Sustainability and Success of the Acute Care Surgery Model in the Nontrauma Setting

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BACKGROUND: The use of an acute care surgical model has been shown to improve patient care and efficiency. We propose that it is possible to apply this model to emergency general surgery patients at a nontrauma hospital. With this acute care surgery service, no change in the quality of care will occur, and improvements in quality, cost, and outcomes may be achieved and sustained.

STUDY DESIGN: A retrospective review was performed of all emergency surgery operations performed at a tertiary referral community hospital without a trauma service. Data were collected from 1 year before and each year up to 4 years after the implementation of an acute care surgical (ACS) service.

RESULTS: There were fewer overall complications with ACS (21% to 12%, $p < 0.0001$), and a shorter length of stay (6.5 days to 5.7 days, $p = 0.0016$). Hospital costs fell from $12,009 to $8,306 ($p < 0.0001$). Post-appendectomy complications decreased (13% to 3.7%, $p < 0.0001$), length of stay was shorter (3.0 to 2.3 days, $p < 0.0001$), and hospital costs decreased from $9,392 to $5,872 ($p < 0.0001$). Post-cholecystectomy complications decreased (21% to 9%, $p = 0.012$), length of stay was shorter (5.3 to 3.8 days, $p = 0.0004$), and hospital costs decreased from $12,526 to $9,348 ($p < 0.0001$).

CONCLUSIONS: An acute care surgery service can be successfully implemented at a nontrauma hospital. The improvements seen in outcomes and finances are sustainable over time. This sort of coordinated, consistent care is successful and allows alignment of the goals of surgeons, hospitals, and patients. (J Am Coll Surg 2014;■:1−9. © 2014 by the American College of Surgeons)

Emergency surgical coverage and associated access to care has been an ongoing concern over the past decade.[1-3] In the discussion of solutions to this problem, the "Acute Care Surgery" model has gained acceptance. This term, coined during the debates over the future of trauma care,[4] and modeled at trauma centers over the last 3 decades,[1,2] combines aspects of trauma, critical care, emergency general surgery, and elective general surgery in order to use the capacity and capabilities of referral centers to address the growing need for emergency general surgery coverage.

Multiple models of acute care surgery have been developed.[5] In many instances, emergency surgery care has been incorporated into trauma programs to create a model of acute care surgery that uses the structure of trauma services to provide care for emergency general surgery patients. This provides acutely ill surgical patients with physicians who are specifically trained to care for them, increases the caseload of trauma surgeons, and better uses the resources available at trauma centers. This has resulted in improvements in the care of emergency surgical patients: decreasing time to operation,[6-9] decreasing time to consult,[6,9,10] and decreasing length of stay.[8,9,11] Acute care surgery models are associated with decreased complications,[9,11] decreased cost,[9] improved surgeon satisfaction,[3] more off-hours care,[8,11] and improved surgeon availability.[12] At many of these programs, the emergency general surgery service is separate from the rest of the trauma service and stands as an independent product line.[12-14] The segregation of emergency general surgery

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from trauma surgery has shown that the 2 can stand together and function as independent entities.

This has led to the application of the acute care surgery model to emergency general surgery at nontrauma centers.[6,8] This model has been successful, showing similar outcomes to the previous models of emergency surgery coverage, with the acute care model functioning no worse, and often better, than traditional models of call coverage and coverage panels.[4,6,11] This has led to the question of how the patients are best served, whether by a service dedicated to the care of the emergency surgical patient, or by an individual surgeon dedicated to the care of the single patient.[15] We propose that it is possible to take the "service model" developed for the care of the trauma patient, and apply it to emergency general surgery patients. With this acute care surgery service, no change in the quality of care will occur, and improvements in quality, cost, and outcomes may be achieved and sustained.

METHODS

We undertook a retrospective review of all emergency surgery operations performed at a single institution before and after implementation of an acute care surgical service.

Table 1. Complications Included in Analysis

Category	Specific complications	Category	Specific complications
Biliary	Bile leak Biloma Common bile duct injury Retained common bile duct stone	Medication	Allergic reaction – hives Medication overdose
Bleeding/Coagulation	Arterial thrombosis Deep venous thrombosis Disseminated intravascular coagulation Intra-abdominal bleeding Postoperative coagulopathy with bleeding Pulmonary embolism Thrombocytopenia Wound site bleeding	Neurologic	Cerebral vascular infarct Hepatic encephalopathy
Cardiac	Arrhythmia Cardiac arrest/asystole Congestive heart failure Exacerbation Hypertensive episode, acute myocardial infarction	Pulmonary	Acute respiratory distress syndrome Acute respiratory failure Aspiration event Hypoxia Pneumothorax Pulmonary edema Respiratory arrest Stridor/bronchospasm
Gastrointestinal	Diarrhea (unspecified) Enterocutaneous fistula Gastrointestinal bleeding Hepatic failure Pancreatic pseudocyst Pancreatitis Peptic ulcer Perforation/leak of anastamosis Prolonged ileus Small bowel infarction Small bowel obstruction	Renal/electrolyte/fluids	Acute renal failure Gout exacerbation Urinary retention
Infectious	Bacterial peritonitis Cellulitis *Clostridium difficile* infection Disseminated zoster Intra-abdominal abscess Liver abscess Pneumonia Sepsis Soft tissue abscess Thrush Urinary tract infection Wound infection	Wound	Abdominal compartment syndrome Dehiscence Failure of hernia repair Negative laparotomy Wound necrosis

This study was approved by the Sutter Health Central Area Institutional Review Committee.

The year 2007 was used as a control. In that year, 9 general surgeons constituted the "call panel" and covered call on a rotating basis as part of medical staff requirements, each covering 24 consecutive hours of consults. Surgeons were paid a stipend by the hospital for this coverage. Patients evaluated by a surgeon during this time period were maintained in that surgeon's practice and cared for by that surgeon and his or her partners. Critical care of these patients was shared by the surgeon and a consulting pulmonary critical care service. Surgeons were required to evaluate all emergency and inpatient consults, with definitive therapy left to the clinical judgment of the surgeon.

The acute care surgery service was instituted on January 1, 2008, and the years 2008 through 2011 were compared with the control year of 2007. This service consisted of 4 principal general surgeons, all board certified in general surgery, and 2 with additional certification in surgical critical care. These surgeons covered the acute care surgery service in 24-hour rotations, provided all patient care, evaluated all consults, covered the outpatient clinic, and performed all operations and procedures for the service during their hours of coverage. Surgeons were paid a salary with incentive bonuses. The hospital contracted with an independent group for this coverage. The surgeons were assisted during their 24-hour rotation by a nurse practitioner or physician assistant. These midlevel providers worked in blocks of 4 to 6 days, covering the service during the day, providing assistance in the outpatient clinic, and taking call during the day and at night to assist the surgeon during any procedures or operations. Surgeons participated in face-to-face transfer of patients at the beginning and end of each 24-hour shift. The midlevel providers were present for and participated in the daily patient transfer, providing day-to-day continuity. Primary critical care was provided by the acute care surgeons with consultation from the same pulmonary critical care service as was present before the acute care service was put into place. Critical care coverage and billing by the acute care surgeons was done only in situations in which direct critical care time was spent with the patient. The majority of critical care was provided by the consultant pulmonary critical care service. The acute care surgeons did not consult on patients for critical care in isolation, but only to evaluate a patient for surgical need. The acute care surgeons were required to evaluate all emergency and inpatient consults, providing definitive operative or nonoperative care as was defined by management guidelines agreed on by the group. Patients who required ongoing outpatient care beyond the normal postoperative evaluations were referred to 1 of 9 elective general surgeons based on specialty need, insurance coverage, and availability. In the rare case that a patient could not be seen by one of these providers, the acute

Table 2. Operation Distribution, Acuity, and Outcomes Measures, All Patients

Variable	Pre-ACS	ACS-1	ACS-2	ACS-3	ACS-4	p Value
Total operations, n	497	656	639	699	640	
Operation types, n						0.0006*
Appendectomy	196	201	227	236	218	
Cholecystectomy	178	231	201	212	198	
Laparotomy	74	119	120	133	105	
Drainage/debride	38	69	57	87	74	
Herniorrhaphy	3	18	13	11	12	
Tracheostomy	7	9	4	3	11	
Laparoscopy, other	1	3	8	4	8	
Other	0	15	9	13	14	
Case mix index	1.96 ± 1.80	2.17 ± 2.51	2.25 ± 2.42	2.38 ± 2.57	2.24 ± 2.30	0.047†
Complications, n (%)	105 (21)	120 (18)	78 (12)	74 (11)	75 (12)	<0.0001‡
Reoperations, n (%)	16 (3.2)	42 (6.4)	30 (4.7)	19 (2.7)	33 (5.2)	0.0097*
Readmissions, n (%)	32 (6.4)	37 (5.6)	19 (3.0)	30 (4.3)	30 (4.7)	0.059*
Mortality, n (%)	7 (1.4)	27 (4.1)	10 (1.6)	13 (1.9)	14 (2.2)	0.0082*
Length of stay, d	6.5 ± 9.6	6.0 ± 10.1	5.7 ± 9.0	6.1 ± 8.4	5.9 ± 10.1	0.0016§

*Chi-squared analysis, no linear trend identified, indicating the distribution/proportion varies without an identifiable pattern to the variation.
†One-way ANOVA, pre-ACS was significantly lower than ACS-3 ($p < 0.05$).
‡Chi-squared analysis, with linear trend ($p < 0.0001$), indicating an overall downward trend of complication rate.
§Kruskal-Wallis Test (nonparametric ANOVA), Pre-ACS was significantly longer than ACS-2 and ACS-4 ($p < 0.01$).
ACS, acute care surgery.

care surgery service provided the ongoing outpatient care and follow-up surgery.

Sutter Medical Center Sacramento (SMCS) is a tertiary referral community hospital that is not affiliated with an academic institution and does not have a surgical residency. Trauma referrals are made to a level 2 trauma center in the same system or to a level 1 trauma center less than a mile away. A total of 3 level 2 and 1 level 1 trauma centers provide care for the metropolitan area. No organized trauma care is provided at this facility. Sutter Medical Center Sacramento supports 652 beds on 2 campuses less than a mile apart and evaluates between 60,000 and 75,000 emergency room patients per year.[16]

Data were collected on all emergency and urgent operations performed at SMCS from 2007 to 2011. Charts were reviewed and the operating room and hospital financial records were queried. The hospital financial office provided all cost (direct and indirect) information by patient account number. These costs were calculated by standard internal methods, and the process did not change during the course of the study. Patient acuity was determined using diagnosis-related group (DRG) weight to determine case mix index. The index procedure was identified, defined as the first procedure performed by the acute care surgery service or surgeon covering emergency surgery on the patient for the initial presenting problem. Outcomes data included length of stay, need for readmission, death, complication, need for conversion of laparoscopic procedures, and need for reoperation. Complications were identified by individually reviewing all patient records and the records of the acute care surgery service. Any complication identified in the record or reviewed by the ACS service as part of internal quality evaluation (morbidity and mortality peer review conference) was considered significant. Complications identified are listed in Table 1. Financial data included patient payer, total patient hospital charges, and total hospital costs. Financial data were obtained from the SMCS financial department, using total cost/charges (direct + indirect). Payer source was grouped into private insurance (including managed care), self-pay (no stated insurance, uninsured, county insurance, and charity pay), and government insurance (federal programs including Medicare, Medical or Medicaid, and veterans' benefits).

Cases were grouped by year for analysis to minimize the effect of changes other than the presence of the acute care surgery service. The control year, 2007, is indicated in the analysis as Pre-ACS; the subsequent years, with the acute care surgery service in place, are indicated as ACS-1 for 2008, ACS-2 for 2009, ACS-3 for 2010, and ACS-4 for 2011. Subgroup analyses for patients undergoing appendectomy or cholecystectomy were performed because these were the 2 most commonly performed operations. The effect of the acute care surgery group on the practice of elective surgeons was analyzed by reviewing total numbers of cases performed by the associated elective

Table 3. Financial Measures, All Patients

Variable	Pre-ACS	ACS-1	ACS-2	ACS-3	ACS-4	p Value
Total cases, n	497	656	639	699	640	
Payer source, n (%)						<0.0001*
Private	252 (51)	280 (43)	207 (32)	188 (27)	217 (34)	
Government	193 (39)	277 (42)	296 (46)	357 (51)	309 (48)	
Self-pay	51 (10)	96 (15)	100 (16)	139 (20)	99 (15)	
Unknown	1 (0.2)	3 (0.5)	36 (6)	15 (2)	15 (2)	
Total hospital charges, $	57,130 (14,508−909,489)	59,040 (7,802−1,979,793)	58,874 (16,478−1,562,031)	61,573 (21,191−1,509,368)	60,951 (23,033−1,686,771)	0.0011†
Total hospital cost, $	12,009 (2,175−224,053)	9,986 (2,096−388,608)	10,809 (3,362−369,048)	11,333 (3,864−340,683)	10,685 (3,652−373,517)	0.0001‡
Adjusted hospital charges, $§	57,130 (14,508−909,489)	55,178 (7,292−1,850,274)	51,713 (14,474−1,372,032)	50,545 (17,396−1,239,042)	47,381 (17,905−1,311,243)	<0.0001‖
Adjusted hospital cost, $§	12,009 (2,175−224,053)	9,332 (1,959−363,185)	9,495 (2,954−324,158)	9,303 (3,172−279,667)	8,306 (2,839−290,360)	<0.0001¶

Cost and charge data are presented as median (range).
*Chi-squared analysis, no linear trend identified, indicating the proportions vary without an identifiable trend.
†Kruskal-Wallis Test (nonparametric ANOVA), Pre-ACS was significantly less than ACS-3 ($p < 0.05$).
‡Kruskal-Wallis Test (nonparametric ANOVA), Pre-ACS was significantly greater than ACS-1 ($p < 0.01$) and ACS-1 was significantly less than ACS-3 ($p < 0.001$).
§Adjusted to 2007 dollars based on the hospital and related services portion of the consumer price index.
‖Kruskal-Wallis Test (nonparametric ANOVA), Pre-ACS and ACS-1 were both significantly greater than ACS-4 ($p < 0.001$).
¶Kruskal-Wallis Test (nonparametric ANOVA), Pre-ACS was significantly greater than ACS-1, ACS-2, ACS-3, and ACS-4 ($p < 0.001$).
ACS, acute care surgery.

Table 4. Operation Distribution, Acuity, and Outcomes Measures, Appendectomy

Variable	Pre-ACS	ACS-1	ACS-2	ACS-3	ACS-4	p Value
Total appendectomies, n	196	201	227	236	218	
Laparoscopic, n (%)	166 (85)	165 (82)	224 (99)	235 (99)	216 (99)	<0.0001*
Open, n (%)	30 (15)	36 (18)	3 (1.3)	1 (0.4)	2 (0.9)	
Laparoscopic converted to open, n (%)	13 (6.6)	5 (2.5)	5 (2.2)	5 (2.1)	12 (5.5)	0.014†
Case mix index	1.29 ± 0.62	1.16 ± 0.39	1.31 ± 1.42	1.30 ± 0.97	1.40 ± 1.12	<0.0001‡
Complications, n (%)	25 (13)	14 (7.0)	8 (3.5)	9 (3.8)	8 (3.7)	<0.0001§
Reoperations, n (%)	4 (2.0)	3 (1.5)	2 (0.9)	4 (1.7)	6 (2.8)	0.66†
Readmissions, n (%)	4 (2.0)	6 (3.0)	5 (2.2)	7 (3.0)	8 (3.7)	0.85†
Mortality, n (%)	0	0	1 (0.4)	0	0	N/A
Perforated, n (%)	57 (29)	39 (19)	27 (12)	29 (12)	32 (15)	<0.0001§
Normal, n (%)	6 (3.1)	5 (2.5)	3 (1.3)	12 (5.1)	10 (4.6)	0.16†
Length of stay, d	3.0 ± 3.1	1.9 ± 2.2	1.9 ± 2.1	2.1 ± 3.3	2.3 ± 3.6	<0.0001‖

*Chi-squared analysis, with linear trend ($p < 0.0001$), indicating a decrease in the rate of open appendectomies.
†Chi-squared analysis, no linear trend identified, indicating no difference or trend exists in the proportions identified.
‡Kruskal-Wallis Test (nonparametric ANOVA), ACS-1 was significantly less than ACS-2 ($p < 0.001$).
§Chi-squared analysis, with linear trend ($p < 0.001$), indicating the complication and perforation rates both decrease in a linear fashion.
‖Kruskal-Wallis Test (nonparametric ANOVA), Pre-ACS was significantly longer than ACS-1, ACS-2, ACS-3, and ACS-4 ($p < 0.001$).

surgeons before and after implementation of the service. Relative value units and other financial data for the associated surgeons were not available for analysis.

In the analysis, financial information is presented as actual dollars and as corrected to 2007 dollars based on the hospital and related services portion of the consumer price index.[17] Statistical analysis was done using GraphPad InStat version 3.00 for Windows 95 (GraphPad Software, www.graphpad.com). For continuous variables, a 2-sided *t*-test was used for binary comparisons and ANOVA for comparison of multiple sets. For proportions Fisher's exact test or chi-square analysis was used. Significance was set at $p < 0.05$.

RESULTS

The ACS service saw an increase in the number and acuity of patients (Table 2), as depicted by the increase in case mix index in the later years, rising from 1.96 in the Pre-ACS group, to a peak of 2.38 in ACS-3 ($p = 0.047$). Fewer complications were identified with the ACS service, falling from a rate of 21% Pre-ACS, to 12% in ACS-4 ($p < 0.0001$). This showed a linear trend, with a stepwise decrease in rate of complications. Readmissions showed a downward trend (not significant, $p = 0.059$) with the ACS service, falling from 6.4% Pre-ACS, to 5.6% in ACS-1 and then remaining below 5%. Reoperations did increase with the ACS service, rising from 3.2% Pre-ACS and ranging from 2.7% to 6.4% with the ACS service ($p = 0.0097$). There was a spike in mortality the first year of the ACS service (ACS-1), with mortality rising from 1.4% in Pre-ACS to 4.1% in ACS-1. This was mitigated with continuation of the ACS service, falling to 1.6% in ACS-2, 1.9% in ACS-3, and 2.2% in ACS-4 ($p = 0.0082$). There was no difference between the pre-ACS mortality and mortality in any specific year of the ACS service. When the ACS service years were pooled, the mortality rate was 2.4% (64 of 2,634 patients), not significantly different from pre-ACS ($p = 0.21$). Length of stay decreased, from 6.5 days (median 4 days) Pre-ACS to a low of 5.7 days with the ACS service (median 3 days, ACS-1 through ACS-4, $p = 0.0016$).

The ACS service had a lower percentage of private pay patients and a greater percentage of government pay patients (Table 3). Unadjusted charges saw an increase through the years of this study. Unadjusted cost fell in the first year of the ACS service (ACS-1), then rose again, but never again reached the pre-ACS median total hospital cost. Hospital charges adjusted to 2007 dollars (Pre-ACS) fell from a pre-ACS median of $57,130, to a low in ACS-4 of $47,381 ($p < 0.0001$). In a similar fashion, adjusted total hospital costs fell from a pre-ACS median of $12,009 to a low in ACS-4 of $8,306 ($p < 0.0001$).

Patients undergoing appendectomy were analyzed as a subgroup (Table 4). There was a significant trend with the introduction of the ACS service to an increased proportion of appendectomies completed as laparoscopic cases (this was chosen by the group as their standard method), with fewer operations being converted to open ($p = 0.014$). The ACS service managed patients with increased acuity, evidenced by the increase in case mix index in the later years, rising from 1.29 in the Pre-ACS group to 1.40 in ACS-4 ($p < 0.0001$).

Outcomes after appendectomy for the ACS service were no worse and showed some improvements (Table 4). There were fewer complications with the ACS service,

Table 5. Financial Measures, Appendectomy

Variable	Pre-ACS	ACS-1	ACS-2	ACS-3	ACS-4	p Value
Total appendectomies, n	196	201	227	236	218	
Payer source, n (%)						0.0003*
Private	129 (66)	134 (67)	112 (49)	105 (45)	121 (56)	
Government	45 (23)	40 (20)	69 (30)	88 (37)	69 (32)	
Self-pay	22 (11)	27 (13)	30 (13)	34 (14)	24 (11)	
Unknown	0	0	16 (7.0)	9 (1.8)	4 (1.8)	
Total hospital charges, $	47,801 (22,316–255,308)	46,714 (7,802–253,648)	45,512 (25,219–699,124)	50,520 (23,060–835,573)	48,517 (24,634–664,024)	0.0001†
Total hospital cost, $	9,392 (3,690–49,993)	6,784 (2,096–49,515)	7,108 (4,732–143,642)	7,761 (4,508–172,094)	7,553 (3,652–142,705)	<0.0001‡
Adjusted hospital charges, $§	47,801 (22,316–255,308)	43,658 (7,292–237,054)	40,009 (22,474–614,085)	41,472 (18,930–685,922)	37,716 (19,150–516,191)	<0.0001‖
Adjusted hospital cost, $§	9,392 (3,690–49,993)	6,340 (1,959–46,276)	6,244 (4,156–126,170)	6,371 (3,701–141,272)	5,872 (2,839–110,935)	<0.0001¶

Cost and charge data are presented as median (range).
*Chi-squared analysis, no linear trend identified, indicating the proportions vary without an identifiable trend.
†Kruskal-Wallis Test (nonparametric ANOVA), ACS-3 was significantly greater than Pre-ACS, ACS-1, and ACS-2 ($p < 0.05$).
‡Kruskal-Wallis Test (nonparametric ANOVA), Pre-ACS was significantly greater than ACS-1, ACS-2, and ACS-4 ($p < 0.05$); ACS-1 was significantly less than ACS-3 and ACS-4 ($p < 0.01$); and ACS-2 was significantly less than ACS-3 ($p < 0.01$).
§Adjusted to 2007 dollars based on the hospital and related services portion of the consumer price index.
‖Kruskal-Wallis Test (nonparametric ANOVA), Pre-ACS was significantly greater than ACS-2, ACS-3, and ACS-4 ($p < 0.001$) and ACS-1 was significantly greater than ACS-4 ($p < 0.01$).
¶Kruskal-Wallis Test (nonparametric ANOVA), Pre-ACS was significantly greater than ACS-1, ACS-2, ACS-3, and ACS-4 ($p < 0.001$).
ACS, acute care surgery

falling from a rate of 13% Pre-ACS, to 3.7% in ACS-4 ($p < 0.0001$). Readmissions and reoperations were unchanged with the ACS service. There was 1 mortality associated with an appendectomy during the course of this study (ACS-2). This was in a morbidly obese patient with advanced cirrhosis who presented with perforation and peritonitis. The proportion of perforated appendices at the time of surgery fell with the ACS service, from 29% pre-ACS to 15% by ACS-4 ($p < 0.0001$). The proportion of normal appendices at removal remained 5.1% or less throughout the course of the study, both before and with the ACS service. Length of stay fell with the ACS service, from 3.0 days (median 2 days) Pre-ACS to a low of 1.9 days with the ACS service (median 1 day, ACS-1 through ACS-4, $p < 0.0001$).

There was a trend for the ACS service of having a lower percentage of private pay patients and a greater percentage of government pay patients (Table 5). Unadjusted charges varied through all of the years, without an identifiable pattern. Unadjusted cost fell in the first year of the ACS service (ACS-1), then rose again, but never again reached the pre-ACS median total hospital cost. Hospital charges adjusted to the 2007 dollars (Pre-ACS) fell from a pre-ACS median of $47,801, to a low in ACS-4 of $37,716 ($p < 0.0001$). In a similar fashion, adjusted total hospital costs fell from a pre-ACS median of $9,392 to a low in ACS-4 of $5,872 ($p < 0.0001$).

Patients undergoing cholecystectomy were analyzed as a subgroup (Table 6). The majority of cases were accomplished using laparoscopy. There was no change in the percentage converted to open or in the use of cholangiogram. The ACS service saw no change in acuity, with the case mix index steady through the course of this study.

Cholecystectomy outcomes for the ACS service showed some improvements over pre-ACS (Table 6). There were fewer complications with the ACS service, falling from a rate of 21% Pre-ACS, to a low of 9% in ACS-3 ($p = 0.012$). Readmissions and reoperations were unchanged with the ACS service, although readmissions showed a downward trend, from 7.9% pre-ACS to 3.0% in ACS-4 ($p = 0.058$, p value for trend $= 0.005$). Length of stay fell with the ACS service, from 5.3 days (median 4 days) Pre-ACS to a low of 3.8 days by ACS-4 (median 3 days, ACS-1 through ACS-4, $p = 0.0004$).

For cholecystectomy patients, there was a significant change from pre-ACS to the ACS service in payer mix, with a fall in private pay and a rise in proportion of self-pay patients (Table 7). Private pay fell from 50% Pre-ACS to 27% in ACS-4, and self-pay rose from 8% Pre-ACS to 18% in ACS-3 ($p < 0.0001$). Unadjusted charges were not different across the years of the study. Unadjusted cost fell in the first year of the ACS service (ACS-1, $p = 0.040$), then rose again, rising above the pre-ACS total hospital costs. Hospital charges

Table 6. Operation Distribution, Acuity, and Outcomes Measures, Cholecystectomy

Variable	Pre-ACS	ACS-1	ACS-2	ACS-3	ACS-4	p Value
Total cholecystectomies, n	178	231	201	212	198	
Laparoscopic, n (%)	177 (99)	229 (99)	201 (100)	212 (100)	198 (100)	N/A
Open, n (%)	1 (0.6)	2 (0.9)	0 (0)	0 (0)	0 (0)	
Laparoscopic converted to open, n (%)	9 (5.1)	6 (2.6)	12 (6.0)	16 (7.6)	7 (3.5)	0.14*
With cholangiogram, n (%)	26 (16)	33 (15)	36 (19)	27 (14)	30 (16)	0.70*
Case mix index	1.74 ± 0.77	1.70 ± 0.71	1.88 ± 1.48	1.87 ± 1.00	1.73 ± 0.65	0.36†
Complications, n (%)	37 (21)	37 (16)	34 (17)	19 (9.0)	24 (12)	0.012‡
Reoperations, n (%)	0	2 (0.9)	4 (2.0)	2 (0.9)	6 (3.0)	0.10*
Readmissions, n (%)	14 (7.9)	14 (6.1)	8 (4.0)	5 (2.4)	6 (3.0)	0.058*
Mortality, n	0	1	1	0	0	N/A
Length of stay, d	5.3 ± 4.6	4.3 ± 4.8	4.4 ± 5.1	4.0 ± 3.7	3.8 ± 3.4	0.0004§

*Chi-squared analysis, no linear trend identified, indicating the proportions vary without an identifiable trend.
†Kruskal-Wallis Test (nonparametric ANOVA).
‡Chi-squared analysis, with linear trend ($p < 0.02$), indicating a linear decrease in complication rate.
§Kruskal-Wallis Test (nonparametric ANOVA), Pre-ACS was significantly longer than ACS-1, ACS-2, ACS-3, and ACS-4 ($p < 0.01$).

adjusted to 2007 dollars (Pre-ACS) fell from a pre-ACS median of $62,054, to a low in ACS-3 of $50,080 ($p = 0.0015$). Adjusted total hospital costs also fell from a pre-ACS median of $12,526 to a low in ACS-4 of $9,348 ($p < 0.0001$).

The non-ACS surgeons who were covering emergency surgery cases in the year pre-ACS had no decrease in annual number of operations performed after the implementation of the acute care surgery service. These surgeons performed emergency operations only on patients who were known to them or who were specifically referred to them. This accounted for less than 5% of their cases. There was no difference in the number of cases performed by them on average, nor was the total number of cases performed different (Table 8). Pre-ACS had 9 surgeons who performed 256 ± 130 operations. The same 9 surgeons saw no decline in their numbers of total operations or in the average number of operations performed at Sutter Medical Center Sacramento, with a peak of 282 operations per surgeon, and a low of 256 operations per surgeon.

DISCUSSION

Implementation of an acute care surgery model results in sustainable improvements: decreased length of stay, reduction in complications, and decreased hospital costs. This can be achieved without affecting the operative volume of the nonacute care surgeons at the same facility. Our data are consistent with those from previous studies that have likewise confirmed consistent operative volume for the general surgeons after the institution of an acute care surgery service.[18,19] We were not able to assess the financial records for these affiliated general surgeons in this study; they remained financially independent from the hospital and from the ACS surgeons. Although we saw no decrease in the number of cases performed by the nonacute care general surgeons, a shift presumably did occur in their mix of cases. Traditionally, these emergency cases are the means by which a new surgeon builds a practice. During the course of this study no new surgeons started practice at this facility. It remains unclear as to why the case volume of the ACS service was able to support 2,600+ cases without affecting the case volume for the non-ACS surgeons and will be a specific data point included in future studies.

The mortality spike in the first year of the acute care service is of unclear etiology, but is likely multifactorial. The ACS surgeons may have been more willing to operate on severely ill patients who would not have been offered operation in the previous model. This is evident in the increased proportion of laparotomies performed, as well as in the higher reoperation rate. In the first year of the ACS service, all returns to the operating room after laparotomy were planned returns. The ACS service instituted damage control procedures and increased second-look laparotomies, interventions well known to trauma and acute care surgeons, but a practice that had been previously underused at this institution. Part of the increased mortality could be due to the immaturity of the new service. A similar rise in mortality has been noted with newly designated trauma centers, which can see a significant rise in mortality in years 1 and 2, and which is generally reversed by year 3.[20] This pattern was noted here, with a return of mortality rate to pre-ACS levels despite an increase in the acuity of patients. When the ACS service years were pooled, there was no difference in mortality compared with pre-ACS.

Complications and readmissions decreased after implementing the acute care surgery service. Along with the

Table 7. Financial Measures, Cholecystectomy

Variable	Pre-ACS	ACS-1	ACS-2	ACS-3	ACS-4	p Value
Total cholecystectomies, n	178	231	201	212	198	
Payer source, n (%)						<0.0001*
Private	89 (50)	91 (39)	55 (27)	47 (22)	54 (27)	
Government	75 (42)	108 (47)	108 (54)	124 (59)	115 (58)	
Self-pay	14 (7.9)	31 (13)	35 (17)	38 (18)	27 (14)	
Unknown	0	1 (0.4)	3 (1.5)	3 (1.4)	2 (0.9)	
Total hospital charges, $	62,054 (25,805–270,344)	61,013 (24,009–831,531)	61,048 (29,423–1,062,528)	61,007 (30,101–463,585)	67,154 (29,659–267,340)	0.60†
Total hospital cost, $	12,526 (5,332–52,951)	10,805 (3,856–170,493)	11,469 (5,434–240,762)	11,472 (5,416–102,199)	12,026 (5,483–75,104)	0.040‡
Adjusted hospital charges, $†,§	62,054 (25,805–270,344)	57,021 (22,439–777,132)	53,622 (25,844–933,287)	50,080 (24,710–380,557)	52,203 (23,056–207,821)	0.0015‖
Adjusted hospital cost, $†	12,526 (5,332–52,951)	10,098 (3,603–159,339)	10,074 (4,773–211,477)	9,418 (4,446–83,895)	9,348 (4,262–58,383)	<0.0001¶

Cost and charge data are presented as median (range).
*Chi-squared analysis, no linear trend identified, indicating the proportions vary without an identifiable trend.
†Kruskal-Wallis Test (nonparametric ANOVA).
‡Kruskal-Wallis Test (nonparametric ANOVA), Pre-ACS was significantly greater than ACS-1 ($p < 0.05$).
§Adjusted to 2007 dollars based on the hospital and related services portion of the consumer price index.
‖Kruskal-Wallis Test (nonparametric ANOVA), Pre-ACS was significantly greater than ACS-3 and ACS-4 ($p < 0.01$).
¶Kruskal-Wallis Test (nonparametric ANOVA), Pre-ACS was significantly greater than ACS-1, ACS-2, ACS-3, and ACS-4 ($p < 0.01$).

decreases seen in length of stay, we attribute this to the implementation of guidelines and protocols for patient care that were used by the surgeons and the service. Twenty-four–hour in-house availability allowed concerns to be addressed immediately and in person. Care was provided in a defined and repeatable fashion. Outside distractions did not delay discharge or operative intervention. Outpatients had immediate access to a nurse practitioner or physician assistant who could address their issue or bring them in to clinic, rather than the patient arriving at the emergency room and getting admitted until the surgeon was available to evaluate the issue, as had been done before implementation of the acute care service, therefore likely reducing readmissions. These midlevel providers also used the guidelines to assure consistent care of the pre- and postoperative patients, assisting in complication prevention.

The decrease in cost realized by the hospital after implementation of the ACS service seems to be in large part due to the decrease in length of stay. Although the decreased length of stay seems to correlate with cost, this does not appear to be the whole story. This decreased cost, which was maintained over the course of this study, is likely attributable to many factors, including the decreased complications, decreased readmissions, and earlier treatment of problems. Although ACS services have previously been associated with increased revenue and income for surgeons,[6] no previous evaluation has shown to consistently decrease cost to the hospital and payer charges that we report here. This occurred despite a shift in the payer mix that was seen by the ACS service. It is unclear why this shift occurred. Our suspicion is it was in large part due to the emergency physicians knowing that the ACS service was available and was not revenue-based, allowing a higher level of comfort from the emergency department in knowing a rapid response and follow-up would occur. Also, in the years of the study (2007 to 2011), Sacramento, CA was particularly hard hit by the financial downturn and this may have affected insurance coverage in our patient population.

What is not included here is the cost to the hospital for the new acute care service and how this compares to the call coverage stipends that were paid before the service was put into place. The actual numbers for this are not available. The hospital and the contracting agent providing the acute care surgery service report that the

Table 8. Operations by Nonacute Care Surgery Surgeons

Variable	Pre-ACS	ACS-1	ACS-2	ACS-3	ACS-4	p Value
Total operations, n	2,306	2,395	2,542	2,253	2,301	
Average operations per surgeon (9 surgeons)	256 ± 129	266 ± 134	282 ± 149	250 ± 127	256 ± 128	0.93

Kruskal-Wallis Test (nonparametric ANOVA), no significant differences.

cost savings more than made up for the new costs incurred by the salaries and support structure of the acute care surgeons. The hospital had expected to lose money with the new service, anticipating that the level of service, the increased accountability of the surgeons and the contracting agency, and the ease of administration through contractual arrangements would offset the cost. Instead, both parties were pleasantly surprised by the costs decreasing to the point that the service became a financial sum gain. So, the potential savings of up to $2 million was offset by the cost of the service, but the cost of the service was less than the money saved.

This study is limited by its retrospective and observational nature. Values were adjusted due to the changes in time and financial environment. Although grouped by year to minimize outside effects, other cost-saving measures were occurring at the hospital and likely contributed to the differences seen. Complications were broadly defined and extracted from the records. Other morbidities may have been present that were missed because the patient may have presented elsewhere or were not documented. We believe that a more thorough scrutiny was placed on the ACS service because it had an internal quality process that occurred concurrently with patient care, and these data were included in this review.

CONCLUSIONS

We believe that this study has shown the acute care surgery model can be successfully implemented at a nontrauma center, and that it can be successfully maintained. Cost savings is remarkable: potentially $2 million or more in a single year for a service this size, which converted a money-losing emergency service to one that sustained a profit. Hospital operative volume rose without detriment to the existing surgeons, and the benefit to patients is measurable. In our assessment, key to this success is creation of a system that standardizes high-quality care. It is possible to do this with the participation of the local nonacute care surgeons,[7] and in fact, can only be truly successful with collaboration between acute care surgeons, nonsurgical intensivists, elective general surgeons, the medical staff at large, and the hospital administration. One must avoid the model of the itinerant surgeon and rather, create a model of sustained, supported, optimized surgical care.

Author Contributions

Study conception and design: O'Mara, Owens
Acquisition of data: O'Mara, Owens
Analysis and interpretation of data: O'Mara, Wisner
Drafting of manuscript: O'Mara, Scherer
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REFERENCES

1. Spain DA, Richardson JD, Carrillo EH, et al. Should trauma surgeons do general surgery? J Trauma 2000;48:433–438.
2. Scherer LA, Battistella FD. Trauma and emergency surgery: an evolutionary direction for trauma surgeons. J Trauma 2004; 56:7–12.
3. Kim PK, Dabrowski GP, Reilly PM, et al. Redefining the future of trauma surgery as a comprehensive trauma and emergency general surgery service. J Am Coll Surg 2004;199:96–101.
4. Britt RC, Bouchard C, Weireter LJ, Britt LD. Impact of acute care surgery on biliary disease. J Am Coll Surg 2010;210:595–601.
5. Richardson JD, Miller FB. Is there an ideal model for training the trauma surgeons of the future? J Trauma 2003;54: 795–797.
6. Maa J, Carter JT, Gosnell JE, et al. The surgical hospitalist: a new model for emergency surgical care. J Am Coll Surg 2007; 205:704–711.
7. Qureshi A, Smith A, Wright F, et al. The impact of an acute care emergency surgical service on timely surgical decision-making and emergency department overcrowding. J Am Coll Surg 2011;213:284–293.
8. Lau B, DiFronzo A. An acute care surgery model improves timeliness of care and reduces hospital stay for patients with acute cholecystitis. Am Surg 2011;77:1318–1321.
9. Cubas RF, Gomez NR, Rodiguez S, et al. Outcomes in the management of appendicitis and cholecysititis in the setting of a new acute care surgery service model: impact on timing and cost. J Am Coll Surg 2012;215:715–721.
10. Ball CG, MacLean AR, Dixon E, et al. Acute care surgery: the impact of an acute care surgery service on assessment, flow, and disposition in the emergency department. Am J Surg 2012; 203:578–583.
11. Earley AS, Pryor JP, Kim PK, et al. An acute care surgery model improves outcomes in patients with appendicitis. Ann Surg 2006;244:498–504.
12. Britt RC, Weireter LJ, Britt LD. Initial implementation of an acute care surgery model: implications for timeliness of care. J Am Coll Surg 2009;209:421–424.
13. Austin MT, Diaz JJ, Feuer ID, et al. Creating an emergency general surgery service enhances the productivity of trauma surgeons, general surgeons, and the hospital. J Trauma 2005; 58:906–910.
14. Miller PR, Wildman EA, Chang MC, Meredith JW. Acute care surgery: impact on practice and economics of elective surgeons. J Am Coll Surg 2012;214:531–538.
15. Kaplan LJ, Frankel H, Davis KA, Barie PS. Pitfalls of implementing acute care surgery. J Trauma 2007;62:1264–1271.
16. State of California, Office of Statewide Planning and Development. Available at: www.oshpd.ca.gov. Accessed March 19, 2013.
17. Bureau of Labor and Statistics. Available at: www.bls.gov/cpi. Accessed March 19, 2013.
18. Barnes SL, Cooper CJ, Coughenour JP, et al. Impact of acute care surgery to departmental productivity. J Trauma 2011;71: 1027–1034.
19. Procter L, Bernard AC, Korosec RL, et al. An acute care surgery service contributes a positive contribution margin in an appropriately staffed hospital. J Am Coll Surg 2013;216:298–301.
20. Ciesla DJ, Tepas JT, Pracht EE, et al. Fifteen-year trauma system performance analysis demonstrates optimal coverage for most severely injured patients and identifies a vulnerable population. J Am Coll Surg 2013;216:687–698.