ORIGINAL ARTICLE

Cyclical Increase in Diverticulitis During the Summer Months

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Objective: We hypothesized that the rate of nonelective hospital admissions for diverticulitis conforms to seasonal variation.

Design: Retrospective cohort analysis.

Setting: Patients admitted to hospitals in the Nationwide Inpatient Sample, a 20% sample of US community hospitals.

Patients: We identified patients with a nonelective admission or discharge for diverticulitis from January 1, 1997, through December 31, 2005, and determined the proportion of diverticulitis admissions (standardized to all inpatient admissions) for a particular admission month or discharge quarter. Next, we analyzed the potential effects of region, age, sex, and race on excess seasonal admissions for diverticulitis.

Results: On average, total nonelective admissions for diverticulitis were lowest in February (23 744 admissions) and highest in August (29 733 admissions), a 25.2% increase in cases. Similarly, diverticulitis discharges increased by 14.3% during the third quarter compared with the first ($P < .001$). A significant seasonal pattern of diverticulitis admissions was identified that conformed to a major sinusoidal component ($P < .001$). The excess seasonal burden of nonelective diverticulitis admissions in the third quarter was noted across US census regions, age, sex, and race.

Conclusions: Hospitalization for diverticulitis adheres to a sinusoidal pattern, with more nonelective admissions occurring during the summer months. The excess summer burden of diverticulitis is noted across US census regions, age, sex, and race. A more thorough understanding of these trends may provide a mechanism to identify a potential trigger for diverticulitis.

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Diverticular disease is one of the most common conditions that affect men and women older than 50 years; yet, little is known about the epidemiology of the disease or its potential causes. The presence of diverticula, which is obviously essential to the development of diverticular disease, was relatively uncommon at the turn of the 20th century but has become much more common in the last several decades. In addition, higher rates of diverticulosis are noted in Western nations compared with African and Asian nations.[1,2] Much of the increased prevalence of diverticulosis may be due to changes in diet, specifically more processed foods and a deficiency of insoluble fiber.[3] The diet hypothesis for diverticulosis is further reinforced by the understanding that Japanese immigrants experience an increased prevalence of diverticulosis after assimilating a Western diet and lifestyle.[4,5]

See Invited Critique at end of article

Despite some understanding of the association between the development of diverticulosis and diet, no actual cause for a discrete episode of diverticulitis has been uncovered at this time. It had been postulated that a diet high in nuts, corn, and popcorn led to diverticular disease through luminal trauma[6-8]; however, recent data from the Health Professionals Follow-up Study revealed no increase in diverticular disease with the consumption of these dietary items. In fact, this recent study revealed that a diet high in popcorn may actually be beneficial in reducing the risk of diverticulitis.[9] With no obvious causative agent for diverticulitis, we sought to define epidemiologic clues to an acute inpatient episode of diverticulitis. In the past, a seasonal pattern of disease was identi-

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fied with other inflammatory conditions[10]; for this reason, we postulated that diverticular disease may similarly follow a seasonal pattern. Determination of a seasonal pattern to diverticular disease might provide clues to potential etiologic triggers of acute diverticulitis.

METHODS

DATA SOURCE

We obtained hospital discharge data from the Nationwide Inpatient Sample (NIS) to include January 1, 1997, through December 31, 2005, via the Healthcare Cost and Utilization Project of the Agency for Healthcare Research and Quality. The NIS—the largest source of all-payer hospital discharge information in the United States—is a unique, powerful tool that includes data from approximately 7 to 8 million hospital stays per year in 1000 hospitals located in 35 states, thus approximating a 20% stratified sample of hospitals in the United States.[11] Others have used NIS data to review trends in surgical care and outcomes,[12] the volume-outcome relationship,[13] and disparities in care.[14] We have a data-use agreement with Agency for Healthcare Research and Quality; in addition, our study protocol was considered exempt by the Lahey Clinic Institutional Review Board. The NIS provides information on patient characteristics, socioeconomic factors, admission profiles, hospital profiles, state codes, admission month, discharge diagnoses, procedure codes, total charges, vital status, and time of discharge.

PATIENTS

We used diagnostic codes from the *International Classification of Diseases (ICD-9)* to identify all patients who were discharged with diagnostic codes specific to diverticulitis (562.11 or 562.13).[15-17] The code is not specific to sigmoid diverticulitis and thus includes patients with right-sided, transverse, and left-sided diverticulitis. We included only patients with nonelective admissions for diverticulitis by excluding all patients with hospital admission for elective reasons. We evaluated both admissions and discharges for diverticulitis to ensure consistency of the seasonal findings.

COVARIATES

We evaluated seasonal differences in the general population of NIS inpatients as well as among census regions as classified by the US Census Bureau. The sampling frame of the NIS has been weighted to represent the entire nation; however, the NIS sample frame is not designed to specifically approximate inpatient stays across United States regions. In addition to US census region, we analyzed seasonal admission and discharge trends in relation to demographics such as age, sex, and race.

DATA PRESENTATION AND STATISTICAL ANALYSIS

We calculated total admissions and discharges as well as the ratio of inpatient admissions and discharges for diverticulitis on a monthly and quarterly basis among all NIS inpatients. Ratios were presented as monthly, quarterly, or annual admissions or discharges in a cohort of 100 000 NIS inpatients. To examine changes across seasons, we identified the proportion of patients with nonelective diverticulitis admissions or discharges in quarters: the first comprised January, February, and March; second, April, May, and June; third, July, August, and September; and fourth, October, November, and December. We then used 3 methods to identify temporal changes in admissions or discharges: χ^2 test, spectral analysis, and the X11 procedure for seasonality.

The χ^2 test was used to examine the difference between the proportions of patients admitted (or discharged) with nonelective diverticulitis in the third quarter compared with the first quarter across all calendar years. A similar analysis was performed to evaluate changes by month of admission.

Statistical Analysis Software spectral analyses (SAS Institute Inc, Cary, North Carolina) were conducted to assess cyclical patterns in event occurrence on a monthly basis.[10] The Spectra procedure performs spectral and cross-spectral analyses of time series to look for periodicities or cyclical patterns in data.[18] The Spectra procedure contains the Fisher kappa test ($F\kappa$) and the Bartlett Kolmogorov-Smirnov test, which tests departures from the white noise hypothesis over all frequencies.[10,19] In time series analyses, white noise indicates zero autocorrelation, ie, variables taken at different moments in time are unassociated.

The X11 procedure (SAS Institute Inc) seasonally adjusts monthly or quarterly time series, making additive or multiplicative adjustments. This test combines *F* tests with the Kruskal-Wallis χ^2 test for stable seasonality. We assessed stable seasonality using a 1-way analysis of variance on the detrended series with months as the factor of interest and moving seasonality using a 2-way analysis of variance with month and year as the factors of interest.[20-22] We also used a series of symmetrical moving average filters to evaluate the original time series components. The Arima option smoothes the seasonal factors and initial estimates of the trend data.

RESULTS

DIVERTICULITIS CASES

A total of 374 123 patients were admitted with nonelective diverticulitis from a total of 67 909 747 total NIS patients (550.9 diverticulitis cases per 100 000 NIS inpatients). During the same time period, 373 823 patients were discharged for the same reason, while 300 patients were likely discharged in a later time period not captured by our data set (ie, calendar year 2006 or later). A total of 46 774 patients (12.5%) did not have admission month information. Almost all of these patients were admitted from Florida hospitals, which do not collect month of admission information. However, discharge quarter is available for all hospitals in the NIS including the state of Florida. During the study period, nonelective diverticulitis admissions increased from 36 549 cases in the 1997 calendar year to 48 499 in 2005. The ratio of diverticulitis admissions thus increased from 511.3 cases per 100 000 NIS inpatients in 1997 to 606.6 cases per 100 000 NIS inpatients in 2005.

MONTHLY AND QUARTERLY CASES

During the 9-year study period, nonelective diverticulitis admissions were lowest in February (n = 23 744 admissions) and highest in August (n = 29 733 admissions), a 25.2% increase. During the same time period, the NIS sampled a low of 4 886 820 patients in February and a high of 5 291 595 patients in January. The ratio of nonelective diverticulitis admissions to all NIS inpatients was lowest in January (485.0 cases per 100 000 NIS

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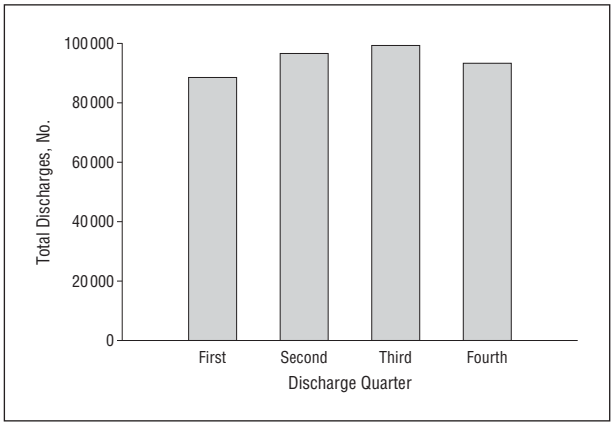

Figure 1. Total number of nonelective diverticulitis discharges in Nationwide Inpatient Sample hospitals by quarter. First indicates January, February, and March; second, April, May, and June; third, July, August, and September; and fourth, October, November, and December.

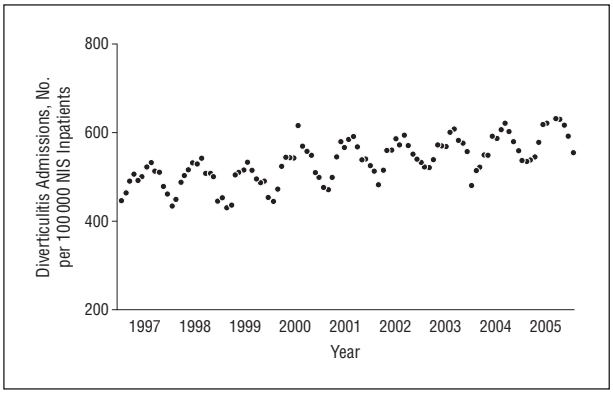

Figure 2. Nonelective diverticulitis admissions in Nationwide Inpatient Sample (NIS) hospitals as a proportion of all inpatients. The ratio of monthly nonelective diverticulitis admissions are plotted as a function of time.

inpatients) and highest in July (584.8 cases per 100 000 NIS inpatients), a 20.6% increase (χ^2 test, $P<.001$).

Nonelective admissions for diverticulitis were lowest in the first quarter (January, February, March; n=76 523) and highest during the third quarter (July, August, September; n=87 448), a 14.3% increase (**Figure 1**). Admission quarters for all NIS inpatients ranged from a low of 15 109 647 patients in the fourth quarter to a high of 15 467 984 patients in the first quarter. The ratio of nonelective diverticulitis admissions to all NIS inpatients was lowest in the first quarter (494.7 cases per 100 000 NIS inpatients) and highest in the third quarter (576.4 cases per 100 000 NIS inpatients), a 16.5% increase (χ^2 test, $P<.001$).

Nonelective discharges for diverticulitis were lowest in the first quarter (n=87 524) and highest during the third quarter (n=98 389), a 12.4% increase. In the total NIS sample, discharge quarters ranged from a low of 16 849 615 patients in the third quarter to a high of 17 269 938 patients in the first quarter. The ratio of nonelective diverticulitis discharges to all NIS inpatients was lowest in the first quarter (506.8 cases per 100 000 NIS inpatients) and highest in the third quarter (583.9 cases per 100 000 NIS inpatients), a 15.2% increase (χ^2 test, $P<.001$).

SPECTRAL ANALYSIS AND THE X11 PROCEDURE

The monthly analysis of nonelective diverticulitis admissions revealed a major seasonal component ($F\kappa=22.2$; $P<.01$) and a significant departure from the white-noise hypothesis (Bartlett Kolmogorov-Smirnov statistic=0.76; $P<.001$). These findings indicate significant monthly variation in the ratio of nonelective diverticulitis cases to all NIS inpatients. Similar results were noted when the monthly cases for nonelective diverticulitis admissions were entered as whole numbers and not standardized to all NIS inpatients ($F\kappa=29.5$; Bartlett Kolmogorov-Smirnov statistic=0.78; $P<.001$). The peaks were highest in the summer months while the valleys were noted in the winter months (**Figure 2**). Confirmation of seasonality was performed with the Statistical Analysis Software X11 procedure. The X11 analysis similarly revealed significant seasonality on a monthly basis ($F=62.7$; $P<.001$). The original series components were also filtered from the original data using a series of symmetrical moving average filters and confirmed seasonality of the results.

Spectral analyses uncovered similar seasonal patterns for nonelective diverticulitis admissions when subdivided into US census regions (Midwest, Northeast, South, and West), age (<50 or ≥50 years), race (white, black), and sex (male, female) (**Table**).

Table. Nonelective Diverticulitis Admissions by Month as a Function of US Census Region, Age, Race, and Sex

Characteristic	Third Quarter Increase, %	Fisher κ	BKS Statistic
US region			
Midwest	14.0	31.3	0.76
Northeast	15.1	27.2	0.76
South	14.2	32.1	0.78
West	11.8	13.4	0.61
Age, y			
<50	16.6	32.0	0.77
≥50	13.1	28.1	0.77
Race			
White	12.5	17.4	0.75
Black	14.4	30.2	0.67
Sex			
Male	12.5	30.9	0.78
Female	14.8	28.3	0.76

Abbreviation: BKS, Bartlett Kolmogorov-Smirnov.

COMMENT

Our data reveal a clear seasonal pattern to admissions for diverticulitis, with an increased proportion of diverticulitis admissions during the summer and far fewer admissions during the winter. Although our data set is administrative in origin, and thus does not allow access to actual medical records of patients, it is unlikely that these findings are the result of coding inaccuracies. While we acknowledge that the diagnosis of "diverticulitis" can sometimes be made in error, it would be unlikely that such errors would be made preferentially in one season over another. Another potential weakness of the analysis is that

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readmission for failure of initial medical therapy is recorded in the data set as a separate admission for diverticulitis. If early discharge (and thus the tendency for readmission) was more common in one season, it could skew the data. Yet, this scenario is unlikely to occur preferentially in one season in favor of another. Given these limitations, the strengths of the study are its size and long duration of observation. The NIS is the largest source of all-payer hospital discharge information in the United States and thus affords the best possible estimate of admission rate for diverticulitis. We analyzed data over a 9-year period, making it unlikely that the seasonal variation we observed is a spurious result.

Our findings do not provide an obvious cause or trigger for diverticulitis, but could lead to hypothesis generation regarding predisposing factors for acute diverticulitis and potential research targets. Any progress in this direction would be of potential value given the frequency with which diverticulitis afflicts the population. According to the Agency for Healthcare Research and Quality, more than 295 000 patient discharges for diverticulitis were reported at United States hospitals in 2006.[23] Furthermore, in a recent review of national practice patterns for diverticulitis, the frequency of inpatient diverticulitis cases increased significantly over an 8-year study period.[15] In addition to the increased burden of disease, diverticulitis is one of the 5 most costly gastrointestinal conditions treated in the United States, with total direct and indirect costs estimated at $2.5 billion per year.[24] Despite the frequency and relatively high cost associated with diverticular disease, nonsurgical methods to prevent diverticulitis are lacking. Thus, an understanding of the causes of an acute episode of diverticulitis would help clinicians counsel patients as to methods to reduce future occurrences of this condition.

Similar seasonal variation has been reported for other conditions including appendicitis,[10] pneumonia,[25] myocardial infarction,[26] and atrial fibrillation.[20] Interestingly, admissions for acute appendicitis are also more common in the summer months.[10] Both diverticulitis and appendicitis are acute inflammatory conditions of the gastrointestinal tract, and thus hypotheses can be generated regarding predisposing factors for both conditions. A recent study investigating the relationship between viral diseases and appendicitis revealed cointegration between the annual incidence rates of influenza and nonperforated appendicitis, implicating a shared common etiologic determinate, pathogenetic mechanism, or environmental factor that might similarly affect their incidence.[27] This preliminary study in infectious mechanisms of appendicitis also poses an exciting possibility for future diverticulitis research.

In addition to infectious causes, dietary triggers may explain seasonality in diverticulitis admissions. Data exist that people eat more fresh fruits and vegetables in the summer months.[28] One could speculate that such dietary variation fits nicely with the long-held belief that diverticulitis results from ingestion of indigestible food items that impact the lumen of a diverticulum.[6-8] As the theory goes, diverticular lumen impaction leads to increased diverticular luminal pressure, which eventually produces erosion or breakdown of the diverticular wall, resulting in microscopic or macroscopic perforation.[29] Thus, to reduce the possibility of food items impacting a diverticulum and causing diverticulitis, patients with diverticulosis or a history of diverticulitis were often counseled to avoid nuts, corn, and popcorn.[30-32] Scientific evidence to support the "nuts and seeds" theory of diverticulitis has been lacking but the concept was attractive to the public and to many health care workers and became common folklore. However, recent data from the Health Professionals Follow-up Study revealed that this commonly held belief might be well off the mark.[9] The authors found that nut, corn, and popcorn consumption did not increase the risk of diverticular complications in men without a history of diverticulosis.[9] On the contrary, a diet high in popcorn was protective against the development of diverticulitis.[9]

Another possible dietary link to diverticulitis that may be linked with seasonal variation is fiber intake. Dietary fiber intake and diverticulitis risk have been studied in the prospective cohort detailed in the preceding paragraph.[3] That study documented an inverse relationship between dietary fiber consumption and diverticular complications. Although it is understood that fiber is of some value in protecting a patient from diverticulosis, and thus potentially diverticulitis, seasonal variation in fiber consumption has not been described.

Other than diet and infectious causes, other potential causes for the observed variation in diverticulitis admissions include climate changes, migration or vacation patterns, other lifestyle factors, and medication use. However, our data reveal similar seasonal variation across geography for diverticulitis admissions, ie, the seasonal admission trends for diverticulitis were recognized in the Northern United States as in the Southern United States. These data indicate that climate changes and vacation patterns are unlikely to account for the finding of seasonal diverticulitis variation. In addition, we found that regardless of age, sex, or race, seasonal differences in diverticular admissions were consistently observed; therefore, whatever the trigger may be, it seems to be shared by all demographic groups, with no particular predilection to a specific group. Lastly, the use of nonsteroidal anti-inflammatory drug use has also been associated with symptoms of severe diverticular disease[33] but we know of no seasonal differences in use of these medications.

In conclusion, we observed a sinusoidal seasonal variation in the rate of hospital admission for acute diverticulitis, with the highest rates found during the summer months. The excess summer burden of diverticulitis was noted across US census regions, age, sex, and race, indicating universality to these findings. Thus, it is unlikely that this summer predilection for diverticulitis is related to a particular demographic group or other seasonal climate changes. A more thorough understanding of these seasonal differences may provide a mechanism to identify a potential trigger for individual episodes of diverticulitis.

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