58
Biceps Tenodesis	16.23	3.89	0.21	4.17	0.0000	8.57	23.90
Labral Debridement	-6.02	4.03	-0.07	-1.49	0.1363	-13.95	1.91
Number of support staff present	11.11	3.78	0.15	2.94	0.0036	3.67	18.56

Discussion

In an era of increased focus on cost containment, efforts to increase operating room efficiency are imperative. While the orthopedic literature demonstrates various techniques to increase OR efficiency, specifically with regard to implementing dedicated OR teams and dedicated traumatology suites, physical space redesign, and throughput analysis, modifiable patient factors influencing OR throughput time at an ambulatory center is less clear.[7-14] Our study identified many patient-related factors that were associated with longer OR times.

We found that patients in the beach-chair position spent a significantly longer time in the operating room and recovery room compared to patients positioned in the lateral decubitus position. Strong arguments exist for both lateral decubitus and beach-chair positioning with respect to sufficient visualization, intra operative access and surgical risks.[15-19,22,23] These arguments are also based on equipment needs, support staff requirements, perceived ease of set up, and associated complications. In general, supporters of lateral decubitus position cite the ability to obtain a range of arm positions as a significant advantage to this position, while beach-chair advocates tout the ability to manipulate the operative extremity throughout the procedure.

A surgeon's preference for patient position is greatly impacted by their training and it is hypothesized that familiarity with a set up should impact set up time. While ease of set up has been a stated advantage of beach-chair position in the literature, our data has found the perceived ease of set up does not result in more efficient operating

room throughput.[16] An average difference of 27.98 minutes in the OR and 9.61 minutes in the recovery room represent substantially different demands on hospital resources and staff, implying considerable financial implications of performing rotator cuff repairs in the beach chair rather than the lateral decubitus position.

In terms of patient demographics, male patients were found to have longer operating room times than females. We hypothesized this difference may be due to differences in ease of positioning and manipulation of the extremity during surgery. Furthermore, men typically have greater muscle mass, which can lead to a more difficult surgery and prolong operative time. Another variable which significantly impacted operating room time was the type of support staff present in the univariate analysis with faster OR times when PGY 4 and 5 residents and physician assistants were present. Furthermore, the multivariable analysis performed for OR time found that OR time increased as the number of support staff present in the room increased. This likely is due to an increased amount of teaching time dedicated to residents and mid-level providers assisting with the case. As expected, the severity of the pathology, as well as concomitant procedures performed during the case also lengthened operating room duration and included the number of tendons involved, the addition of distal clavicle excision, biceps tenodesis or labral debridement. Each of these additional procedures logically added time in the OR when adjusting for the other variables in the model. With regard to recovery room time, cardiac history led to an additional 11.64 minutes of recovery room time (P=0.004), likely secondary to need for additional monitoring as the patient recov-

ered from anesthesia medications. While the rates of nausea/vomiting and acute complications were both low, it is interesting to note the types of patients who experienced these adverse events. Although not statistically significant, beach-chair patients were nearly six times more likely to experience nausea/vomiting, possibly induced by the position change from reclined to supine postoperatively. Female patients were also more likely to experience nausea/vomiting, which is consistent with prior research; however, the reason for these differences remains unknown[24]. All rotator cuff repairs included in this analysis were performed at an outpatient facility, selecting for overall healthier patients with lower ASA scores. However, those with higher ASA scores were significantly more likely to have an acute complication. This implies that even if a patient is deemed an acceptable surgical candidate by their primary provider, the ASA score is predictive of increased risk of postoperative complications. Our study does have limitations. Although we were able to control for many variables, such as RC tear size, surgeries included within this study were performed by many surgeons and we were unable to control for inherent variations in surgical speed among surgeons. Additionally, since the data is gathered from an ambulatory care center, all patients included in the study are relatively medically uncomplicated. Complications were tracked by medical records and therefore may underestimate the number of complications and readmissions since a patient seeking care from an out of network provider may not be documented in his/her record.

Conclusions

To our knowledge, this is the first study to evaluate the impact of patient position and other associated patient factors on operating and recovery room time for arthroscopic rotator cuff repairs. Our study found the beach chair position added statistically significant duration of time in both the operating and recovery rooms. While ease of set up has been a stated advantage of beach-chair position in the literature, our data has found the perceived ease of set up does not result in more efficient operating room throughput.

Table 5. Relationship between postoperative and patient-reported factors and operating room time.

Operating Room time	N (%)	Mean±SD, OR time	P-value
Acute Complications			0.778
No	293 (92.7)	109.83±38.29	
Yes	23 (7.3)	112.17±40.60	
Pt Readmission			0.749
No	305 (97.1)	110.18±38.25	
Yes	9 (2.9)	106.00±48.66	
Patient Satisfied with Surgery			0.677
No	10 (3.7)	104.50±25.89	
Yes	257 (96.3)	109.32±36.14	
Nausea or Vomiting			-
No	246 (91.1)	109.51±36.65	
Yes	24 (9.9)	103.08±26.02	
Pain control			0.663
No	62 (22.9)	107.16±31.86	
Yes	209 (77.1)	109.42±36.92	

References

1. Hariri S, Bozic KJ, Lavernia C, et al. Medicare physician reimbursement: past, present, and future. J Bone Joint

Surg Am 2007;89:2536-46.
2. Iglehart JK. Medicare's declining payments to physicians. N Engl J Med 2002;346:1924-30.
3. Bozic KJ, Rubash HE, Sculco TP, et al. An analysis of medicare payment policy for total joint arthroplasty. J Arthroplasty 2008;23:133-8.
4. Wilensky GR. Reforming Medicare's physician payment system. N Engl J Med 2009;360:653-5.
5. McLaren JM, Reynolds JA, Cox MM, et al. Decreasing the length of stay in phase I postanesthesia care unit: an evidence-based approach. J Perianesth Nurs 2015;30:116-23.
6. Renson L, Poilvache P, Van den Wyngaert H. Improved alignment and operating room efficiency with patient-specific instrumentation for TKA. Knee 2014;21:1216-20.
7. Althausen PL, Kauk JR, Shannon S, et al. Operating room efficiency: benefits of an orthopaedic traumatologist at a level II trauma center. J Orthop Trauma 2014;28:e101-6.
8. Small TJ, Gad BV, Klika AK, et al. Dedicated orthopedic operating room unit improves operating room efficiency. J Arthroplasty 2013;28:1066-71.
9. Berlet GC, Weil LS Sr., Fooman A, et al. Contemporary trends in operating room efficiency. Foot Ankle Spec 2013;6:125-31.
10. Ranawat AS, Koenig JH, Thomas AJ, et al. Aligning physician and hospital incentives: the approach at hospital for special surgery. Clin Orthop Relat Res 2009;467:2535-41.
11. Collantes E, Mauffrey C, Lewis C, et al. A review of 1241 trauma cases: a study of efficiency in trauma theatres. Injury 2008;39:742-7.
12. Olmstead J, Coxon P, Falcone D, et al. World-class OR turnaround times: secrets uncovered. AORN J 2007;85:942-9.
13. Bhattacharyya T, Vrahas MS, Morrison SM, et al. The value of the dedicated orthopaedic trauma operating room. J Trauma 2006;60:1336-41.
14. Overdyk FJ, Harvey SC, Fishman RL, et al. Successful strategies for improving operating room efficiency at academic institutions. Anesth Analg 1998;86:896-906.
15. Frank RM, Saccomanno MF, McDonald LS, et al. Outcomes of arthroscopic anterior shoulder instability in the beach chair versus lateral decubitus position: a systematic review and meta-regression analysis. Arthroscopy 2014;30:1349-65.
16. Li X, Eichinger JK, Hartshorn T, et al. A comparison of the lateral decubitus and beach-chair positions for shoulder surgery: advantages and complications. J Am Acad Orthop Surg 2015;23:18-28.
17. Laflam A, Joshi B, Brady K, et al. Shoulder surgery in the beach chair position is associated with diminished cerebral autoregulation but no differences in postoperative cognition or brain injury biomarker levels compared with supine positioning: the anesthesia patient safety foundation beach chair study. Anesth Analg 2015;120:176-85.
18. Pant S, Bokor DJ, Low AK. Cerebral oxygenation using near-infrared spectroscopy in the beach-chair position during shoulder arthroscopy under general anesthesia. Arthroscopy 2014;30:1520-7.
19. Salazar D, Sears B, Acosta A, et al. Effect of head and neck positioning on cerebral perfusion during shoulder arthroscopy in beach chair position. J Surg Orthop Adv 2014;23:83-9.
20. Salazar D, Sears BW, Aghdasi B, et al. Cerebral desaturation events during shoulder arthroscopy in the beach chair position: patient risk factors and neurocognitive effects. J Shoulder Elbow Surg 2013;22:1228-35.
21. Parikh SN, Schuppner PW. Arthroscopic posterior capsulolabral repair in a beach-chair position. Orthopedics 2013;36:270-4.
22. Gillespie R, Shishani Y, Streit J, et al. The safety of controlled hypotension for shoulder arthroscopy in the beach-chair position. J Bone Joint Surg Am 2012;94:1284-90.
23. Salazar D, Sears BW, Andre J, et al. Cerebral desaturation during shoulder arthroscopy: a prospective observational study. Clin Orthop Relat Res 2013;471:4027-34.
24. Apfel CC, Heidrich FM, Jukar-Rao S, et al. Evidence-based analysis of risk factors for postoperative nausea and vomiting. Br J Anaesth 2012;109:742-53.