National trends in ambulatory surgery for upper extremity fractures: a 10-year analysis of the US National Survey of Ambulatory Surgery

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Abstract

Background Upper extremity fractures are increasing in frequency and have profound socioeconomic implications. The purpose of this study was to assess trends in ambulatory upper extremity fracture fixation in the USA from 1996 to 2006 using data from the National Survey of Ambulatory Surgery (NSAS). **Methods** The NSAS was used to identify cases of closed forearm, carpal, metacarpal, and phalanx fractures treated with open or closed reduction with internal fixation in 1996 and 2006. Data were analyzed for trends in fracture location, age, gender, facility type, payor status, and anesthesia type. US census data were used to obtain national population estimates. **Results** Over the 10-year study period, there was a 54.4 % increase in the population-adjusted rate of upper extremity fractures treated with internal fixation (34.6 to 53.4 per 100,000 capita). There was a 173 % increase in the age-adjusted rate of patients over 55 years treated with internal fixation. There was a 505 % increase in the number of cases performed at freestanding surgical centers compared to hospital-based facilities. Though the majority of cases involved general anesthesia, regional anesthesia (16.6 versus 20.6 %) and monitored anesthesia care (7.1 versus 11.8 %)

increased in frequency. Private insurance groups funded the majority of surgeries in both study years.

Conclusion The volume of ambulatory surgery for upper extremity fractures has increased dramatically from 1996 to 2006. Operative treatment of upper extremity fractures has increased markedly. Our analysis provides valuable information for providers and policy-makers for allocating the appropriate resources to help sustain this volume.

Keywords Trends · Fractures · Ambulatory · Fixation · National · Upper extremity

Introduction

Upper extremity injuries account for 18 million emergency room visits every year in the USA, with approximately 1.5 million cases involving hand or forearm fractures [6]. These injuries have profound socioeconomic consequences, accounting for an average of 8 weeks of time off work per injury [32]. Frequently amenable to definitive management with closed reduction and immobilization, operative treatment for upper extremity fractures may allow for quicker rehabilitation and earlier mobility. Previous studies have demonstrated a trend towards increased operative management of pediatric upper extremity fractures and distal radius fractures in the elderly [5, 14]. However, epidemiological studies regarding US national trends in the incidence and management of forearm and hand fractures are lacking. Knowledge of national patterns of disease burden is necessary for the creation of injury prevention programs [12, 31] and for the allocation of limited health-care resources. The purpose of this study was to determine trends in the utilization of ambulatory surgery for forearm and hand fractures between 1996 and 2006 in the USA with a specific focus on (1) demographics, (2) setting of

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surgical treatment, (3) source of payment, (4) type of anesthesia used, and (5) anatomic location of the fracture.

Materials and Methods

The National Survey of Ambulatory Surgery (NSAS), conducted by the Centers for Disease Control and Prevention (CDC) [3], was analyzed to evaluate trends in the surgical management of forearm and hand fractures in the outpatient setting in 1996 and 2006. The NSAS was conducted by the National Center for Health Statistics (NCHS) to provide a comprehensive overview of ambulatory surgery in both hospital-based and freestanding surgical facilities [23]. Data for the NSAS comes from Medicare-participating, non-institutional hospitals (excluding military hospitals, federal facilities, and Veteran Affairs hospitals) in all 50 states and the District of Columbia. The survey recorded medical information on patient abstracts coded by NCHS contract staff and uses International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes [2] to classify medical diagnoses and procedures. The NSAS database produces an unbiased national estimate by using multistage estimate procedures including inflation by reciprocals of the probabilities of sample selection, adjustment for no response, and population weighting ratio adjustments [7, 11]. This study did not require a review by the institutional review board, as the database does not contain any personal identifying information.

The study sample consisted of data in the NSAS for 1996 and 2006. Demographic and medical information was obtained for entries with an ICD-9 diagnosis code of a forearm or hand fracture (Table 1). The database was then queried for discharges with a procedure code (ICD-9-CM) of closed reduction with internal fixation (i.e., percutaneous fixation) or open reduction with internal fixation (Table 2), using previously described techniques [21, 30]. Codes for closed reduction without fixation, debridement of open fractures, and unspecified operations were excluded. Data were recorded for each group, including age, sex, facility type, insurance type, anesthesia type, diagnoses, and procedures. The NSAS database does not include clinical outcomes or data after the date of discharge, and therefore more specific data was not available for review.

Descriptive statistical analysis consisted of means and standard error for continuous variables and frequency and percentages for discrete variables. NSAS survey data were collected based on a probabilistic sample scheme. The data were analyzed using a sampling weighting method to account for unequal sampling probabilities. Sampling weights (the inverse of selection probability) provided by the CDC allowed us to produce estimates for all visits in the USA. A Taylor linearization model provided by CDC estimates was used to calculate standard error and confidence intervals. Standard error describes the sampling variability that occurs by chance

because only a sample rather than the entire universe is surveyed. To define population parameters, 95 % confidence intervals along with a point estimate were selected. When compared between years, confidence intervals can be suggestive of statistical differences if the data are non-overlapping. Direct statistical comparison between years, however, could not be performed due to sampling differences in the database. US census data from 1996 to 2006 were used to obtain national population estimates for each year of the study [4]. Rates were presented as the number of upper extremity fractures per 100,000 standard population. Gender-specific rates were applied for the standard population, and dividing by the total in the standard population, we calculated gender-adjusted rates for each year. For age, a direct adjustment procedure was used and the US population in 2000 was selected as the standard population, as previously described [7]. All data were analyzed using the software Statistical Package for Social Sciences [SPSS] version 20 (Chicago, IL, USA).

Results

A cohort representative of 93,169 (95 % CI 100,984–84,353) forearm and hand fractures treated with internal fixation (34.6 per 100,000 capita) was recorded in 1996 (Table 3). In 2006, 159,295 (95 % CI 174,843–143,747) fractures were treated with internal fixation (53.4 per 100,000 capita). Overall, there was a 54.4 % increase in the population-adjusted rate of upper extremity fractures treated with internal fixation from 1996 to 2006.

The mean age of patients treated with internal fixation increased between 1996 (34.52 years, standard error=0.06) and 2006 (37.41 years, standard error=0.06) (Table 3). At both time points, the majority of patients were between 15 and 34 years; however, the age distribution varied considerably. For instance, after population-based adjustments for age, there was a 172.7 % (46.8 to 127.6 per 100,000 capita) increase in the age over 55 years in groups between the study years. In comparison, an age range of 15–34 years had only a 25.3 % increase (147.2 to 184.4 per 100,000 capita). In both study years, after population-based adjustments for gender, more males underwent internal fixation than females (Table 3). However, there was a greater change among females undergoing surgery for an upper extremity fracture (44.8 versus 67.7 per 100,000 capita; 59.1 % increase) compared to males (22.9 versus 41.2 per 100,000 capita; 51.1 % increase).

Facility type shifted from hospital to freestanding sites over the study period (Table 3). The proportion of internal fixation cases performed at a freestanding facility increased from 8.0 to 31.3 %. Adjusting for population variance, this represents a 505 % increase in the number of procedures performed in freestanding facilities compared to only 15.2 % increase in hospital-based facilities. Payor status for surgery did not vary dramatically between the study years. In both 1996 and 2006,

Table 1 Diagnosis codes used for analysis

Category	ICD-9 code	Description
Forearm (proximal)	813.0	Fracture of upper end of radius and ulna closed
	813.00	Closed fracture of upper end of forearm, unspecified
	813.01	Closed fracture of olecranon process of ulna
	813.02	Closed fracture of coronoid process of ulna
	813.03	Closed Monteggia's fracture
	813.04	Other and unspecified closed fractures of proximal end of ulna (alone)
	813.05	Closed fracture of head of radius
	813.06	Closed fracture of neck of radius
Forearm (midshaft)	813.07	Other and unspecified closed fractures of proximal end of radius (alone)
	813.08	Closed fracture of radius with ulna, upper end [any part]
	813.2	Fracture of shaft of radius and ulna closed
	813.20	Closed fracture of shaft of radius or ulna, unspecified
	813.21	Closed fracture of shaft of radius (alone)
Forearm (distal)	813.22	Closed fracture of shaft of ulna (alone)
	813.23	Closed fracture of shaft of radius with ulna
	813.4	Fracture of lower end of radius and ulna closed
	813.40	Closed fracture of lower end of forearm, unspecified
	813.41	Closed Colles' fracture
	813.42	Other closed fractures of distal end of radius (alone)
	813.43	Closed fracture of distal end of ulna (alone)
	813.44	Closed fracture of lower end of radius with ulna
	813.45	Torus fracture of radius (alone)
	813.46	Torus fracture of ulna (alone)
Forearm	813.47	Torus fracture of radius and ulna
	813.8	Fracture of unspecified part of radius with ulna closed
	813.80	Closed fracture of unspecified part of forearm
	813.81	Closed fracture of unspecified part of radius (alone)
	813.82	Closed fracture of unspecified part of ulna (alone)
Carpal	813.83	Closed fracture of unspecified part of radius with ulna
	814.0	Closed fractures of carpal bones
	814.00	Closed fracture of carpal bone, unspecified
	814.01	Closed fracture of navicular [scaphoid] bone of wrist
	814.02	Closed fracture of lunate [semilunar] bone of wrist
	814.03	Closed fracture of triquetral [cuneiform] bone of wrist
	814.04	Closed fracture of pisiform bone of wrist
	814.05	Closed fracture of trapezium bone [larger multangular] of wrist
	814.06	Closed fracture of trapezoid bone [smaller multangular] of wrist
	814.07	Closed fracture of capitate bone [os magnum] of wrist
Metacarpal	814.08	Closed fracture of hamate [unciform] bone of wrist
	814.09	Closed fracture of other bones of wrist
	815.0	Closed fracture of metacarpal bones
	815.00	Closed fracture of metacarpal bone(s), site unspecified
	815.01	Closed fracture of base of thumb [first] metacarpal
	815.02	Closed fracture of base of other metacarpal bones
	815.03	Closed fracture of shaft of metacarpal bone
	815.04	Closed fracture of neck of metacarpal bone
	815.09	Closed fracture of multiple sites of metacarpus

Table 1 (continued)

Category	ICD-9 code	Description
Phalanx	816.0	Closed fracture of one or more phalanges of hand
	816.00	Closed fracture of phalanx or phalanges of hand, unspecified
	816.01	Closed fracture of middle or proximal phalanx or phalanges of hand
	816.02	Closed fracture of distal phalanx or phalanges of hand
	816.03	Closed fracture of multiple sites of phalanx or phalanges of hand
	817.0	Multiple closed fractures of hand bones

the most common payors were private insurance (63.2 versus 51.4 %) and Medicare (9.3 versus 16.0 %). Worker's compensation made up only 7.2 and 7.9 %, respectively, per year.

Over the decade, general anesthesia remained predominant in all surgical settings (Table 3). There was an increase in the use of regional blocks (16.6 to 20.6 %) and monitored anesthesia care (MAC) (7.1 to 11.8 %). Topical/local anesthesia decreased (9.6 to 7.2 %), as did intravenous sedation (17.5 to 14.0 %).

Adjusting for population variations, there was an increase in internal fixation of all diagnoses except metacarpal fractures (−29.6 %) (Table 4). The greatest changes occurred for internal fixation for midshaft forearm fractures (221.7 %), distal forearm fractures (125.6 %), and carpal bones (118.7 %). Metacarpal fracture was the most common diagnosis in 1996 (9.4 per 100,000 capita), and distal forearm fracture was the most common diagnosis in 2006 (16.6 per 100,000 capita).

Discussion

The results of this study demonstrate that ambulatory operative treatment of forearm and hand fractures has increased substantially from 1996 to 2006 in the USA. These results are similar to previous reports of the epidemiology of upper extremity fractures in other countries. For example, results from the Finnish National Hospital Discharge Register, over a 25-year period, reported significant increases in operative

fixation for clavicle, proximal humerus, humeral shaft, and distal radius fractures [15–17, 22]. There are several potential explanations for the observed change in surgical volume. Primarily, the American population is more active and demanding than before, and surgical treatment serves as an option to allow for earlier mobilization [19]. Second, as surgical approaches and methods of fracture fixation have improved, there has been a trend towards operative treatment for

Table 3 Trends in upper extremity fracture fixation by year

Category		1996	2006
Total number of procedures ^a		34.6	53.4
Age	Average (years)/standard error	34.5 (0.06)	37.4 (0.06)
	0–14 years ^b	45.8	94.0
	15–34 years ^b	147.2	184.4
	35–54 years ^b	99.4	176.3
	>55 years ^b	46.8	127.6
Gender	Male ^c	44.8	67.7
	Female ^c	25.9	41.2
Facility type	Hospital	92.0 %	68.7 %
	Freestanding	8.0 %	31.3 %
Payor status	Workers compensation	7.2 %	7.9 %
	Medicare	9.3 %	16.0 %
	Medicaid	4.1 %	8.5 %
	Other governmental payments	1.0 %	3.7 %
	Private	63.2 %	51.4 %
	Self pay	7.9 %	9.3 %
	Other	7.4 %	3.3 %
Anesthesia type	Topical or local	9.6 %	7.2 %
	IV sedation	17.5 %	14.0 %
	MAC	7.1 %	11.8 %
	Regional block	16.6 %	20.6 %
	General	58.2 %	66.4 %

^a Population-adjusted rate per 100,000 capita

^b Age-adjusted rate per 100,000 capita

^c Gender-adjusted per 100,000 capita

Table 2 Procedure codes used for analysis

Category	ICD-9 code	Description
Closed with internal fixation	79.12	Radius and ulna
	79.13	Carpals and metacarpals
	79.14	Phalanges of hand
Open reduction internal fixation	79.32	Radius and ulna
	79.33	Carpals and metacarpals
	79.34	Phalanges of hand

Table 4 Trends in surgical volume by diagnosis (per capita 100,000 population)

Category	1996	2006	Percent change
Forearm (proximal)	2.1	4.0	89.1
Forearm (midshaft)	1.0	3.4	221.7
Forearm (distal)	7.4	16.6	125.6
Forearm (other)	2.8	4.9	75.4
Carpal	2.9	6.4	118.7
Metacarpal	9.4	6.6	−29.6
Phalanx	8.9	11.5	28.6

certain extremity injuries, such as the increase in distal radius fixation after the introduction of volar plating in 2000 [20]. With evolving trends in health-care politics and economics, there continues to be an increasing disparity between charges and reimbursement rates in orthopedic surgery [26]. In effect, this may result in an increase in surgical treatment of otherwise non-operative fractures to compensate for this discrepancy. This speculation has been postulated to be a cause for several trends in surgical volume, including total joint arthroplasty, spinal fusion, arthroscopy, and pediatric fracture fixation [5, 7, 10, 14, 24, 26, 27]. Secondary to economic strain, there may have been a need for quicker return to work to minimize time-off for the employed population. This can be corroborated from prospective data demonstrating that surgical treatment is more cost-effective than non-operative treatment for scaphoid fractures, resulting in a 47-day difference in return to work [1]. However, high-quality evidence regarding US national procedural charges, reimbursement rates, and work data during our study years is unavailable; therefore, conclusions regarding treatment options based on the results of this study are purely speculative.

This study also demonstrated a large increase in the age-adjusted rate of fracture fixation among patients over 55 years of age. This is similar to results obtained by Cuenca et al. who described an increase in the incidence of distal forearm fractures among patients over 50 years of age [8]. Labor force estimates from the Current Population Survey (CPS) may help explain this change [25]. March 2001 marked the beginning of the USA's most recent recession and a subsequent fall in labor force participation. Partially offsetting the decline was a sharp increase in participation of the population specifically over 55 years of age. The CPS notes that this increase coincided with the movement of the baby-boomer generation into the 55-years-and-older age range in 2001. As such, increased involvement of this population in the work force may help explain the increased volume of surgically managed fractures. Moreover, a large increase in surgical volume was also present for patients under the age of 15 years. This finding has been previously explained to have possibly been a result of the

changes in leisure-time activity, obesity-related skeletal overloading, and changes in operative indications [14].

Our results indicate an increase in procedures performed in freestanding facilities. The rise in the ambulatory surgical volume has been previously speculated to result from more procedures being performed in freestanding facilities [9]. Similar findings have been reported with knee and shoulder arthroscopy, noting a 300 % increase in cases performed in freestanding facilities [24]. Though general anesthesia remains the most utilized technique, the results of this study demonstrate a shift towards alternate anesthesia techniques, specifically peripheral nerve blocks. The increase of nerve blocks has also been noted in joint arthroscopy, which has been linked to the advent of nerve localizing technology, such as nerve stimulation and ultrasound guidance [24]. Peripheral nerve blocks have been shown to be favorable in both economic and quality measures, associated with fewer opioid-related side effects, and overall provide better analgesia in comparison to opioids, highlighting their importance in the ambulatory setting [28].

Though it provides a comprehensive and reliable source of national data, the NSAS has limitations. As the database is primarily for ambulatory cases, there is little clinical information on more specific demographics, co-morbidities, indications, and outcomes. There is also no accurate method to determine the total of number of fractures treated without surgery, as the coding is only representative of those present in the ambulatory surgical setting. Our most current ambulatory data was from 2006. Due to insufficient funding, the NSAS could not be conducted on a continual basis past 2006 and therefore was modified and integrated into other surveys for subsequent years [29]. Data on specific fracture patterns and details of fixation are not provided. Also, the NSAS does not record specific current procedure terminology (CPT) codes, which may result in broad interpretation of the ICD-9 procedure codes. Like all large databases, the NSAS is subject to errors in data entry and coding by the participating facilities [13]. Also, the data is broad but cannot be generalized to facilities that do not participate, such as the Veterans Affairs hospitals, military centers, and federal facilities. However, the NSAS has taken measures to account for adequate data sampling, including complex weighting adjustments by population and uniform data collection [18].

In spite of these limitations, this study highlights important trends in upper extremity fracture surgery. Hand and forearm fractures are some of the most common injuries and have marked impact on health-care costs and work-related losses. As such, the information in this study is useful for hand surgeons in accurately identifying and counseling individuals who may be amenable to operative intervention. The data also augments our knowledge regarding the growing financial burden of surgery on our current health-care system. Our national database analysis provides valuable information to

allocate appropriate resources and modify health policy in favor of this large population.

Conflict of Interest Amar A. Patel declares that he has no conflict of interest.

Leonard T. Buller declares that he has no conflict of interest.

Megan E. Fleming declares that she has no conflict of interest.

David L. Chen declares that he has no conflict of interest.

Patrick W. Owens declares that he has no conflict of interest.

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Statement of Informed Consent There were no human subjects required for this study and therefore informed consent was not required.

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