PAPER

Inpatient Surgery in California: 1990-2000

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Background: The practice environment for surgery is changing. However, little is known regarding the trends or current status of inpatient surgery at a population level.

Hypothesis: Inpatient surgical care has changed significantly over the last 10 years.

Design: Longitudinal analysis of California inpatient discharge data (January 1, 1990, through December 31, 2000).

Setting: All 503 nonfederal acute care hospitals in California.

Patients: All inpatients undergoing general, vascular, and cardiothoracic surgery in California from January 1, 1990, through December 31, 2000, were obtained.

Main Outcome Measures: Volume, mean age, comorbidity profile, length of hospital stay, and in-hospital mortality were obtained for inpatient general, vascular, and cardiothoracic surgical procedures performed during the period 1990 to 2000. Rates of change and trends were evaluated for the 10-year period.

Results: Between January 1, 1990, and December 31, 2000, 1.64 million surgical procedures were performed. The number of surgical procedures increased 20.4%, from 135 795 in 1990 to 163 468 in 2000. Overall, patients were older and had more comorbid disease in 2000 compared with 1990. Both crude and adjusted (by type of operation) in-hospital mortality decreased from 3.9% in 1990 to 2.75% ($P<.001$) and 2.58% ($P<.001$), respectively, in 2000. Length of hospital stay decreased over the period for all operations analyzed.

Conclusions: The total number of inpatient general, vascular, and cardiothoracic surgical procedures has increased over the past decade. Furthermore, our findings indicate that the outcomes of care (eg, in-hospital mortality and length of hospital stay) for patients who undergo general, vascular, and cardiothoracic surgical procedures have improved. However, continued evaluations at the population level are needed.

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THE ENVIRONMENT for the practice of surgery has changed significantly over the last 10 years as a result of at least 3 important influences. First, advancements in medical and noninvasive technologies, such as proton pump inhibitors, endoscopy, and laparoscopy, have affected the scope of practice. Second, there was a rapid rise in health maintenance organization penetration especially in California where health maintenance organization enrollment doubled and penetration increased from 30.7% to 53.5% between January 1, 1990, and December 31, 2000 (Bryan Brandt, oral communication, February 5, 2003). Third, increased attention has been placed on medical errors, safety, and quality of care since the Institute of Medicine reported in 1999 that 98 000 people died of medical errors.[1]

The explicit effects of these external pressures on inpatient surgery in California have been minimally addressed. Specifically, little is known regarding either the changes in inpatient surgery over the last decade or the current status of inpatient surgery at a population level. Changes in the age, comorbidity, volume, and outcomes of inpatient operations at a population level have not been reported. In a health care era that is focused on both quality and financing, broad population-level evaluations are increasingly important in the assessment of surgery.

The goals of our study were to use population-level data to clarify and to identify important trends with respect to operative volume, patient characteristics, and in-hospital outcomes for 3 areas in surgery: general, vascular, and cardiothoracic surgery. We specifically address the following 3 questions: (1) What is the overall volume of inpatient surgery for these 3 specialties? (2) What are the characteristics (ie, age and level of comorbid disease) of the patients undergoing surgery? (3) Have the outcomes improved over time? The answers to these questions will offer insight toward characterizing the present state of inpatient general, vascular, and cardiothoracic surgery in California.

METHODS

DATA SOURCE

Data for all hospitalizations in California from January 1, 1990, through December 31, 2000, were obtained from California's Office of Statewide Health Planning and Development, Sacramento. The Office of Statewide Health Planning and Development's database includes discharge abstracts from all 503 nonfederal hospitals throughout California and is compiled annually. Each discharge abstract contains information regarding the hospitalization, including codes for up to 20 inpatient procedures and 24 diagnoses per hospitalization. All procedures and diagnoses are categorized using the *International Classification of Diseases, Ninth Revision, Clinical Modification* coding scheme.

SELECTION OF PROCEDURES

A list of candidate procedures was generated based on the 1996 National Hospital Discharge Survey and the National Survey of Ambulatory Surgery. The National Hospital Discharge Survey and National Survey of Ambulatory Surgery are high-quality sources for inpatient and outpatient procedure data based on a random sample of hospitals and ambulatory surgery centers in the United States. The method and accuracy of these surveys have been described previously.[2]

From the most recent available National Hospital Discharge Survey and National Survey of Ambulatory Surgery data, we selected all general, vascular, and cardiothoracic surgical procedures that were performed on an inpatient basis at least 90% of the time. As such, operations that were performed on an outpatient basis more than 10% of the time were excluded to avoid potential biases on inpatient volume as a result of secular trends in shifting operations to ambulatory settings (eg, laparoscopic cholecystectomy). From this candidate list, nonspecific procedures were eliminated (eg, other repair of intestine). Likewise, surgical procedures that are obviously inpatient but sampled without sufficient frequency on the national survey were added (eg, Whipple procedure). Cases were analyzed based on the primary procedure code. The primary procedure refers to the definitive operation most relevant to the hospitalization and most significant in terms of risk. The final list of operations and their associated *International Classification of Diseases, Ninth Revision, Clinical Modification* codes is given in **Table 1**.

Table 1. ***International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)*** **Procedure Codes**

Surgical Procedure	*ICD-9-CM* Procedure Code
Adrenalectomy	7.2, 7.3
Aortic surgery	38.34, 38.44, 38.64, 39.25
Appendectomy	47.0
Biliary surgery	51.3-51.5, 51.7
Cardiac valve	35.1, 35.2
Carotid endarterectomy	38.12, 38.32, 38.42
Colon resection	45.7, 45.8
Coronary bypass	36.1
Esophagectomy	42.4
Extremity bypass	39.29
Gastrectomy	43.5-43.9
Gastric bypass	44.31
Gastroenterostomy	44.39
Liver resection	50.22, 50.3
Liver transplantation	50.5
Lung resection	32.3-32.5
Lysis of adhesions	54.5
Nissen fundoplication	44.66
Open liver biopsy	50.12
Pancreatic resection	52.5, 52.7
Parathyroidectomy	6.8
Pleurectomy	34.5
Pyloromyotomy	43.3
Pyloroplasty	44.29
Rectal resection	48.4-48.6
Renal transplantation	55.6
Repair VSD/ASD	35.5-35.7
Small-bowel resection	45.6
Splenectomy	41.5
Thyroidectomy	6.2-6.4
Ulcer surgery	44.41, 44.42
Vagotomy	44.0

Abbreviations: ASD, atrial septal defect; VSD, ventricular septal defect.

DATA ANALYSIS

All patients undergoing an inpatient surgical procedure between January 1, 1990, and December 31, 2000, who met our inclusion criteria were identified. Age, sex, comorbidity, length of hospital stay (LOS), and in-hospital mortality data were obtained. Patient comorbidity was graded according to the adaptation of the Charlson Index[3] by Deyo et al[4] and D'Hoove et al.[5] The Charlson Index is a validated tool that correlates comorbidity with risk of death. By convention, it is commonly used for risk adjustment in administrative data. Length of hospital stay, age, and in-hospital mortality data were calculated and reported for each surgical procedure.

Tests for mortality trends were performed using linear regression. A log transformation was performed on the mortality rate and then fitted to a regression line with time (year) as the independent variable. Statistically significant regression lines ($P<.05$) with a nonzero slope indicate changes in mortality over time.[6] Differences in the Charlson Index, age, and LOS were determined using the nonparametric Wilcoxon rank sum test for discrete, ordered variables. Tests were considered significant if they had a 2-sided P value less than .05. All statistical computations were performed using SAS Version 8.01 (SAS Institute, Cary, NC).

RESULTS

PROCEDURAL VOLUME

Thirty-two separate surgical procedures fulfilled the inclusion criteria. A total of 1.64 million patients underwent 1 of the 32 surgical procedures between January 1, 1990, and December 31, 2000, and were included in the analysis. There was a 20.4% increase in the number of surgical procedures performed, from 135 795 in 1990 to 163 468 in 2000. Of the 32 surgical procedures, 21 (65.6%) increased in volume while 11 (34.4%) decreased in vol-

Table 2. Number of Surgical Procedures Performed (1990-2000) by Operation

Surgical Procedure	Study Year 1990	1992	1994	1996	1998	2000	% Change
Adrenalectomy	271	250	265	309	346	358	32
Abdominal aortic surgery	5651	5295	5068	5041	4890	4307	−24
Appendectomy	31 442	32 115	31 536	31 428	32 790	36 706	17
Biliary surgery	1636	1558	1388	1234	1067	972	−41
Cardiac valve	5660	6152	6179	6900	8003	8327	47
Carotid endarterectomy	6627	8472	8942	11 468	11 564	11 047	67
Colon resection	16 796	17 638	17 424	18 045	18 764	19 480	16
Coronary bypass	22 738	24 462	25 295	28 752	28 085	27 579	21
Esophagectomy	230	255	255	291	290	330	43
Extremity bypass	6421	6014	6395	6634	6984	6508	1
Gastrectomy	2751	2537	2444	2210	2073	2271	−17
Gastric bypass	149	377	626	1101	2840	6281	4115
Gastroenterostomy	791	764	808	730	766	870	10
Liver resection	457	481	487	482	497	625	37
Liver transplantation	333	517	556	586	551	571	71
Lung resection	4043	3905	3719	3723	3704	3660	−9
Lysis of adhesions	6220	6066	5981	6084	6023	5658	−9
Nissen fundoplication	952	1219	1594	2224	2729	3411	258
Open liver biopsy	406	396	361	335	342	323	−20
Pancreatic resection	545	604	667	673	725	871	60
Parathyroidectomy	1073	1094	1280	1514	1376	1259	17
Pleurectomy	526	655	762	821	1017	1197	128
Pyloromyotomy	1106	973	882	1191	1036	1059	−4
Pyloroplasty	462	390	365	318	307	283	−39
Rectal resection	2697	2706	2678	2975	3259	3407	26
Renal transplantation	1260	1205	1304	1386	1556	1590	26
Repair VSD/ASD	1032	1175	1321	1255	1196	1263	22
Small-bowel resection	3879	4137	4144	4286	4238	4319	11
Splenectomy	2167	2070	2013	1828	1763	1744	−20
Thyroidectomy	5274	5378	4980	5031	5181	5739	9
Ulcer surgery	1469	1396	1560	1325	1286	1278	−13
Vagotomy	731	632	554	306	240	175	−76
Total Operations	**135 795**	**140 888**	**141 833**	**150 486**	**155 488**	**163 468**	20.4

Abbreviations: ASD, atrial septal defect; VSD, ventricular septal defect.

ume (**Table 2**). The 5 operations having the largest percentage of growth were gastric bypass for obesity (+4115%), gastric fundoplication (+258%), pleurectomy (+128%), liver transplantation (+71%), and carotid endarterectomy (+67%). The 5 operations showing the largest percentage of decrease were vagotomy (−76%), biliary surgery (−41%), pyloroplasty (−39%), abdominal aortic surgery (−24%), and open liver biopsy (−20%).

The total number of operations (vagotomy, pyloroplasty, and ulcer surgery) performed for ulcerative disease decreased from 2662 in 1990 to 1736 in 2000. The percentage of cases performed on an urgent basis increased from 87.7% in 1990 to 92.7% in 2000. Although the proportion of urgent cases increased, the total number of urgent operations for ulcerative disease decreased 31% from 2335 in 1990 to 1610 in 2000. Likewise, the total number of nonurgent cases decreased 61% from 327 in 1990 to 126 in 2000.

PATIENT CHARACTERISTICS

The median age of patients undergoing a surgical procedure in 2000 was older than in 1990. Of the 32 surgical procedures, 21 operations (65.6%) were performed on older patients in 2000 compared with 1990 (**Table 3**). There were no statistical differences in age between 1990 and 2000 for 8 of the surgical procedures. Only 3 surgical procedures (9.4%) were performed on younger patients in 2000 compared with 1990. Between 1990 and 2000, the level of coexistent disease (ie, the Charlson Index) for patients undergoing 26 of the surgical procedures changed significantly. Of these 26 surgical procedures, 22 had patients with a higher Charlson Index (ie, more comorbidity) in 2000 vs 1990 (Table 3). Furthermore, the percentage of patients with chronic lung disease increased from 9.7% to 12.6% ($P<.001$), the percentage of patients with prior myocardial infarction or congestive heart failure increased from 10.1% to 12.3% ($P<.003$), and the percentage of patients with diabetes mellitus increased from 8.6% to 15.4% ($P<.001$).

MAIN OUTCOME MEASURES

Despite the overall shift toward older and sicker patients, LOS decreased between 1990 and 2000 (Table 3). For all operations, both the mean and the median LOS were shorter in 2000 than in 1990 ($P<.05$ for all operations). The largest decreases in LOS were seen for Nissen fundoplication (−12.8 days), pancreatic resec-

Table 3. Mean Charlson Index, Age, and Length of Hospital Stay (LOS) by Operation

Surgical Procedure	Charlson Index 1990	Charlson Index 2000	Age, y 1990	Age, y 2000	LOS, d* 1990	LOS, d* 2000*
Adrenalectomy	1.89	1.75	45.5	46.4	9.0	5.9
Abdominal aortic surgery	1.44	1.57†	67.0	68.0†	11.5	9.3
Appendectomy	0.05	0.10†	27.3	29.0†	4.2	3.1
Biliary surgery	2.79	2.49†	64.6	60.3†	14.0	11.0
Cardiac valve	0.85	0.99†	62.7	63.2†	15.2	10.7
Carotid endarterectomy	1.59	1.73†	70.1	72.3†	5.0	2.8
Colon resection	2.77	2.67†	65.0	64.6†	12.8	10.2
Coronary bypass	0.87	1.15†	65.0	66.1†	11.6	8.6
Esophagectomy	3.99	3.92	60.5	58.5	22.1	17.5
Extremity bypass	1.37	1.46†	69.2	69.9†	10.2	7.3
Gastrectomy	3.42	3.88†	62.5	62.8	16.5	13.2
Gastric bypass	0.24	0.43†	37.6	41.5†	4.0	3.7
Gastroenterostomy	3.51	3.03†	59.1	56.9†	16.4	12.0
Liver resection	3.54	4.15†	49.3	54.2†	12.5	9.1
Liver transplantation	3.00	3.29†	36.8	43.8†	35.0	30.8
Lung resection	3.82	4.00†	61.6	63.3†	11.1	8.6
Lysis of adhesions	0.66	0.85†	51.8	55.4†	10.1	9.0
Nissen fundoplication	0.18	0.20†	22.2	40.9†	18.6	5.8
Open liver biopsy	4.32	4.46	52.2	50.1	13.4	12.2
Pancreatic resection	3.44	4.10†	57.9	59.7	24.9	16.7
Parathyroidectomy	0.62	0.70†	55.6	57.2†	4.6	3.3
Pleurectomy	1.47	1.65†	51.5	53.9†	18.7	14.0
Pyloromyotomy	0.01	0.02	0.2	0.8†	3.4	3.4
Pyloroplasty	1.14	1.32	58.0	57.8	13.9	13.6
Rectal resection	3.50	3.60	62.2	63.0	11.6	8.5
Renal transplantation	2.07	1.60†	40.3	43.5†	14.0	8.1
Repair VSD/ASD	0.21	0.27†	12.8	16.1†	9.6	7.5
Small-bowel resection	1.46	1.49†	54.9	57.2†	16.9	14.2
Splenectomy	0.69	0.85†	40.5	44.6†	10.6	8.2
Thyroidectomy	0.98	1.24†	45.8	48.4†	2.5	1.8
Ulcer surgery	1.34	1.75†	63.6	64.0	13.5	12.1
Vagotomy	1.08	1.50†	56.7	62.7†	13.0	10.7

Abbreviations: ASD, atrial septal defect; VSD, ventricular septal defect.
*Length of hospital stay uniformly decreased between 1990 and 2000 with $P<.05$ for all operations using the Wilcoxon rank sum test.
†$P<.05$ for difference by the Wilcoxon rank sum test.

tion (−8.2 days), renal transplantation (−6.0 days), pleurectomy (−4.7 days), and esophagectomy (−4.5 days).

Between 1990 and 2000, the crude in-hospital mortality decreased from 3.90% to 2.75% ($P<.001$). However, since the crude mortality can be biased by secular shifts in the types of surgical procedures performed (ie, more low-risk operations), the adjusted in-hospital mortality controlling for type of operation was computed. The overall, adjusted in-hospital mortality (relative to a 1990 case mix) decreased from 3.90% to 2.58% ($P<.001$). When examining specific surgical procedures, 18 demonstrated significant trends in mortality over the last 10 years. Of these, 17 (94.4%) had decreasing mortality and only 1 had increasing mortality (**Table 4**). Although the mortality rates of the other 14 operations may have changed, the trends were not statistically significant. The most significant reductions in the rate of in-hospital mortality occurred for gastric fundoplication (−63.2%), pancreatic resection (−56.9%), liver resection (−56.9%), carotid endarterectomy (−51.2%), and esophagectomy (−47.7%).

COMMENT

This population-based analysis of inpatient surgery in California shows that the number of inpatient general, vascular, and cardiothoracic surgical procedures increased 20.4% over the last decade. The specific findings provide an accurate characterization of inpatient surgery throughout the state. Because of the large sample size and the inclusion of all California hospitals, the findings are more representative than smaller, institution-specific case series. Our population-based study yielded 3 major findings.

First, the volume and rate of surgery is increasing. The 20.4% increase in operative volume exceeds the rate of population growth in California, which increased 13.8% between 1990 and 2000.[7] This is especially concerning as we enter an era of potential physician shortage and declining medical student interest in general surgery.[8,9] This suggests that the workload for surgeons will increase significantly in the future, especially if the rates

Table 4. In-Hospital Mortality Overall and by Operation (1990-2000)

Surgical Procedure	Study Year 1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Adrenalectomy	1.1	1.6	1.6	0.4	1.5	2.2	1.0	0.3	0.9	1.2	1.7
Abdominal aortic surgery*	11.7	10.1	10.7	9.9	9.4	9.5	8.8	9.8	10.3	9.6	8.8
Appendectomy	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Biliary surgery*	6.5	5.4	4.5	4.4	5.4	5.2	4.6	5.0	4.2	3.5	4.1
Cardiac valve*	8.0	6.6	7.1	6.1	5.7	6.1	6.7	6.2	5.8	5.7	5.9
Carotid endarterectomy*	1.2	1.0	1.0	0.9	0.9	0.6	0.7	0.6	0.6	0.7	0.6
Colon resection*	5.3	5.3	5.1	5.3	4.9	4.8	4.4	4.7	4.9	4.7	5.0
Coronary bypass*	3.9	4.0	3.5	3.5	3.4	3.2	2.9	3.1	2.8	2.9	2.8
Esophagectomy*	13.9	14.6	12.2	7.9	10.2	5.6	11.0	6.9	6.9	7.6	7.3
Extremity bypass*	3.0	2.9	3.2	2.4	2.3	2.5	2.2	2.0	2.4	1.9	2.5
Gastrectomy*	8.6	8.0	9.1	8.5	7.0	7.1	6.7	7.6	6.9	7.9	6.2
Gastric bypass	0.7	0.0	0.3	0.0	0.0	0.2	0.1	0.1	0.2	0.3	0.2
Gastroenterostomy	9.7	7.1	8.0	5.2	7.7	6.5	8.6	6.5	6.5	6.3	6.4
Liver resection*	13.4	11.3	11.6	6.8	10.5	9.6	8.1	6.0	4.8	4.0	5.8
Liver transplantation	13.5	8.9	9.3	12.1	7.2	7.7	9.0	7.9	7.4	10.6	8.1
Lung resection*	4.8	4.3	3.6	4.1	3.5	3.4	3.3	3.5	4.1	3.3	3.1
Lysis of adhesions	3.2	2.9	2.8	3.1	3.0	3.2	2.8	3.0	3.2	3.4	2.8
Nissen fundoplication*	1.0	1.3	0.6	0.6	1.0	1.0	0.5	0.4	0.4	0.3	0.4
Open liver biopsy*	11.8	12.7	11.1	12.5	11.6	9.6	7.8	10.0	9.1	10.0	9.9
Pancreatic resection*	10.6	7.8	7.1	8.3	8.1	5.9	7.0	7.4	5.4	6.3	4.6
Parathyroidectomy	0.2	0.5	0.3	0.6	0.6	0.7	0.3	0.5	0.3	0.3	0.3
Pleurectomy	4.2	5.1	6.6	4.1	4.6	5.7	4.4	4.7	5.7	4.7	5.4
Pyloromyotomy	0.2	0.1	0.1	0.2	0.1	0.0	0.1	0.1	0.1	0.0	0.2
Pyloroplasty	8.2	8.1	12.8	8.4	10.7	5.2	12.9	9.8	7.2	9.4	9.5
Rectal resection*	2.3	1.7	2.0	1.9	1.8	1.9	2.1	1.8	1.7	1.6	1.7
Renal transplantation	1.4	0.8	1.0	1.0	0.3	0.9	0.8	0.8	1.0	1.1	0.4
Repair VSD/ASD*	4.9	5.4	4.2	3.8	3.6	3.5	2.9	3.1	2.6	2.9	2.8
Small-bowel resection*	10.3	10.2	9.2	9.8	8.5	8.4	8.1	9.3	9.2	8.3	8.9
Splenectomy	6.7	8.3	6.6	7.1	7.3	7.2	6.9	6.7	6.4	6.2	6.8
Thyroidectomy	0.2	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.1
Ulcer surgery	15.9	16.4	16.1	15.1	15.5	13.8	15.3	16.1	14.5	15.7	15.1
Vagotomy*	6.4	5.7	4.4	5.9	6.3	8.0	3.9	8.7	7.1	10.8	11.4
Overall mortality*	3.90	3.67	3.53	3.44	3.26	3.09	2.94	3.04	2.96	2.86	2.75
Adjusted mortality*†	3.90	3.63	3.45	3.39	3.18	3.01	2.78	2.89	2.78	2.69	2.58

Abbreviations: ASD, atrial septal defect; VSD, ventricular septal defect.
*$P<.05$ for trend. Data are given as percentages.
†Value adjusted for operative caseload relative to 1990.

of surgical procedures continue to rise. The exact effects of increasing operative volume on the surgical workforce will need to be investigated.

However, not all surgical procedures increased in volume. Several general surgical procedures experienced marked decreases in volume over the last 10 years. Between 1990 and 2000, there were significant declines in the number of biliary (eg, common bile duct exploration) and peptic ulcer operations. For example, both the number of urgent and nonurgent operations for peptic ulcer disease (eg, vagotomy, pyloroplasty, and ulcer surgery) decreased 31% and 61%, respectively. Although a definitive causal effect is difficult to establish, it is likely that these operations have been supplanted by more advanced medical therapies (eg, proton pump inhibitors) or less-invasive technology (eg, endoscopy or endoscopic retrograde cholangiopancreatography). So, as the use of medical therapy has increased and been proven effective, fewer patients need ulcer-related surgery. Of the patients who do require surgery, these data demonstrate that most are performed on an urgent basis. These findings support the notion that medical therapy has decreased the need for ulcer surgery and that surgery is reserved for treatment failures that are usually performed on an urgent basis.

Advances in technology and surgical technique have also led to enormous increases in the number of gastric bypass (for obesity) operations and gastric fundoplications (eg, Nissen). The development of advanced laparoscopic techniques has certainly played a role in the proliferation of these 2 operations. The empirical evidence examining the use of laparoscopic cholecystectomy supports this notion. Escarce et al[10] showed that the dissemination of laparoscopy both lowered the threshold and increased the rate of cholecystectomy.

A second important finding in our study is that the surgical patients were older and had more coexistent disease in 2000 compared with surgical patients in 1990. This is not an unexpected finding considering the aging of the population and the ability of technology to make surgery safer for older and sicker individuals. However, as the reporting of clinical outcomes increase, it is imperative that these reporting systems adjust for patient comorbidities and risks—otherwise, the validity of the reports, both to the patients and health care providers, will be tainted. Research following the release of the New York Cardiac Surgery Reporting System indicated a reluctance of some surgeons to operate on poor-risk patients.[11,12] To prevent this from happening, it is imperative that surgeons remain committed and involved with developing and maintaining an accurate system of reporting.

Third, even with patients who were older and who had more comorbid conditions, we found that the outcomes of surgery (ie, LOS and in-hospital mortality) improved over the last 10 years. Although in-hospital mortality is only 1 of many possible indicators of quality, its decline over the last 10 years is a notable accomplishment. However, further outcomes assessment should be expanded to include not only in-hospital mortality but also to address specific aspects of perioperative care using process quality indicators. Process quality refers to specific actions or treatments provided to patients that may influence a patient's outcome such as giving preoperative antibiotics, starting prophylaxis therapy for deep venous thrombosis, or using an incentive spirometer. Incorporation of a broader range of measures may provide a more accurate assessment of the overall quality of surgical care.

Although this population-based analysis of inpatient surgery has yielded many significant findings, there are several limitations. First, the Office of Statewide Health Planning and Development data only collects inpatient information so the outpatient component of surgery cannot be assessed. Although the rate of inpatient surgical procedures has increased, it is unlikely that outpatient operations are decreasing. Rather, it is more likely that both inpatient and outpatient surgical procedures are increasing together. Second, patients were selected based on an a priori list of inpatient surgical procedures. While this list is comprehensive, surgical procedures that were categorized under more obscure primary procedure codes may not have been captured. However, any omissions would only lead to an underestimation of the total volume of inpatient surgical procedures. Despite these inherent limitations, these discharge data are well suited for evaluating population-level trends and outcomes.

Overall, these analyses have identified the major trends for inpatient surgery in California between January 1, 1990, and December 31, 2000. During this period, operative volume has increased significantly, patients tended to be older and have more comorbidities, and postoperative in-hospital mortality and LOS improved. While these findings indicate that the quality of care for general, vascular, and cardiothoracic surgery patients is improving, continued evaluations at the population level will be needed.

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DISCUSSION

Michael J. Stamos, MD, Torrance, Calif: You have used a seemingly powerful database to provide information that corroborates what we believe to be true, namely, that we are seeing more patients, sicker patients, and performing more operations. Do you have any data on the number of surgeons or the trend in the number of surgeons in California to further validate this impression?

My second question would be whether similar databases exist in other states or nationwide? If these trends could be substantiated on a nationwide basis, this would have a much more profound influence on plans for adequate numbers of surgeons to train. Next, can you share with us even preliminary data on the outcomes of emergency vs elective cases? Most notably in your LOS and mortality data, this information would be vital to adequately interpret the information. For example, you show a mortality of 8.8% for aortic surgery with an LOS of 9.3 days, and a mortality of 5.0% and an LOS of 10.2 days for colon resection. Presumably these data reflect a fairly large proportion of emergency operations. On the other hand, your data on pancreatic resections and esophagectomies almost certainly are made up of a preponderance of elective cases, and the mortality in those groups are still substantially above benchmark data reported by "centers of excellence." Since most surgeons do not have audited results from their own practice, they must rely on mortality figures from large published series when providing informed consent to patients. If your data were presented exclusive of emergency operations and it still showed a substantially higher mortality and LOS than are commonly relied on, this would be of significant importance and concern. Along those same lines, does your database allow you to break out the mortality and LOS data between high-volume hospitals and low-volume hospitals? Ultimately, this type of data would be extremely useful for improving overall quality of care if we can use it to recognize the factors, which produce an apparent heterogenous experience.

Julie Freischlag, MD, Baltimore, Md: I enjoyed these data as well, and my question was to ask not only how we are going to plan training for physicians but also in building institutions? I just came from UCLA [University of California, Los Angeles] where we are building a new hospital, and [Johns] Hopkins [Baltimore, Md] is going to be embarking on a huge building program. We were at a meeting last week talking about how much inpatient and how much outpatient facility to build, how to anticipate inpatient vs outpatient needs, and many people believe that the number of inpatient operations are going to continue to go down as the patients' numbers will go down, and this article seems to tell us exactly the opposite. So my question is how should we use these data for our buildings that are going to have to be built in the next 10 to 15 years.

Clifford W. Deveney, MD, Portland, Ore: Did you do any analysis on population demographics in California? That is, did the increase in the number of operations increase with an increase in population? Did the population age change during this time? If not, if the population is stable and the age is stable, then it reflects a change in our approach to things. Are we operating on older and sicker persons, or are these data simply a reflection that the population itself is becoming older and a little frailer?

Stanley R. Klein, MD, Torrance: I rise to echo what the authors have pointed out. This is an inpatient database. I would like the authors to address the unknown, but important, component of patient care in transitional units. When you include both the present day inpatient and transitional unit care, is it equivalent to the total inpatient days in bygone eras?

Daniel R. Margulies, MD, Los Angeles, Calif: I can understand why a number of the other operations increased, but the absolute value of appendectomies increased significantly, and I was wondering if this increase is above the percentage population increase and, if not, what is the reason for this? Could it be the use of laparoscopy or something else, because I cannot imaging the disease process has changed in this time frame?

Thomas R. Russell, MD, Chicago, Ill: As Dr Hiyama comes up, many of the increases in operations deal with lifestyle issues, like a 240% increase in obesity, and the 258% increase in Nissen fundoplications.

Dr Hiyama: In response to Dr Stamos' question regarding the number of surgeons with the trend in the number of surgeons in California, we actually did not, for this database, have specific numbers or any provider identification data. We do have other databases that we can subsequently link with this database to look at that. If you want to look or extrapolate from some physician workforce study data and taking general surgeons as an example, there are about 20 000 general surgeons in the United States, and that number has remained relatively stable, even with the influx of about 500 new graduates each year. In addition, if you want to look at the State of California in particular, if you look at our ratio of general surgeons to the population, a ratio of surgeon to 100 000 per population, ours was about 5.8, which is one of the lowest in the country. So given that the population of this state has probably increased by about 12% over that time, you can see that we probably, indeed, are seeing more patients and we perform more operations.

To address Dr Stamos' second question about the existence of similar databases in other states, yes, other states do have similar databases. The data set that we used, the Office of Statewide Health Planning and Development data, is an all-inclusive one for California. There are high-quality data sets available for a national sampling, but these are, indeed, samples for about 20% of the population. And interestingly, much of the data that comes into those sampling datasets are from California. When you compare the results of this study against the national data sets, excluding the increase in the gastric bypass operations, the trends identified in our study correlate well with those observed in the national sampling.

In response to Dr Stamos' question about segregating emergency and elective cases, the coding of the cases does allow us to discern the elective or the emergent nature of the case. We did look at this aspect for some selected diagnoses but not for all of them. Clearly, we all realize that the acuity of the case does have an effect on outcome. For example, a colorectal surgeon, Dr Stamos, someone coming in with an emergency colorectal operation has a much higher LOS and a higher likelihood of inpatient mortality. Clearly, the mortality and overall patient outcomes are improving, but they are still worse for an acute case as opposed to an emergency case. Maybe I should reemphasize that this is really a first-look study if you want to envision from 30 000 ft, and we are now starting to look at specific types of surgical procedures as well as the individual procedures in our work.

This sort of leads into the last issue that Dr Stamos brought up about the issue of high- and low-volume hospitals. This is not something really that we examined with this current study. On a number of previously reported studies, these data concluded that patient outcomes, particularly for more complex operations, are better when the care is delivered in a high-volume institution, but our previous work really indicates that other variables have a much greater impact on outcome, those variables such as acuity of the situation and comorbidities.

This fact would really suggest to us that perhaps it is not so much that the cases should be referred to single institutions but rather to develop systems and practices that really enable individual surgeons to enhance and improve their care so that even in a low- or high-volume institution, whatever it may be, that they can provide a high-quality, safe, and evidence-based level of care.

To address Dr Freischlag's question about how to use such data for the planning of capital projects, this is again just a first-look study. So I do not know what to tell you, and we do not have right now the other half, which is the outpatient numbers. These are purely inpatient numbers. I think you would have to put inpatient and outpatient together to really get an idea of what the trends are going to be.

Dr Klein, regarding your question about these data, we really did not have that data with this particular review. We can go back and look at it and figure out which the discharge institution was but we did not look at it here.

Dr Margulies, regarding your question about the number of appendectomies, the overall population increase for the decade was about 12%, but the number of operations is increasing in excess of that 12% rate, so part of the increase in the number of appendectomies may also be a difference in the makeup of the population.