National Trends in Rotator Cuff Repair

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Background: Recent publications suggest that arthroscopic and open rotator cuff repairs have had comparable clinical results, although each technique has distinct advantages and disadvantages. National hospital and ambulatory surgery databases were reviewed to identify practice patterns for rotator cuff repair.

Methods: The rates of medical visits for rotator cuff pathology, and the rates of open and arthroscopic rotator cuff repair, were examined for the years 1996 and 2006 in the United States. The national incidence of rotator cuff repairs and related data were obtained from inpatient (National Hospital Discharge Survey, NHDS) and ambulatory surgery (National Survey of Ambulatory Surgery, NSAS) databases. These databases were queried with use of International Classification of Diseases, Ninth Revision (ICD-9) procedure codes for arthroscopic (ICD-9 codes 83.63 and 80.21) and open (code 83.63 without code 80.21) rotator cuff repair. We also examined where the surgery was performed (inpatient versus ambulatory surgery center) and characteristics of the patients, including age, sex, and comorbidities.

Results: The unadjusted volume of all rotator cuff repairs increased 141% in the decade from 1996 to 2006. The unadjusted number of arthroscopic procedures increased by 600% while open repairs increased by only 34% during this time interval. There was a significant shift from inpatient to outpatient surgery ($p < 0.001$).

Conclusions: The increase in national rates of rotator cuff repair over the last decade has been dramatic, particularly for arthroscopic assisted repair.

Considerable literature exists regarding the surgical management of rotator cuff tears. Arthroscopic and open rotator cuff repairs have had comparable clinical results in the literature, with distinct advantages and disadvantages to both procedures[1,2]. Arthroscopy allows for preservation of the deltoid muscle[3], improved ability to treat intra-articular lesions[3], improved ability to mobilize and release the rotator cuff[3], and less immediate postoperative pain[4]. Open and mini-open repair techniques allow for easier transosseous fixation to better replicate the footprint of the supraspinatus tendon[5] and theoretically may provide a better potential for healing[5], although transosseous equivalent constructs with use of suture anchors have been described that also show improved pressurized contact area[6,7]. Open repair and mini-open repair also allow for the placement of a modified Mason-Allen stitch, which, in comparison with the simple stitch, is a stronger method to grasp the tendon[8,9].

Several studies have examined geographic variation in the number of rotator cuff surgical procedures performed as well as variations in what surgeons deemed to be indications for rotator cuff surgery. For example, Vitale et al. found a large geographic variation in the number of rotator cuff surgical procedures that were performed in Medicare beneficiaries in 1992[10]. This variation may have reflected a lack of clear operative indications and/or an understanding of the risks and benefits of surgery at the time of the study. With respect to surgical indications, Green et al. reported that surgeon preference was the primary deciding factor for performing inpatient rotator cuff surgery[11]. Dunn et al. also found significant variation in indications for rotator cuff surgery in a survey of selected members of the American Academy of Orthopaedic Surgeons as of the year 2002[12]. Surgeons who had a higher procedure volume favored rotator cuff surgery more than those who had a lower volume[12]. Mini-open repair was the most frequently used method of repair (46.2%) followed by open (36.6%) and arthroscopic (14.5%)[12].

Despite many publications addressing rotator cuff repair techniques, indications for rotator cuff surgery, and outcomes in selected groups of patients, little information has been reported recently on trends of use at the national level.

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The purpose of our study was multifold. First, we sought to determine current trends in resource utilization for rotator cuff repairs, including type and setting of surgical treatment as well as type of anesthesia. The impact of age and sex on resource utilization was also examined. Finally, we also studied other variables (e.g., procedure length) that contribute to health-care costs.

The hypotheses of our study were that (1) surgeons are now performing more arthroscopic rotator cuff repairs, (2) more of these repairs are being performed in ambulatory surgery settings, (3) patients who undergo surgery in an inpatient setting are more likely to be older and have more comorbidities, (4) surgical time is longer for arthroscopic repairs, and (5) the use of interscalene block for anesthesia is increasing.

Materials and Methods

Data Source

The rates of open and arthroscopic rotator cuff repairs for the years 1996 and 2006 in the United States were examined. We used publicly available national health-care surveys conducted by the Centers for Disease Control and Prevention (CDC) for our study. The national estimates of rotator cuff repairs and related data were obtained from the National Hospital Discharge Survey (NHDS), which is an inpatient database, and the National Survey of Ambulatory Surgery (NSAS), which is an outpatient surgery database. Data on ambulatory medical services utilization were obtained from two databases: (a) the annual National Ambulatory Medical Care Survey (NAMCS), which records physician office visits, and (b) the National Hospital Ambulatory Medical Care Survey (NHAMCS), which includes emergency department and hospital outpatient department visits.

Population data were obtained from the U.S. Census Bureau[13]. The NAMCS, the NHAMCS, the NSAS, and the NHDS are each National Center for Health Statistics (NCHS) surveys that are designed to be representative of health-care services delivered by non-federally employed health-care providers. They each may include disproportionate sampling in an effort to achieve a meaningful national sample that allows subgroup analysis. The NSAS collects data from a sample of hospital and freestanding ambulatory surgery centers and describes outpatient procedures performed at short-stay hospitals located in all fifty states and the District of Columbia. The NHDS is a national probability sample designed to meet the need for information on characteristics of inpatient discharges from non-federal short-stay hospitals in the United States. The NHDS collects data from a national sample of about 500 non-federal short-stay hospitals, defined as hospitals with an average length of stay of fewer than thirty days, and including major medical centers. Federal, military, and Department of Veterans Affairs hospitals as well as hospital units of government institutions (such as prison hospitals), and hospitals with fewer than six beds are excluded from both the NSAS and the NHDS. The weighting procedure used in the NSAS and the NHDS produces essentially unbiased national estimates. These numbers are derived from a multistage estimate procedure that includes three basic components: inflation by reciprocals of the probabilities of sample selection, adjustment for no response, and population weighting ratio adjustments.

The NAMCS and the NHAMCS are nationally representative surveys with similar methodologies, collecting chart review data from a probability sample of outpatient visits to physician offices, while the NHAMCS collects similar data from hospital outpatient departments and emergency departments. Data for NAMCS are collected from 112 geographic areas located among the fifty states and the District of Columbia, including 3000 physicians and consisting of 25,000 annual visits for national estimations. Data for NHAMCS are also collected from 112 geographic areas located among the fifty states and the District of Columbia, including 500 hospitals with 400 emergency departments and 250 outpatient departments and consisting of 37,000 emergency and 35,000 outpatient department visits. Combined NAMCS and NHAMCS databases for 2006 provided a national estimation of 1,123,353,924 ambulatory visits.

TABLE I ICD-9 Procedure Codes Used for Analysis*

ICD-9 Procedure Code	Description
83.63 with 80.21	Arthroscopic rotator cuff repair
83.63	Open rotator cuff repair

*ICD-9 = International Classification of Diseases, Ninth Revision.

Study Population

Hospitalizations from the NHDS or the NSAS were identified by ICD-9 procedure codes for arthroscopic (ICD-9 codes 83.63 and 80.21) and open (code 83.63 without code 80.21) rotator cuff repair (Table I). We examined where the surgery was performed (inpatient or ambulatory surgery center) and patient characteristics, including age, sex, and comorbidities. ICD-9 diagnosis codes identified as having a high frequency of association with rotator cuff procedures in the NHDS and NSAS databases were used to query NAMCS and NHAMCS databases to identify ambulatory medical visits for rotator cuff tears. These codes included: 726.10 (rotator cuff syndrome of shoulder, disorder of bursae and tendons in shoulder region, unspecified), 726.11 (calcifying tendinitis of shoulder), 726.19 (other specified rotator cuff syndrome of shoulder and allied disorders), 727.61 (complete rupture of rotator cuff, nontraumatic), and 840.4 (sprains and strains of rotator cuff) (Table II).

For 1996, the NSAS database produced a national estimation of 21,236,913 ambulatory surgical procedures of which 58,846 (0.3%) were estimated to be rotator cuff repairs. For 2006, the national estimate was 34,738,440 ambulatory surgical procedures of which 272,148 (0.8%) were rotator cuff repairs. There were 34,470,485 inpatient hospitalizations in 1996 and 50,754 (0.15%) inpatient rotator cuff repairs based on the NHDS database. In 2006, the number of inpatient hospitalizations increased to 38,873,777 while the number of inpatient rotator cuff repairs decreased to 20,433 (0.05%).

Statistics

We used the SAS survey procedures (SAS Institute, Cary, North Carolina) to estimate the variance of data regarding the number of rotator cuff repairs and the number of ambulatory medical visits with a diagnosis related to rotator cuff tears. The analysis took into account survey design, including sampling weights, primary sample units, stratification, and clustering. Univariate analyses were conducted with use of t tests for continuous variables and the chi-square test for dichotomous variables (i.e., sex, comorbidities, insurance status, anesthesia type, and surgical intervention). Significance was expressed as both probability

TABLE II ICD-9 Diagnosis Codes Used for Analysis*

ICD-9 Diagnosis Code	Description
726.10	Rotator cuff syndrome of shoulder, disorder of bursae and tendons in shoulder region, unspecified
726.11	Calcifying tendinitis of shoulder
726.19	Other specified rotator cuff syndrome of shoulder and allied disorders
727.61	Complete rupture of rotator cuff, nontraumatic
840.4	Sprains and strains of rotator cuff

*ICD-9 = International Classification of Diseases, Ninth Revision.

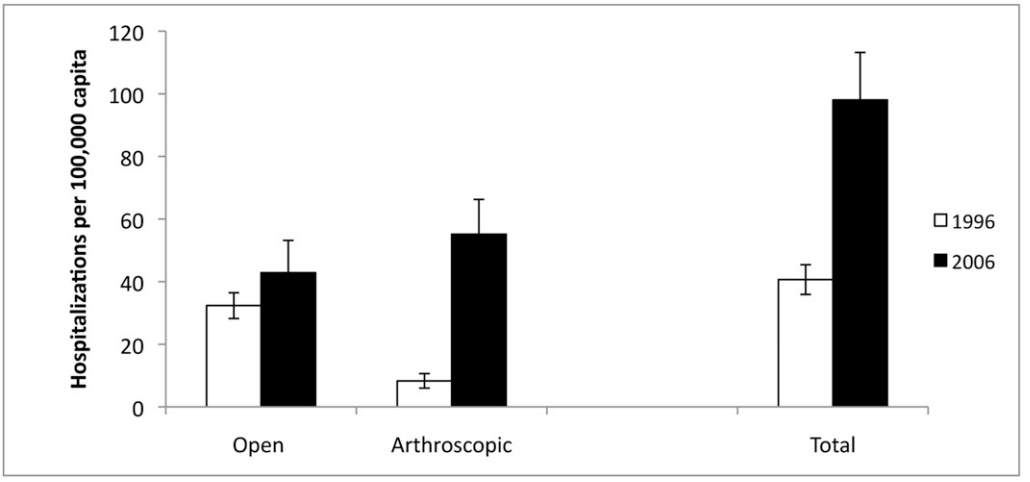

Fig. 1

Comparison of volume of open and arthroscopic rotator cuff repairs in 1996 and 2006.

values and 95% confidence interval (CI). Values of $p < 0.05$ were considered significant. Data sets were analyzed with SAS version 9.13 statistical software (SAS Institute).

We used a direct adjustment procedure to account for changes in sex and age in the U.S. population over time. The U.S. population in 2000 was selected as the standard population. The age and sex-adjusted rates were calculated by applying the age-specific and sex-specific rates to the standard population and dividing by the total in the standard population. Rates adjusted for age and sex were presented as the number of rotator cuff repairs per 100,000 standard population.

Source of Funding

No external funding source was used for this study.

Results

There was a substantial growth in the number of medical visits for shoulder pain over the ten-year study period: visits increased from 1070 per 100,000 population in 1996 to 1524 per 100,000 population in 2006. Furthermore, there was an increase in the number of rotator cuff surgical procedures performed per visit for shoulder pain. In 1996, there were twenty-six nonsurgical visits per one rotator cuff repair, and, in 2006, there were sixteen visits per one rotator cuff repair.

The use of both open and arthroscopic repairs increased substantially during the decade of study (Fig. 1). Open repairs increased by 34% (from approximately thirty-two per 100,000 population in 1996 to approximately forty-three per 100,000 population in 2006), while arthroscopic repairs increased by 600% (from approximately eight per 100,000 population in 1996 to approximately fifty-eight per 100,000 population in 2006). Overall, there was a 141% increase in the number of rotator cuff repairs performed (from approximately forty-one per 100,000 population in 1996 to approximately ninety-eight per 100,000 population in 2006).

With use of the U.S. population in 2000 as a control, the age and sex-adjusted rates for rotator cuff repairs are shown in Table III. After excluding the impact of changes in population structure over the decade on the rates of rotator cuff repairs, there was an overall 115% increase in the number of rotator cuff repairs performed. Open repairs increased by 21%, while arthroscopic repairs increased by 530%.

As the total number of procedures performed during the decade increased, there was substantial growth of the number of surgical procedures performed in an ambulatory surgery setting. The observed rate of outpatient surgical procedures more than quadrupled during the decade (from twenty-two to ninety-one per 100,000 capita) while inpatient surgical procedures decreased 63%, from nineteen per 100,000 to seven per 100,000 capita (Fig. 2). This increase in outpatient surgery centers correlated with the shift from open surgery to arthroscopic surgery. In fact, the rate of arthroscopic surgery in outpatient centers increased from six per 100,000 population in 1996 to fifty-four per 100,000 population in 2006.

As would be expected, the patients who had inpatient surgery had significantly more comorbidities (diabetes [$p = 0.007$], hypertension [$p < 0.0001$], chronic obstructive pulmonary disease [$p < 0.0001$], and coronary artery disease [$p = 0.0002$]) than the ambulatory surgery group had.

Several trends were seen with age (Fig. 3). The total number of open repairs increased both for patients who were younger than forty-five years (from six to eleven repairs per 100,000 capita younger than forty-five years of age) and those who were sixty-five years of age or older (from ninety-two to 131 patients per 100,000 capita sixty-five years of age or older). For the age group from forty-five to sixty-four years old, open repairs actually decreased during this period of time (from eighty-one to seventy-seven per 100,000 capita age forty-five to sixty-four years). During this same period of time, the number of arthroscopic repairs increased among all age groups. For those who were younger than forty-five years, the increase was from two to ten per 100,000 capita, for those who were forty-five to sixty-four years of age, the increase was from twenty-one to 146 per 100,000 capita, and for those who were sixty-five years or older, the increase was from twenty to ninety-nine per 100,000 capita.

In general, patients who underwent ambulatory surgery were younger than those who had an inpatient procedure (57.3

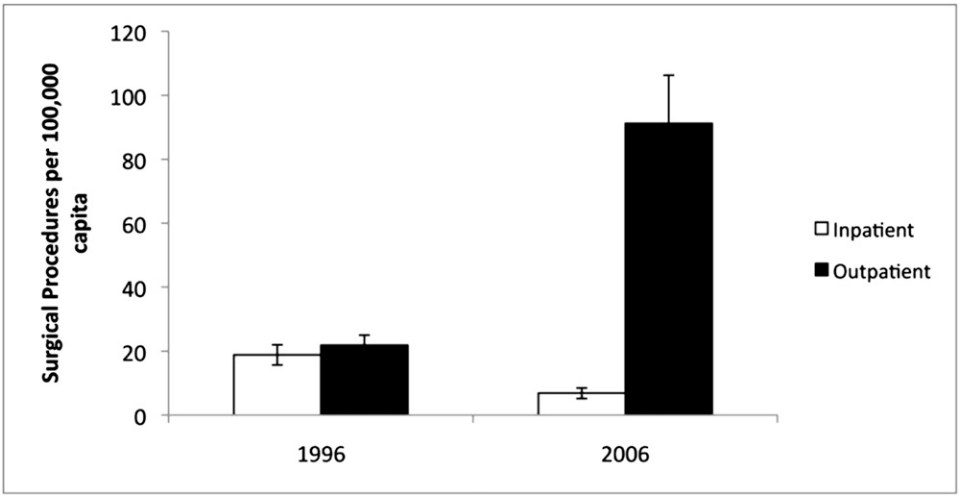

Fig. 2

Comparison of volume of inpatient versus outpatient rotator cuff repairs in 1996 and 2006.

years old versus 61.6 years old, p = 0.002) and the age difference increased over time; in 1996, the difference in average age was three years (57.4 vs. 60.4, p = 0.065) and in 2006, it was approximately seven years (57.2 years old versus 64.5 years old, p = 0.0003). In general, female patients who underwent rotator cuff repair were significantly older than their male counterparts

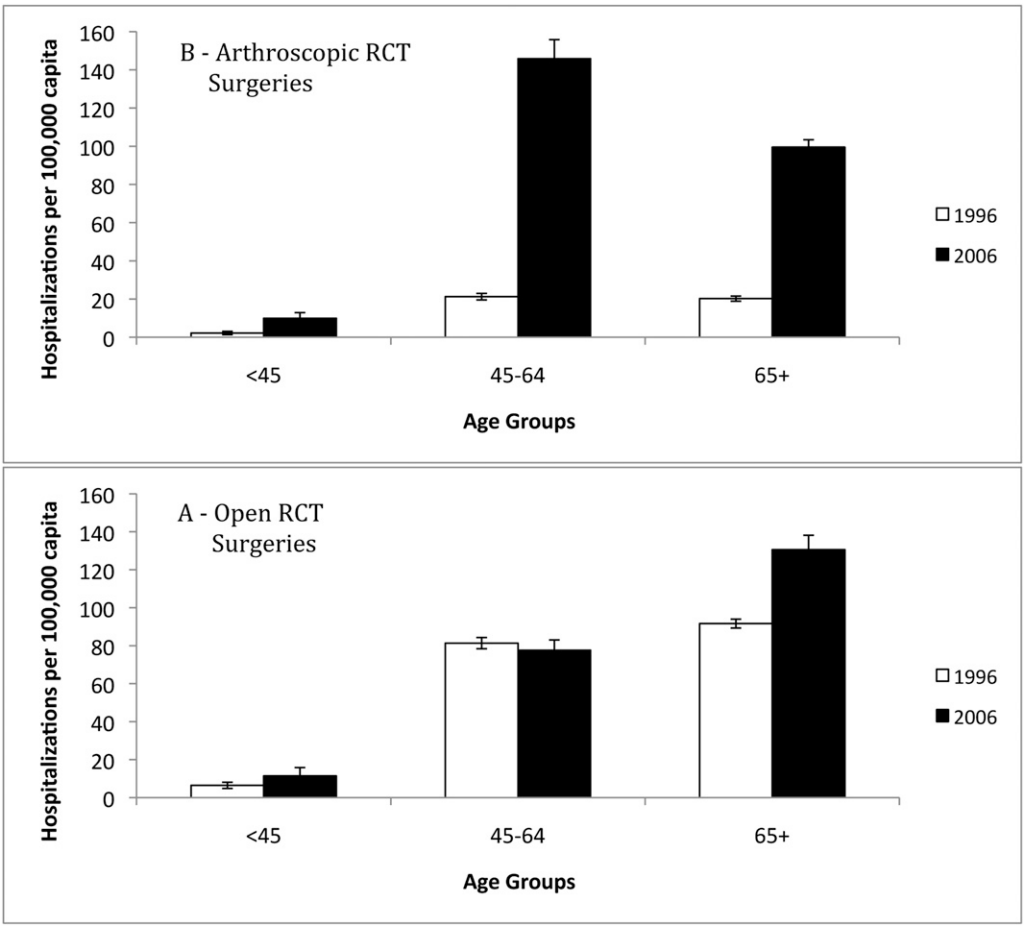

Fig. 3

Comparison of volume of open (Fig. 3-A) and arthroscopic (Fig. 3-B) rotator cuff repairs by age group in 1996 and 2006. RCT = rotator cuff tear.

TABLE III Observed and Adjusted Rates of Rotator Cuff Repair in 1996 and 2006 with Use of the U.S. Population in 2000 as the Control

	Observed Rate		Adjusted Rate		Percent Change for Adjusted Rates (2006 vs. 1996)
	1996	2006	1996	2006	
Inpatient					
Men	22.04	7.12	23.20	6.62	–71%
Women	15.78	6.58	16.34	6.32	–61%
Overall	18.84	6.85	19.71	6.47	–67%
Ambulatory					
Men	31.41	103.06	32.97	96.99	194%
Women	12.68	79.72	13.23	74.08	460%
Overall	21.84	91.21	22.91	85.32	272%
Inpatient and ambulatory combined					
Men	53.44	110.19	56.16	103.62	84%
Women	28.46	86.30	29.57	80.40	172%
Overall	40.68	98.06	42.62	91.79	115%
Arthroscopic rotator cuff repair					
Men	11.18	61.19	11.67	57.37	392%
Women	5.50	54.77	5.62	51.03	808%
Overall	8.28	57.93	8.59	54.14	530%
Open rotator cuff repair					
Men	41.58	48.82	43.80	46.40	6%
Women	22.90	37.13	23.89	35.33	48%
Overall	32.04	42.89	33.66	40.76	21%

(average age, 60.6 years for women and 56.1 years for men; p = 0.0034). This was reflected in both inpatients (average age, 65.4 years for women and 58.5 years for men; p = 0.0006) and ambulatory patients (average age, 59.5 years for women and 55.7 years for men, p = 0.0315). However, there was a trend toward increasing age among men who underwent inpatient repair (average age, 56.3 years in 1996 compared with 64.7 years in 2006, p = 0.0128).

Overall, there were more men than women who underwent rotator cuff repair; however, this difference diminished over the decade. Ambulatory surgery in 1996 revealed a dramatic difference, with women representing just 29.7% of the patients and men representing 70.3% of the patients. However, sex disparities have decreased over time. By 2006, 44.4% of patients who underwent ambulatory rotator cuff repair were women and 55.6% were men. Interestingly, the sex difference in 1996 was far less among patients who had an inpatient procedure: 42.8% of the patients were women and 57.2% were men. This difference narrowed further in 2006, when 48.8% of the patients were women and 51.2% were men.

We were able to examine surgical, operating room, and post-anesthesia care unit (PACU) time for ambulatory patients in 2006. Surgical time was defined as time from the first incision to the time of wound closure, operating room time was defined as total time that the patient spent in the operating room, and PACU time was defined as the time that the patient spent in the recovery room until discharge. We observed a significantly longer surgical time when the arthroscopic technique was used (eighty-four minutes; 95% CI = seventy-six to ninety-two minutes) as compared with when the open technique was used (sixty-six minutes; 95% CI = fifty-seven to seventy-five minutes) (p = 0.0047). Operating room time for arthroscopic procedures (120 minutes; 95% CI = 111 to 129 minutes) as compared with open procedures (104 minutes; 95% CI = ninety-two to 117 minutes) (p = 0.0454) was also significantly longer. However, no notable difference was detected in the amount of time in the PACU for either technique: the average time for an arthroscopic technique was 107 minutes (95% CI = ninety-four to 120 minutes), and the average time for the open technique was 100 minutes (95% CI = eighty-six to 114 minutes) (p = 0.464).

Over the decade, there was a significant increase in the use of general anesthesia supplemented by a regional nerve block for open procedures (from 3.07% of patients in 1996 to 14.55% of patients in 2006, p = 0.0164). During that same time period, the use of general anesthesia alone decreased significantly (from 83.68% to 68.42% of patients, p = 0.0355). When examined together, anesthesia for arthroscopic and open procedures demonstrated significant increases in the use of combined general

anesthesia and a regional nerve block (from 3.79% to 15.42% of patients over the ten-year period examined [p = 0.0072]). The databases were examined for patients who underwent surgery with regional anesthesia alone; however, the numbers were too small to identify any trends.

Discussion

The number of visits for rotator cuff pathology increased from 1996 to 2006, as did the ratio of subsequent surgical procedures performed per visit. This overall increase in repairs was seen for both open and arthroscopic procedures. Interestingly, the number of open repairs increased for patients who were younger than forty-five years of age. However, there was a much greater increase in the number of arthroscopic repairs, and this increase was seen across all age groups. The number of surgical procedures performed in an ambulatory setting also increased, with a concomitant decrease in inpatient surgery. As would be expected, inpatients tended to be older and had more comorbidities.

The popularization and expansion of outpatient surgery centers have been seen in recent years, and some have questioned the effect that this trend will have on larger hospitals. Some have reported concern for the demand placed on hospitals to care for only the sickest patients needing advanced care[14]. The findings of this study may support such a concern.

There are several possible reasons for the increase in rotator cuff repairs. First, the complexion of the U.S. population is changing. With medical advances, patients are living longer, and a larger percentage of our population is in the elderly demographic (by 2030, approximately 20% of the population will be sixty-five years of age or older)[15]. Older age has clearly been associated with an increase in the prevalence of rotator cuff tears[16,17], and our age-adjusted numbers were consistent with this observation. However, an increase in arthroscopic repairs and a decrease in inpatient surgical procedures were also seen with rate-adjusted numbers, reflecting a change in practice. Surgeons have become more aggressive with regard to early surgical repair after the results of studies demonstrated that older age[18,19] and larger tear size[20] are associated with failure to heal after rotator cuff repair. In addition, a recent study found that, even with a successful repair, preoperative muscle atrophy and fatty infiltration did not improve, and muscle atrophy played an important role in postoperative functional outcomes[21]. In patients with symptomatic rotator cuff tears, an asymptomatic tear in the contralateral shoulder is likewise at risk of size and symptom progression with time[22]. Furthermore, arthroscopy enables the diagnosis and repair of lesions (e.g., partial-thickness rotator cuff tears and upper-margin subscapularis tears) that may not have been as commonly addressed with open surgery.

The dramatic increase in arthroscopic repairs could be influenced by several factors. First, there have been dramatic improvements in both surgical instrumentation and technique that facilitate arthroscopic repair. Younger surgeon age, higher volume of shoulder arthroscopies, and higher volume of rotator cuff repairs have also been associated with significantly higher rates of arthroscopic repair[23]. Fellowship-trained shoulder and sports-medicine surgeons are also more likely to perform arthroscopic repairs than those whose training was limited to orthopaedic residency[23].

With the evolution of advanced arthroscopic techniques, there no longer exists a "gold standard" method for rotator cuff repair. The advantages of arthroscopic as compared with mini-open repair include the ability to mobilize and release the rotator cuff, decreased surgical insult to the deltoid muscle, improved ability to evaluate and treat pathology of the glenohumeral joint, improved visualization, decreased immediate postoperative pain, decreased postoperative stiffness, and no limitation in the size of the tear that can be addressed[24]. Open repair allows the surgeon to perform tendon transfers. There is consensus that functional outcome after rotator cuff repair is dependent on the integrity of the repair[1,25-27]. Even with experienced surgeons performing the repair, recurrent tears of the rotator cuff have been reported after both open[25-27] and arthroscopic repairs[20]. Recent studies have failed to demonstrate a difference in functional outcome scores or complications between the two procedures[2].

In our study, arthroscopic repairs were associated with a significantly longer surgical and operating-room time than open repairs were. The longer operating-room time seen with arthroscopic repair is consistent with the findings of previous studies[28]. The longer surgical time of arthroscopic repairs is attributable to several factors. Arthroscopic rotator cuff repair demands a high level of technical skill, which is associated with a steep learning curve. Guttmann et al. found that the arthroscopic rotator cuff repair time per procedure was significantly longer (mean time plus standard deviation, 96.5 ± 38.7 minutes) in the first ten procedures performed by a single surgeon than it was in the second ten procedures (48.4 ± 35.5 minutes, $p < 0.05$) performed by that same surgeon[29]. A significant decrease in operative time occurred as the number of arthroscopic rotator cuff repairs performed increased.

Anesthesia for rotator cuff repairs has likewise evolved. Over the ten-year time period, there was an increase in the number of surgical procedures performed under general anesthesia supplemented with a regional block. An interscalene block has been shown to be a safe and cost-effective method of pain control for shoulder surgery when compared with general anesthesia[4,30-32].

Drawing inferences from large datasets about clinical activities has limitations. One in particular is lack of clinical detail. Procedure codes are very general and do not differentiate between partial and full-thickness rotator cuff tears, nor do they distinguish tears by size or duration of time since injury. Thus, we are unable to comment on time from presentation to surgery. Furthermore, there is not enough detail for us to determine if the office visit took place preoperatively or postoperatively. We are also unable to determine which cases were associated with the performance of a mini-open technique and if there were any concomitant procedures (e.g., biceps tenotomy or tenodesis) performed at the time of the arthroscopic procedure. The potential for inaccuracies with coding in a large database also exists[33]. Nonetheless, we believe

that our results highlight important trends in rotator cuff surgery. There has been a shift in practice from open rotator cuff surgery performed in an inpatient setting to arthroscopic surgery performed in an outpatient setting. Interestingly, both age and sex affect aspects of surgical intervention. Although it has been reported that women report more disability with lower or similar levels of pathology compared with men[34], women tend to be older than men when they undergo surgery for a rotator cuff repair. Women were also less likely than men to have arthroscopic surgery performed as an outpatient. Future studies could help elucidate which variables are responsible for this difference in utilization of surgical intervention to ensure that appropriate education and access to care are available to all patients. ■

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