

Original Investigation

Trends in Emergent Hernia Repair in the United States

Christopher A. Beadles, MD, PhD; Ashley D. Meagher, MD; Anthony G. Charles, MD, MPH

IMPORTANCE Abdominal wall hernia is one of the most common conditions encountered by general surgeons. Rising rates of abdominal wall hernia repair have been described; however, population-based evidence concerning incidence rates of emergent hernia repair and changes with time are unknown.

OBJECTIVE To examine trends in rates of emergent abdominal hernia repair within the United States for inguinal, femoral, ventral, and umbilical hernias from January 1, 2001, to December 31, 2010.

DESIGN, SETTING, AND PARTICIPANTS A retrospective analysis of adults with emergent hernia repair using National Center for Health Statistics data, a nationally representative sample of inpatient hospitalizations in the United States that occurred from January 1, 2001, to December 31, 2010. All emergent hernia repairs were identified during the study period.

MAIN OUTCOMES AND MEASURES Incidence rates per 100 000 person-years, age, and sex adjusted to the 2010 US census population estimates were calculated for selected subcategories of emergent hernia repairs and time trends were evaluated.

RESULTS An estimated 2.3 million inpatient abdominal hernia repairs were performed from 2001 to 2010; of which an estimated 567 000 were performed emergently. A general increase in the rate of total emergent hernias was observed from 16.0 to 19.2 emergent hernia repairs per 100 000 person-years in 2001 and 2010, respectively. In 2010, emergent hernia rates were highest among adults 65 years and older, with 71.3 and 42.0 emergent hernia repairs per 100 000 person-years for men and women, respectively. As expected, femoral hernia rates were higher among women while emergent inguinal hernia rates were higher among men. Rates of emergent incisional hernia repair were high but relatively stable among older women, with 24.9 and 23.5 per 100 000 person-years in 2001 and 2010, respectively. However, rates of emergent incisional hernia repair among older men rose significantly, with 7.8 to 32.0 per 100 000 person-years from 2001 to 2010, respectively.

CONCLUSIONS AND RELEVANCE These increasing rates of emergent incisional hernia repair are troublesome owing to the significantly increased risk morbidity and mortality associated with emergent hernia repair. While this increased mortality risk is multifactorial, it is likely associated with older age and the accompanying serious comorbidities.

JAMA Surg. 2015;150(3):194-200. doi:10.1001/jamasurg.2014.1242
Published online January 7, 2015.

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Author Affiliations: Center for Health Services Research in Primary Care, Department of Veterans Affairs Medical Center, Durham, North Carolina (Beadles); Cecil G. Sheps Center for Health Services Research, University of North Carolina at Chapel Hill (Beadles, Meagher, Charles); Gillings School of Global Public Health, University of North Carolina at Chapel Hill (Beadles, Charles); Department of Surgery, University of North Carolina at Chapel Hill (Meagher, Charles); School of Medicine, University of North Carolina at Chapel Hill (Charles).

Corresponding Author: Anthony G. Charles, MD, MPH, University of North Carolina School of Medicine, Gillings School of Global Public Health, University of North Carolina, 4008 Burnett Womack Bldg, CB 7228, Chapel Hill, NC 27599 (anthchar@med.unc.edu).

Abdominal hernia repair is one of the most common operations undertaken in routine surgical practice worldwide.^{1,2} It is estimated that 360 000 ventral hernia (VH) repairs and 770 000 inguinal hernia (IH) repairs were performed in 2003.^{2,3} However, the true incidence of abdominal wall hernia is unknown. An estimated 1 in 4 men and 1 in 50 women will require surgery for an IH during their lifetime while 1 in 4 patients undergoing 1 of the 2 million laparotomies performed annually will develop a VH.^{4,5} Rates of VH and IH repairs have been steadily increasing since 2001, with slightly more than half being performed on an outpatient elective basis.^{1,5}

There is a paucity of data concerning rates of emergent abdominal hernia repair compared with elective abdominal hernia repair. Abi-Haidar et al⁶ described the cumulative single-site experience in New England of 1034 consecutive groin hernia repairs between 2001 and 2009. Emergent hernia repairs (6%) were associated with older age, femoral or scrotal location, greater intraoperative organ-resection risk, greater 30-day reoperation risk, and shorter time to death. Similarly, Hernández-Irizarry et al⁷ described the rate of emergent IH repair in Olmsted County, Minnesota, from 1989 to 2008. They reported a declining rate of emergent IH repairs during the study window, with only 3.8% of all repairs performed emergently. Historically, the risk of bowel strangulation and adverse outcomes dictated prompt surgical repair of all abdominal hernias; however, in 2006, a randomized trial comparing watchful waiting of asymptomatic IH with prompt repair found the rate of acute strangulation was relatively low (3 in 1000 patients).⁸ Watchful waiting for asymptomatic IH is becoming an acceptable cost-effective surgical alternative to IH.⁹ Prompt surgical correction for femoral hernia, umbilical hernia, and VH continues to be recommended if associated comorbidities do not preclude surgical repair.³

Ventral hernia repairs are increasing at an estimated rate of 3% per year owing to increasing surgical volume as well as the high rates of hernia recurrence.⁵ Emergent repair of hernia is associated with increased morbidity, length of stay, and mortality as compared with elective hernia repair. With such an increase in hernia burden, the paucity of population-level epidemiologic evidence describing trends in emergent hernia operations within the United States needs to be addressed. We sought to examine trends in rates of emergent abdominal hernia repair within the United States for all abdominal hernias and, more specifically, for IH, VH, femoral, and umbilical hernias from January 1, 2001, to December 31, 2010.

Methods

We retrospectively reviewed data from the National Center for Health Statistics National Hospital Discharge Survey (NHDS, 2001-2010). The NHDS contains medical and demographic information from a random sample of inpatient discharge records selected from a national probability sample of non-federal short-stay hospitals. An extensive description of the survey design, data collection procedures, and estimation process provides additional details beyond the scope of this work.¹⁰

Patient information from the NHDS includes age, sex, race/ethnicity, marital status, admission source, admission and discharge date, discharge status, expected source of payment, and geographic region, while the medical information includes diagnoses and surgical and nonsurgical procedures.

We used the *International Classification of Diseases, Ninth Revision, Clinical Modification* diagnosis and procedure codes to identify and classify abdominal wall hernias (eTable in the Supplement). Procedure codes were used to classify hernia repair while diagnosis codes were used in combination with admission sources to confirm hernia type and classify elective vs emergent repair. For each case, we also captured age, sex, race, admission source, hospital bed size, length of stay, discharge disposition, and expected source of payment.

The study was reviewed and deemed exempt by the institutional review board of the University of North Carolina at Chapel Hill. Patients did not provide written consent for this study owing to the retrospective nature of the database analysis.

Statistical Analysis

We first calculated the weighted total number of hernias and hernia types annually. We then examined annual descriptive characteristics for all emergent hernias. Next, incident rates of emergent hernias and hernia types were calculated as the number per 100 000 person-years. The rates were age-adjusted and sex-adjusted to the distribution of the US population in 2010 to facilitate meaningful comparisons. Because the NHDS is a random sample of records selected from a national probability sample, each observation was weighted to arrive at estimates for a national sample. Complex statistical adjustment was required to estimate standard errors for all variables and the data required to estimate the standard errors was only reported for the most commonly examined characteristics (eg, age, sex, race/ethnicity, and insurance status).¹⁰ All analyses were completed using STATA software (version 12; StataCorp). The a priori level of statistical significance was set at $P < .05$ for all analyses.

Results

We identified an estimated 2.3 million inpatient abdominal hernia repairs performed from January 1, 2001, to December 31, 2010. An estimated 576 000 were performed emergently. Patient characteristics (age, sex, and race/ethnicity) exhibited some degree of variability as shown in **Table 1** but no statistically significant trend was observed during the study. Similarly, the average length of stay varied slightly from 6.2 days (95% CI, 4.74-7.66 days) in 2006 to 8.6 days (95% CI, 5.04-12.16 days) in 2008. The overwhelming majority of patients were discharged home in all years but a significant minority of patients were discharged to a postacute facility or died during their hospitalization. The size of admitting hospitals also exhibited some degree of variability during the study period (**Figure 1**). Expected payment sources demonstrated several trends; in general, the percentage of Medicaid and self-pay admissions increased during the period while the percentage of

Table 1. National Emergent Hernia Characteristics From 2001 to 2010

Characteristic	Mean % (ESE)									
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
No. (%)	39 439 (4122)	48 743 (4693)	59 287 (4927)	55 624 (5620)	60 160 (5462)	55 059 (5310)	60 969 (5526)	71 268 (7306)	78 137 (7568)	47 268 (8260)
Age, y										
15-44	27 (4)	25.9 (4)	17.3 (3)	21.6 (3)	18.4 (3)	16.8 (3)	18 (3)	13.8 (3)	17.7 (3)	16.8 (4)
45-64	26.2 (4)	30 (3)	31.5 (4)	28 (3)	33.3 (3)	28.3 (3)	37 (3)	39.4 (4)	43.7 (4)	36.4 (6)
≥65	46.8 (4)	44.1 (4)	51.2 (4)	50.4 (4)	48.3 (4)	54.9 (4)	45 (3)	46.9 (5)	38.6 (4)	46.8 (6)
Biological sex										
Male	48.9 (4)	48.9 (4)	44.2 (4)	46.4 (4)	46.6 (4)	59.5 (4)	55.4 (3)	49.7 (4)	57.7 (4)	53 (6)
Female	51.1 (4)	51.1 (4)	55.8 (4)	53.6 (4)	53.4 (4)	40.5 (4)	44.6 (3)	50.3 (5)	42.3 (4)	47 (7)
Race/ethnicity										
White	52.4 (5)	64.8 (4)	55.2 (4)	58.4 (4)	60 (4)	60.6 (4)	61.6 (3)	56.6 (5)	67.6 (4)	65.8 (6)
Black	18.6 (3)	9.6 (2)	14.2 (2)	12.9 (2)	10.3 (2)	15.5 (3)	14.1 (2)	13 (3)	16.2 (3)	16.7 (4)
Other	2 (1)	4.2 (1)	3.2 (1)	2.1 (1)	2.3 (1)	2.6 (1)	1.6 (1)	3.6 (1)	2 (1)	3.5 (2)
Unknown	26.9 (3)	21.4 (3)	27.4 (3)	26.7 (3)	27.5 (3)	21.4 (3)	22.8 (3)	26.8 (3)	14.1 (2)	14.1 (3)
Length of stay, d	6.1 (6.6)	7.5 (0.92)	6.9 (6.4)	7.4 (0.93)	6.7 (7.0)	6.2 (0.73)	6.5 (6.8)	8.6 (1.78)	6.5 (7.4)	6.5 (1.49)
Discharge status										
Home	80.3	85.1	78.6	79.8	77.8	80.2	80.2	75.5	79.6	74.6
To facility	10.9	7.7	15.1	6.9	12.3	11.4	11.7	17.3	10.6	12.5
Alive/ location unknown	6.5	3.5	4.4	8.1	5.4	4.8	4.1	3.9	6.7	9.5
Deceased	1.4	3.5	0.6	4.1	2	3.6	3.1	2.9	2.9	2.6
Unknown	0.9	0.3	1.3	1.1	2.6	0.1	0.8	0.4	0.2	0.7
Hospital size, No. of beds										
6-199	50.7	58.3	41	50.6	53.9	41.7	51	38.6	50.2	31.1
200-499	33.1	33.6	47	37	35.9	45.6	37.4	50.8	39.1	62
≥500	16.2	8.2	12.1	12.4	10.2	12.7	11.6	10.6	10.7	6.9
Expected payment source										
Private insurance	21 (3)	16.5 (3)	20.7 (3)	12 (2)	22.9 (3)	16.3 (3)	19.7 (3)	16.2 (3)	17.7 (3)	7.3 (3)
Medicare	45.3 (4)	47.4 (4)	46.6 (4)	51 (3)	44.4 (4)	48.2 (4)	44.7 (4)	47.6 (5)	42.3 (4)	45.6 (6)
Medicaid	6.9 (2)	9.7 (2)	7.4 (2)	12.1 (2)	10.1 (2)	6.5 (2)	8.8 (2)	14.3 (3)	12.2 (3)	17.7 (4)
Self	6.3 (2)	3.6 (1)	7.1 (2)	7.1 (2)	5.2 (2)	6.7 (2)	6.9 (2)	7.1 (2)	9.1 (2)	12.5 (3)
Workers' compensation	2.7 (1)	2.1 (1)	0.6 (1)	2.7 (1)	2.8 (1)	1.5 (1)	1.3 (1)	1.8 (1)	2.4 (2)	1.9 (2)
HMO/PPO	16.6 (3)	16.5 (3)	16 (2)	11.1 (2)	12.2 (2)	16.2 (3)	16.2 (3)	10.4 (2)	13.6 (3)	13.4 (4)
Other	1.2 (1)	4.3 (1)	1.6 (1)	4.1 (1)	2.4 (1)	4.6 (1)	2.4 (1)	2.6 (1)	2.6 (1)	1.7 (1)

Abbreviations: ESE, estimated standard error; HMO, health maintenance organization; PPO, preferred provider organization.

private insurance and health maintenance organization/preferred provider organization-reimbursed admissions declined. Medicare, workers' compensation, and other payment sources remained stable during the study. Visual representations of percentage admissions and hospital length of stay by hospital size are illustrated in Figure 1 and Figure 2, respectively.

Annual rates of incident emergent hernia repair per 100 000 person-years stratified by sex and age during the study are presented in Table 2. All rates were sex-adjusted and age-adjusted to reflect the 2010 population to facilitate meaningful comparison. A general increase in the rate of total emer-

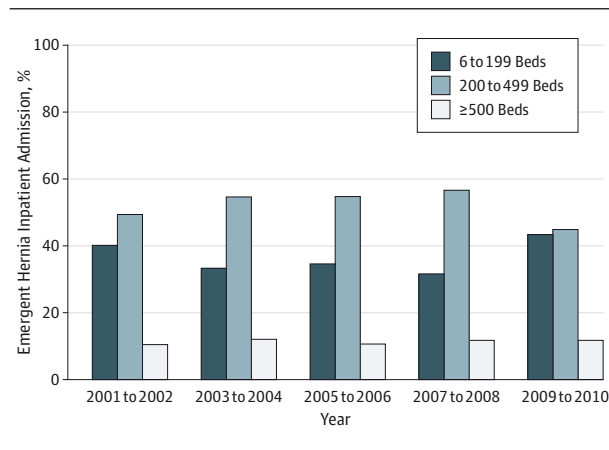
gent hernias was observed. Emergent hernia rates were highest among adults 65 years and older. As expected, femoral hernia rates were higher among women while IH rates were higher among men. Rates of emergent incisional hernia repair were high but relatively stable among women during the study, but rose significantly among men. Total annual incident-emergent hernia repair rates per 100 000 person-years and rates by hernia subtype are visually depicted in Figure 3. The general increase in total emergent hernia repair rates was evident as was the increase in incisional-emergent and umbilical-emergent hernia repair rates. While variability was evident in IH and femoral emergent hernia repair rates, these rates were

generally stable throughout the study. A sharp increase in rates of emergent hernia repair from 2008 to 2009, followed by a sharp decrease from 2009 to 2010, was also observed.

Discussion

Abdominal wall hernias are common, with a prevalence of 1.7% for all ages and 4% for those older than 45 years. Inguinal hernias account for 75% of abdominal wall hernias, with a lifetime risk of 27% in men and 3% in women.¹¹ In high-income countries with increased surgical access, the increasing rates of exploratory laparotomies and the availability of laparoscopy have been associated with a rising incidence of incisional VH, which has become the most common hernia repair procedure performed and is consistent with our findings.¹²

Figure 1. Emergent Hernia Admissions by Hospital Size From 2001 to 2010



Each bar represents a 2-year estimate of the percentage of emergent hernia inpatient admissions by hospital size, defined by 6 to 199 beds, 200 to 499 beds, or 500 or more beds. Transfers are only counted in the facility in which the hernia repair occurred.

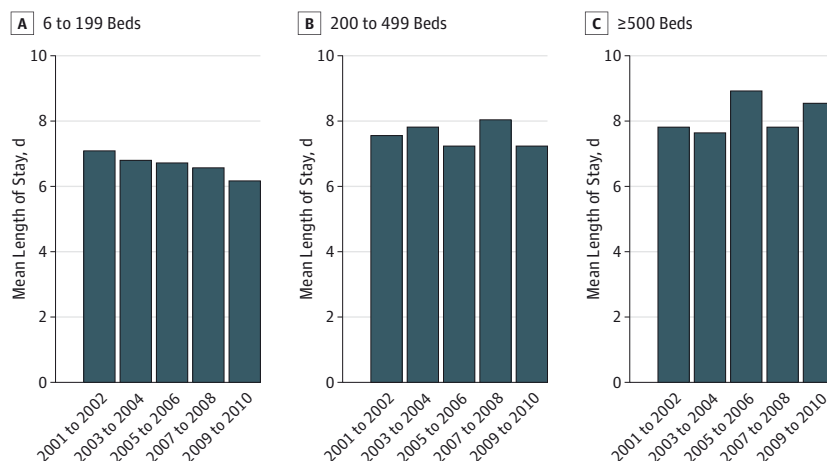
The typical indication for emergent abdominal hernia repair is incarceration. This implies an increased risk of obstruction and strangulation.¹³ Incarcerated external hernias are the second most common cause of small intestinal obstructions.¹⁴ Data from the United Kingdom suggest that approximately 13% of all patients having an operation for external hernia are explored on an emergency basis. Strangulated external hernia is a relatively common and serious surgical emergency and accounts for most of the deaths from this condition.¹⁵

In our study, we showed a 15.6% baseline prevalence of abdominal inpatient emergent hernias repaired during the decade. After sex and age adjustment, the incidence rate for emergent hernia repair increased during the study period, particularly in elderly individuals. We believe this trend was predominantly driven by the increasing rate of incisional and umbilical hernias, particularly in men.

A study by Abi-Haidar et al⁶ within a Veterans Affairs healthcare system population during an 8-year period demonstrated that the frequency of emergent IH repair among all IH repairs was 6.1% (n = 1034), with older-aged patients as well as those with femoral, scrotal, recurrent, or indirect hernias having a higher likelihood of requiring an emergent repair. Similarly, in our study, we observed that older-age patients (>65 years) as well as those with femoral hernia (mainly women) and VH had higher rates of emergent hernia repairs.

Colavita et al¹⁶ evaluated a national sample of ventral hernia repairs with prosthetic mesh in 2 periods (1998-1999 and 2008-2009) to examine evidence trends in volume-based outcomes. They reported an increasing percentage of emergent VH repairs (14.4% to 18.9%) and changes in distribution of emergent VH repairs between high-volume, medium-volume, and low-volume centers. Our observed increasing rate of emergent VH repairs corroborates their findings while providing additional context via inclusion of rates of emergent repair for other common hernia subtypes (inguinal, femoral, and umbilical). We also found evidence for redistribution of emergent hernia repairs by hospital size. However, differences in methods do not allow for direct comparison.

Figure 2. Emergent Hernia Length of Stay by Hospital Size From 2001 to 2010



Each bar represents a 2-year estimate of the mean length of stay in days for emergent hernia repairs. Transfers are only counted in the facility in which the hernia repair occurred.

Table 2. Incident Rate per 100000 Person-Years of Emergent Hernia Repair in the United States From 2001 to 2010

Variable	Age, y	%									
		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
All											
Men	15-44	9.4	9.2	5.1	7.6	5.9	9.7	11.9	9.2	13.8	4.0
	45-64	11.7	16.0	22.6	21.8	24.5	24.4	37.9	43.4	54.5	25.7
	≥65	50.1	67.0	80.7	71.2	84.3	97.7	65.0	71.9	86.5	71.3
Women	15-44	7.6	11.0	11.4	11.8	11.9	5.0	5.5	6.5	8.3	8.8
	45-64	13.9	20.3	23.9	17.0	25.4	14.7	18.8	26.8	31.2	17.2
	≥65	42.1	42.4	70.4	67.5	62.0	57.1	69.8	90.3	65.5	42.0
Total		16.0	19.8	24.1	22.6	24.5	22.4	24.8	29.0	31.9	19.2
Inguinal											
Men	15-44	3.9	3.7	1.7	1.5	1.6	2.6	5.3	5.2	4.8	0.5
	45-64	5.3	3.7	8.8	7.0	8.3	9.1	15.3	12.2	15.6	14.7
	≥65	35.4	33.7	50.8	36.1	39.0	60.4	25.6	37.2	43.1	21.4
Women	15-44	0.0	1.0	0.7	1.2	0.0	0.2	0.0	0.0	0.0	0.0
	45-64	2.2	1.8	0.4	0.6	1.4	0.2	0.0	0.6	0.8	1.1
	≥65	4.7	6.2	12.5	8.9	10.4	6.4	5.1	11.0	8.2	12.3
Total		5.2	5.1	6.9	5.3	5.7	7.1	6.1	7.1	7.7	5.3
Femoral											
Men	15-44	0.0	0.4	0.0	0.1	0.0	0.3	0.0	0.0	0.0	0.0
	45-64	0.3	0.4	0.1	0.2	0.0	0.7	0.4	0.0	0.0	0.0
	≥65	2.4	2.4	7.4	5.6	1.4	3.7	4.2	1.3	0.0	2.4
Women	15-44	0.1	0.1	0.4	0.1	0.7	0.2	0.1	0.0	0.8	0.0
	45-64	0.5	0.2	0.1	0.6	2.7	0.1	0.6	2.0	0.4	0.3
	≥65	5.4	8.6	2.4	10.5	7.2	5.7	7.3	8.1	7.2	9.2
Total		0.9	1.2	0.9	1.6	1.4	1.0	1.2	1.2	0.9	1.1
Umbilical											
Men	15-44	9.4	9.2	5.1	7.6	5.9	9.7	11.9	9.2	13.8	4.0
	45-64	5.1	9.3	7.2	6.9	12.5	9.1	11.5	17.8	23.2	1.4
	≥65	5.0	13.4	17.0	9.7	23.8	10.1	14.9	18.9	14.5	15.5
Women	15-44	4.9	5.4	3.0	2.8	3.3	2.1	2.2	2.3	1.2	3.5
	45-64	2.8	5.4	5.2	2.6	2.8	3.3	4.7	6.1	13.3	1.7
	≥65	9.8	12.0	18.0	18.6	21.7	13.2	19.8	10.5	9.7	3.2
Total		6.2	8.2	7.0	6.6	8.5	7.0	9.1	9.1	11.7	3.8
Incisional											
Men	15-44	2.8	2.3	1.2	2.9	2.2	5.4	3.9	2.3	5.3	1.2
	45-64	2.3	3.5	6.5	10.5	7.6	5.7	12.5	14.3	20.5	9.7
	≥65	7.8	19.6	18.2	20.0	37.4	24.9	21.9	16.3	29.4	32.0
Women	15-44	4.6	4.5	7.7	7.8	8.1	2.8	3.3	4.2	6.3	5.3
	45-64	8.9	14.5	18.2	13.3	18.9	11.2	14.0	18.1	16.9	14.1
	≥65	24.9	19.5	39.8	32.9	28.6	34.8	38.5	64.5	42.9	23.5
Total		6.6	7.9	11.3	11.1	12.3	9.9	11.4	14.2	15.2	10.0

Increasing incidence of emergent hernia repairs mirrors the predominant increase in risk factors associated with hernia development in the US population. Incidence of groin hernia has been found to have a bimodal distribution with peaks in childhood and old age. Our findings demonstrated that incidence of emergent groin hernia repair also increases with age.¹⁷ In addition, obesity has been associated with increased incidence of hernia owing to presumed increase in intra-abdominal pressure on the rectus sheath.³ A meta-analysis of hernia incidence in obese individuals showed that although there is a strong association with incisional VH, there is a lower

incidence of IH in this population.¹⁸ Unfortunately, we did not have any information on body mass index in our data set to correlate this finding.

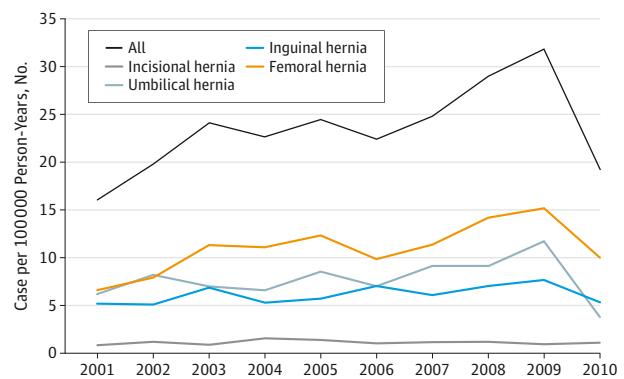
Sex ratios in our study were consistent with prior studies.¹⁹ The ratio of men to women was 5:1 and 1.2:1 for emergent IH and umbilical hernias, respectively, and 1:3 for femoral hernias. Women have been found to have a higher incidence rate of incisional VH and our study showed they also have higher rates of emergent incisional VH repair (Table 2).²⁰

There is an increased mortality among patients who undergo emergent hernia repairs.⁴ In our study, the average

mortality rate was 3.3%. For elective hernia repair, the mortality rate was lower than or similar to the population-standardized mortality rate. Bay-Nielsen and colleagues²¹ published results from the prospective Danish hernia database of 26 304 hernia repairs and found a 30-day mortality rate of 0.02% in patients younger than 60 years and 0.48% in those 60 years and older after elective surgery while emergent hernia repair had a 7% mortality rate. The data from the Scottish Audit of Surgical Mortality give an overall mortality rate of 0.2% for IH repair, with most deaths in the elderly population occurring in patients with higher operative risk as determined by preexisting comorbidities.²²

The strength of this study was reflected in its longitudinal cross-section and population-based random inpatient sampling framework, which minimized referral and selection bias. We acknowledge the limitations of this study inherent in any large retrospective database study; diagnosis and procedure codes undoubtedly have some level of error. However, any 1 source of error would have had to have been systematic to have significantly influenced our results. Similarly, there were likely several unobserved factors associated with emergent hernia repair that were not captured in this data source. For example, body mass index and prior abdominal surgeries were not available. We sought to examine national longitudinal trends in the incidence rate of emergent hernia repair and purposely chose not to explore the multitude of possible factors associated with the occurrence of an emergent hernia repair. Finally, we were interested in describing the incidence rate of emergent hernia repair across time. This data source is a multistage national probability sample of nonfederal short-stay hospitals. In the final 2 years of data availability, the sampling methodology remained identical to prior years; however, the sampling was reduced owing to budget constraints of the National Center for Health Statistics. The reduced sampling increased uncertainty around point estimates and is the likely cause of sharp rate changes from 2008 to 2010. While useful for

Figure 3. US Emergent Hernia Repair Rates From 2001 to 2010



observing time trends, the incidence of emergent hernia repair in any single year was less reliable owing to the sample design. Similarly, because primary sampling unit and stratum information were not available, potential nationally representative statistical analysis and inferences were somewhat limited.

Conclusions

The incidence rate of emergent hernia repair in the United States has increased slightly during the past decade. Although the incidence rates for emergent, inguinal, and femoral hernia remained stable during the study, incisional VH repair rates trended upwards, particularly in men. Furthermore, the increase in emergent hernia rates was highest in the older-adult population (>65 years). This is the fastest growing segment of the US population and, given the associated comorbidities in this age group, efforts to increase access to primary and surgical care are imperative to ameliorate the associated sequelae of emergent hernia repair.

ARTICLE INFORMATION

Accepted for Publication: May 16, 2014.

Published Online: January 7, 2015.
doi:10.1001/jamasurg.2014.1242.

Author Contributions: Dr Beadles had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: All authors.

Acquisition, analysis, or interpretation of data: Beadles, Charles.

Drafting of the manuscript: All authors.

Critical revision of the manuscript for important intellectual content: All authors.

Statistical analysis: Beadles.

Administrative, technical, or material support: Meagher.

Study supervision: Meagher, Charles.

Conflict of Interest Disclosures: None reported.

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