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Changes in anesthesia related factors in ambulatory knee and shoulder surgery: United States 1996–2006

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Abstract

Background—Analyses of existing nationally representative information on how changes in ambulatory orthopedic surgery have affected anesthesia practice over time are rare. We sought to characterize temporal changes in factors surrounding ambulatory orthopedic surgery and anesthesia.

Methods—Data from the National Survey of Ambulatory Surgery for the years of 1996 and 2006 were analyzed. Entries indicating the performance of knee ligamentoplasty, meniscectomy or shoulder arthroscopy were identified and included in the sample. Temporal changes in a number of variables associated with orthopedic ambulatory surgery were assessed, including: 1) the number of procedures being performed, 2) patient and health care system related demographics and 3) anesthesia related variables.

Results—Nationwide, the total number of ligamentoplasties, meniscectomies and shoulder arthroscopies increased from 1996 to 2006 by 66% (N=258,932 to N=428,712), 51% (N=456,698 to N=690,164), and 349% (N=93,105 to N=418,188) respectively (P<0.0001). Between 1996 and 2006 the use of peripheral nerve blocks increased from 0.6% to 9.8% for meniscectomies (P<0.0001), from 1.5% to 13.7% for ligamentoplasties (P<0.0001), and from 11.5% to 23.9% for shoulder arthroscopies (P<0.0001), respectively. Neuraxial anesthesia utilization fell from 11.8% to 6.3% for meniscectomies (P<0.0001) and 13.6% to 7.3% for ligamentoplasties (P<0.0001) from 1996 to 2006, respectively.

Conclusion—Substantial increases in the number of ambulatory knee and shoulder procedures occurred over time, relating to increased demand for anesthesia providers in this field. Trends towards increased use of peripheral nerve blocks may have to be considered by educators when preparing residents for practice.

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Introduction

The number of surgical procedures performed in ambulatory settings in the United States has steadily increased over the last several decades.^{1,2} The reasons for this increase are complex, and may reflect competing influences of patients, hospitals, physicians, and insurers. A significant subset of this population requiring anesthesia for their procedure involves orthopedic patients in need of shoulder and knee surgery. Little is known about how these changes have influenced anesthesia providers and their practice in the orthopedic ambulatory arena. Knowledge about the evolution of factors such as the number of procedures being performed and the types of anesthesia employed for specific procedures is important, as it allows institutions to compare their practices against this benchmark. Analysis of trends further allows anesthesia providers and educators the ability to assess the need for learning and teaching techniques, to direct resources accordingly, and adapt to the dynamic field of orthopedic ambulatory anesthesia. Further, epidemiologic information on trends and utilization is important for the generation of hypotheses by researchers, appropriate planning by administrators and for consideration by policy makers alike.

Although studies reporting trends in orthopedic surgery using national databases are available^{3,4}, the National Survey of Ambulatory Surgery (NSAS), performed by the Centers for Health Statistics and the Center for Disease Control in 1994–6 and in 2006, provides the opportunity for analysis of anesthesia related variables on a nationally representative level. Specifically, the NSAS allows for analysis of factors related to anesthetic technique and anesthesia provider associated with specific procedures.^{5,6}

Taking advantage of this opportunity, we analyzed data collected for this nationally representative ambulatory surgery database for the years of 1996 and 2006 to assess changes over time in a number of variables associated with orthopedic ambulatory care, including: 1) the number of procedures being performed, 2) patient and health care system related demographics and 3) anesthesia related variables, i.e. the types of anesthetics utilized and changes in the anesthesia provider mix.

We hypothesized that changes over time included an increase in the demand for anesthesia services and a change in anesthetic techniques utilized for ambulatory knee and shoulder procedures.

Methods

Data collected for National Survey of Ambulatory Surgery (NSAS) were obtained from the Centers for Disease Control and analyzed for this study. Detailed information regarding the NSAS has been previously published.⁷ In brief, the NSAS was conducted by the National Center for Health Statistics in the years 1994 to 1996 and then again in 2006 with the goal to compile nationally representative data on ambulatory surgery procedures performed in both free-standing ambulatory surgery facilities and hospital-based settings. The NSAS utilizes a complex sample design and provides weighting procedures that allow for the estimate of nationally representative data. The hospital universe for this database included Medicare-participating, non-institutional hospitals exclusive of military institutions, Veteran Affairs hospitals, and other federal facilities in the 50 states and the District of Columbia. To be eligible for inclusion in NSAS, patients had to be scheduled for ambulatory surgery with admission and discharge occurring on the same day. Patients admitted to the hospital either as an inpatient before surgery or through the emergency department were excluded. All participating institutions had at least six beds available for patient use.

Information collected in the survey included age, gender, race, principal expected source of payment (insurance status), type of anesthesia, anesthesia provider, diagnosis codes, and

procedure codes (International Classification of Diseases, Ninth Revision, Clinical Modification [ICD-9-CM]).

As the data used in this study are sufficiently de-identified, this project was exempt from review by our institutional review board.

Selection of Study Sample and Statistical Analysis

Our study sample consists of all data in NSAS for the years of 1996 and 2006. As our specific focus was on orthopedic surgical procedures, entries with an ICD-9-procedure code for knee ligamentoplasty, meniscectomy, and shoulder arthroscopy (81.42–47, 80.6, 80.21, respectively) were included in our analysis. Patient (age, gender) and healthcare system (facility type, health insurance) related demographics, anesthesia type and provider as well as discharge disposition were computed for each year of the survey and by procedure type. Unexpected admissions were defined as any disposition other than routine discharge to home, including admission as an in-patient, discharge to observational status or to a post-surgical/recovery care facility.

In order to adjust the number of procedures for changes in the US population, we obtained population estimates from the US census Bureau for the years 1996 and 2006.⁸

All statistical analyses were performed using SAS version 9.2 (SAS Institute, Cary, NC). The proportional changes between the two years of 1996 and 2006 were analyzed for each variable category using binomial tests. To facilitate analysis of data collected in a complex survey design and to obtain consistent estimates of mean and variance parameters taking into account the complex survey data setting, SAS procedures SURVEYFREQ were utilized for descriptive analyses and statistical testing.

Results

Changes in procedure volume

Based on estimates generated from data analyzed, a total of 2,345,799 procedures of interest were performed in 1996 and 2006 in the US. Nationwide, the total number of ligamentoplasties, meniscectomies and shoulder arthroscopies increased from 1996 to 2006 by 66% (N=258,932 to N=428,712), 51% (N=456,698 to N=690,164), and 349% (N=93,105 to N=418,188) respectively (P<0.0001). When adjusting for changes in the US population, these increases amounted to 47%, 34% and 398%, respectively (Figure 1).

Changes in demographics

Changes in patient and health care system related demographics are shown in table 1. While all procedures were performed more frequently in males across both time periods of interest, the gender gap decreased significantly over time (P<0.0001 for all procedures). Proportionally, more procedures were performed on patients in the age group of 45–64 years in 2006 compared to 1996. The reverse trend was seen for patients aged 15–44 years (P<0.0001 for all procedures). The number of procedures performed in freestanding versus hospital-based facilities increased dramatically between the two observation periods for all procedures (P<0.0001).

Changes in anesthesia related factors

Between 1996 and 2006 the use of peripheral nerve blocks increased from 0.6% to 9.8% for meniscectomy (P<0.0001), from 1.5% to 13.7% for ligamentoplasty (P<0.0001) and 11.5% to 23.9% for shoulder arthroscopy (P<0.0001), respectively. The use of general anesthesia remained the most common type of anesthesia utilized in both years of study for all

procedure types. Significant changes in utilization were seen in meniscectomies and shoulder arthroscopies ($P<0.0001$), but not ligamentoplasties ($P=0.8417$) (Table 2). Neuraxial anesthesia (epidural, spinal, combined spinal/epidural) utilization fell from 11.8% to 6.3% for meniscectomies ($P<0.0001$) and 13.6% to 7.3% for ligamentoplasties ($P<0.0001$), respectively. The use of multiple anesthetic techniques also increased between 1996 and 2006 (13.7% to 23.7% for meniscectomies, 16.1% to 29.7% for ligamentoplasties, and 13.8% to 28.6% for shoulder arthroscopies, respectively ($P<0.0001$ for all comparisons)). Significant changes in the type of anesthesia provider between 1996 and 2006 were found for all procedures ($P<0.0001$, respectively) (Table 2). Interestingly, while solo practice by an anesthesiologist for ligamentoplasties and meniscectomies decreased, this type of practice increased for shoulder arthroscopies ($P<0.0001$ for all procedures).

Changes in disposition status

Unexpected admissions decreased for all procedures between 1996 and 2006 (meniscectomy: 5.8% to 0.7%, ligamentoplasty: 10.7% to 1.0%, and shoulder arthroscopy: 20.6% to 4.6% ($P<0.0001$)).

Discussion

In this study of a nationally representative sample, we were able to identify significant trends in anesthesia related and unrelated variables surrounding ambulatory surgery of the knee and shoulder. Among the noteworthy trends were the utilization of procedures in older age groups, a dramatic increase in the number of procedures performed primarily in freestanding facilities compared to hospital based settings and significant trends in anesthesia practice. The latter included a decline in the use of neuraxial anesthesia and an increase in the use of peripheral nerve blocks. The proportion of cases with involvement of a solo anesthesiologist has risen for shoulder arthroscopies but has declined for ligamentoplasties and meniscectomies. Furthermore, overnight admission rates after ambulatory knee and shoulder surgery have decreased significantly over the decade of study.

The rise in the number of ambulatory surgical procedures compared to inpatient surgery has been described throughout the 1980's and 90's and has continued into the new millennium.^{1, 2} The total number of ambulatory procedures in the US increased from an estimated 380,000 in 1983 and 31.5 million in 1996 to an estimated 53.3 million in 2006.^{1,2} Two reasons are commonly quoted as underlying this trend: 1) advances medical techniques making procedures safer (i.e. minimally invasive approaches and advances in anesthesia techniques)^{9, 10}, and 2) changes in the payment structure favoring the shift of less complex cases to an outpatient basis.¹¹ Cullen et al. reported that the overall increase in the ambulatory surgery volume was primarily due to an increase in procedures being performed in free-standing facilities.¹ This finding is in concordance with our results, which showed an approximately 300% rise of procedures performed in this setting.

The dramatic increase in overall procedure volume, as found in other studies and as shown for ambulatory knee and shoulder surgery here, highlights the continuing demand on our educational system to put increasing numbers of individuals into the anesthesia provider workforce. The potential stresses on meeting the demand are magnified by the fact that although the need for anesthesia providers has increased in the ambulatory arena, concurrent increases in inpatient hospital-based surgery have also increased.^{3, 4}

We found a significant change in the types of anesthesia techniques utilized for ambulatory knee and shoulder procedures. The proportion of knee surgeries under neuraxial anesthesia decreased while the utilization of peripheral nerve blocks increased. General anesthetics still remain the most commonly utilized technique. These findings may be based on a number of

advances in the practice of anesthesia. Neuraxial anesthesia is commonly viewed as an alternative to general anesthesia in the setting of lower extremity surgery. Its attraction for many practitioners may lie in the avoidance of airway instrumentation and its complications and side effects commonly attributed to general anesthetics, i.e. nausea, vomiting.¹² With the advent of potent antiemetic therapy, the use of short acting drugs and less invasive airway devices, these advantages may be less prominent. The potential adverse factors associated with a neuraxial technique, i.e. potential for meningeal puncture headache, transient neurologic symptoms, urinary retention, and block lasting in excess of the surgery, may have become of concern in some settings. However, Liu et al noted that the primary differences between neuraxial techniques and general anesthesia in the ambulatory setting had more to do with measures of efficiency.¹² Patients having a neuraxial technique had longer induction times and were discharged from the facility later compared to general anesthesia counterparts. These economic drivers (as opposed to quality drivers) may be the explanation for the findings in our study.

The increase in the utilization of peripheral nerve blocks performed in the setting of ambulatory knee and shoulder procedures should come as no surprise, as these blocks have been shown to favorably impact both economic and quality measures.^{12, 13} Further, Richman et al. showed that the use of peripheral nerve catheters was associated with better analgesia and fewer opioid related side effects than opioid based pain control strategies¹⁴, thus highlighting an obvious clinical benefit.

In the time period studied (1996 to 2006) the advent of nerve localizing technology such as nerve stimulation has likely added to the popularity of peripheral nerve blocks. The widespread introduction of ultrasound guided regional anesthesia over the last several years will undoubtedly further expand this trend.¹⁵ The demand for peripheral nerve block techniques in ambulatory and surgical procedures may also be reflected in the dramatic increase in regional anesthesia fellowship programs in the country.^{16, 17} Although no causal relationships can be established from our data regarding the increased utilization and need for expanding education in regional techniques, the observed trend supports the notion that demand for anesthesiologists with regional anesthesia skills is likely to increase.

In this study we noted proportional changes in the anesthesia provider category over time. Most notably, the proportion of non-anesthesia professionals decreased for all procedures. While the reason for this change cannot be determined with certainty, it represents a shift to care by specialized and arguably more qualified health care professionals. Further, it is possible that changes in the ability of practitioners to bill for anesthetic care while simultaneously performing a procedure are factors in the trends observed.

The increased involvement of anesthesiologists in shoulder procedures, which may be viewed as more difficult because of challenges associated with the sitting and lateral position and higher demand for peripheral nerve blocks, may represent the demand for more qualified anesthesia providers.

We identified a number of changes in patient and health care system-related demographics as well. Patients between the ages of 45 and 64 years made up the largest proportion of ambulatory orthopedic patients in 2006 as compared to the age group of 15–44 years in 1996. Causes for this shift are likely multi-factorial and may include, 1) the expansion of indications for these procedures for an older group of patients as surgeons become more familiar with techniques, and 2) the increasing demand for these surgeries that preserve function in a growing group of patients who remain active later in life.

Decreased rates of admissions after ambulatory knee and shoulder surgery found in this study are likely multifactorial, but may include better patient selection, development of

discharge pathways, use of better pain management and shorter acting anesthetics with fewer side effects. Certainly, the desire by patients and health care systems to avoid the additional financial burden associated with overnight admissions is a key component to be considered in when interpreting this trend.

Our study is limited by a number of factors inherent to the analysis of databases designed for administrative purposes. As such, information on important variables, such as clinical details and patient preferences, are not available. It is also not possible to determine if, for example, peripheral nerve blocks were utilized with the purpose of being primary anesthetics or targeted for postoperative pain control. In addition, as ambulatory cases tend to be procedure focused, limited information on co-morbidities is available, with the vast majority of entries only including the primary diagnosis necessitating the procedure in the diagnosis fields. Furthermore, no causal relationships can be determined from our data and reasons for our findings have to remain speculative. In this context, we cannot determine if the increase in the use of peripheral nerve blocks is a reflection of increased demand by surgeons and patients or increased supply of trained personnel. In addition, we cannot comment on the overall impact on cost associated with this trend, as factors such time requirement for blocks and impact on discharge readiness were not evaluated. Therefore, our data have to be interpreted in the context of this database construct. Further, as for any database we cannot exclude coding bias and collection errors in the NSAS. However, it must be mentioned that a multitude of steps were taken by the National Center for Health Statistics to assure accurate data sampling, including uniform data collection and the dispatch of field representatives overseeing data entry.⁷

Lastly, our data are based on only two years of study. Unfortunately, the NSAS was only conducted from 1994–1996 and then again in 2006. We chose to compare only 1996 to 2006 as to have the same time frame for each group.

In conclusion, between 1996 and 2006 substantial changes were found in the number of ambulatory knee and shoulder procedures performed. In addition, changes in anesthesia practice were observed with trends towards increased use of peripheral nerve blocks and decreased utilization of neuraxial anesthesia. While causalities cannot be determined from our data, results can be used by individual institution to compare their practice patterns against a national average and for the purposes of directing anesthesia resources to meet ever changing needs in ambulatory surgery. Further, epidemiologic information on trends and utilization is important for the generation of hypotheses by researchers, appropriate planning by administrators and for consideration by policy makers alike.

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Figure 1. Population-adjusted rates of surgical procedures performed per 100,000 US civilians by year of study.

Patient and health care system related characteristics are listed by procedure type and year. Results represent proportions of the total N performed for each year.

Table 1

	Ligamentoplasty				Meniscectomy			Shoulder Arthroscopy			
Year	1996	2006	P-value		1996	2006	P-value		1996	2006	P-value
Total N=	258,932	428,712			456,698	690,164			93,105	418,188	
Age group (%)	<15	1.1	1.6	<0.0001	0.7	0.2	<0.0001		0.1	0.1	0.4392
	15-44	55.8	45.1	<0.0001	43.5	29.6	<0.0001		50.1	28.4	<0.0001
	45-64	32.9	42.5	<0.0001	39.1	51.1	<0.0001		37.9	56.4	<0.0001
	65-74	8.6	7.4	<0.0001	13.7	13.1	<0.0001		9.5	9.4	0.1102
	>75	1.6	3.4	<0.0001	3.1	6.1	<0.0001		2.5	5.7	<0.0001
Gender (%)	Male	57.6	56.5	<0.0001	60.5	55.6	<0.0001		65.8	54.6	<0.0001
	Female	42.4	43.5	<0.0001	39.5	44.4	<0.0001		34.2	45.4	<0.0001
Insurance (%)	Private	70.1	73.2	<0.0001	67.9	69.0	<0.0001		68.1	68.8	<0.0001
	Government	15.3	20.1	<0.0001	13.0	25.7	<0.0001		18.0	27.6	<0.0001
	Medicare	10.8	3.6	<0.0001	16.0	4.0	<0.0001		10.1	2.3	<0.0001
	Other	3.8	3.1	<0.0001	3.2	1.4	<0.0001		3.9	1.4	<0.0001
	Hospital	86.0	52.5	<0.0001	87.2	62.7	<0.0001		83.9	52.4	<0.0001
Facility Type (%)	Free Standing	14.0	47.5	<0.0001	12.8	37.3	<0.0001		16.1	47.6	<0.0001

Tabulated are proportions of cases involving various anesthesia providers by procedure type and year. For anesthesia types a particular anesthetic technique is shown if it was listed as part of the anesthetic. Total percentages may therefore exceed 100%. IV=intravenous; MAC=Monitored Anesthesia Care.

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