The Rising Morbidity of Appendectomy For Acute Appendicitis

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Abstract:

BACKGROUND: High morbidity rates have been reported recently in comparisons of open and laparoscopic appendectomy, raising the question of whether the surgical community is still performing this common procedure well.
STUDY DESIGN: .The English language literature was searched for reports of series of appendectomies between 1892 and 2008. Reported morbidity and mortality rates for appendectomy were evaluated over time.
RESULTS: 399,996 patients were identified over the 116 year period. Mortality from appendectomy showed a predictable, steady decline. The morbidity from appendectomy showed steady improvement until 1962. Since 1962 there has been a statistically significant rise of morbidity from appendectomy, to morbidity rates as high as 29%. The rise in morbidity since 1960 was especially pronounced at teaching hospitals.
DISCUSSION: There has been a statistically significant rise in the morbidity from appendectomy since 1960. The rising morbidity was independent of laparoscopic surgery, and is particularly pronounced at teaching hospitals.

It may be argued that the "Century of Surgery" began in 1886 when Reginald Fitz reported on the pathology of the appendix in acute appendicitis.[1] The decades following this seminal event saw the development of safer surgery in the abdomen, and the development of progressively more complex procedures for intra-abdominal disease. Yet despite the passage of more than a century, appendectomy remains one of the most common surgeries performed in the United States and around the world.

For surgeons, performing one's first appendectomy as an intern is a significant rite of passage, remembered forever. William A. Nolan, in his book, "The Making of A Surgeon," vividly describes this experience in a way that forty years later still resonates.[2] His description of the surgery, however, is also replete with error, injury, and complications for his patient; the direct result of an inexperienced surgeon.

The Institute of Medicine reported on an extraordinary rate of error in Medicine and Surgery.[3] This report, as well as well publicized anecdotes of error, call into question the underlying quality of our patient care, as well as highlight the delicate balance between risk to patients, on the one hand, and the obligation to teach the next generation of physicians, on the other.

Since appendectomy is such a common surgical procedure, and one that is such an integral part of the training process for surgeons, This study attempts to determine how well modern surgeons are performing in achieving patients safety with a common surgical procedure.

STUDY DESIGN

This study is a retrospective statistical analysis of Western Literature reports on the morbidity and mortality of appendectomy for appendicitis over time.

The western, English language literature was carefully searched for peer reviewed medical literature documenting morbidity and mortality for acute appendicitis. These data were extracted from these papers, as well as the time frame discussed for each series. The data were then evaluated using traditional statistical analysis (Analyze-It statistical software program, Analyze-It, LTD, London, England, 2008), simple and polynomial regression analysis, and between groups statistical meta-analysis to evaluate the performance of appendectomy by the surgical community over time, using reported morbidity and mortality as indicators of quality.

In addition, the performance of modern teaching hospitals for appendectomy was evaluated over time and compared with both historical controls and with reports from modern community, or non-teaching facilities.

RESULTS

A total of 76 peer reviewed articles were identified that discussed rates of morbidity and/or mortality in series of patients undergoing appendectomy for acute appendicitis. These reports covered patient experiences from 1892 through 2005 and reported on 399997 appendectomies for acute appendicitis. The literature and morbidity and mortality data are summarized in Table I.

The mortality data was plotted over time, using study midpoint year as the time data for each series. Polynomial regression analysis was performed on the data, and the

plot, with the regression curve ($p<0.0001$) is shown as figure 1. There was a clear, and precipitous decline in mortality from appendectomy between 1920 and 1940 that was followed by a fairly level, nearly zero, mortality rate for this procedure since that time. There was one outlier in the modern data from the VA consortium study which reported a 24% mortality rate in VA patients with acute appendicitis in 1995.

The morbidity data was also plotted over time, again using study midpoint year as the time marker for each series. Polynomial regression analysis was again perforomed on this data, and the regression curve, with confidence intervals are shown in figure 2. There was a clear, statistically significant decline in operative morbidity for appendectomy between 1895 and about 1960. After 1960, however, the morbidity for appendectomy began to rise to an average morbidity for appendectomy since the development of laparoscopic surgery in 1990 of 18%.

The series reported since 1960 were then divided into teaching hospitals, and community, or non-teaching hospitals. Historical controls were also generated of grouped morbidity of appendectomies prior to 1960, 1950, and 1940. These data are summarized in Table 2. The groups were compared using Pearson X^2 analysis. There was a significantly greater morbidity for appendectomies at teaching hospitals than non-teaching hospitals ($p<0.0001$), for teaching hospitals compared with appendectomies prior to 1960 ($p<0.0001$), and prior to 1950 ($p<0.0001$). Appendectomies performed prior to 1940 were associated with a significantly higher morbidity than for modern teaching hospitals ($p<0.01$).

DISCUSSION

The safe surgical treatment of appendicitis is of paramount importance, given the frequency of the operation, and the relative youth and health of the typical appendicitis patient. The data demonstrate significant success in achieving a low morbidity for appendectomy until 1960, and then progressively less success, such that major medical centers are now reporting morbidity rates as high as 30%.

There are a number of possible explanations for this increasing morbidity, such as differing standards of calculating, or reporting complications, severity of disease, and so on. By and large, though, review of the reporting standards for each series, and the complications reported are remarkably uniform over time. The development of antibiotics around 1940 appears to have made a significant difference in the mortality rate from appendicitis, but less of an effect on the infectious complication rates reported. It is hard to argue that the severity of appendiceal disease has worsened over time, given that there has been a clear decline over time in the rate of perforated appendicitis seen, and given that up to 10% of pre 1940 perforated appendicitis was caused by either tuberculosis or Actinomycosis. In addition, the pre-1940 or 1950 appendectomies were performed without muscle relaxation, ventilators, antibiotics, CT scanners, heparin, or reliable suture.

Similarly, since appendicitis is a community disease, generally cared for at the presenting hospital, it is also difficult to maintain that there is a significant difference in patient populations between community and teaching hospitals. One obvious possible explanation for the significantly different morbidity rates between the two types of centers is the level of training or experience of the operating surgeons. There is no data

available from these reported studies of teaching hospital experiences with appendectomy that describes the level of training of the operating surgeon for the appendectomy, and it would be helpful to include this information in future reports in the literature of laparoscopic or open appendectomy experiences.

The successful surgical treatment of acute appendicitis is a landmark triumph in the surgical treatment of a common disease. The combined findings of a steadily rising morbidity from appendectomy since 1960, and a significantly increased risk of morbidity from appendectomy at teaching hospitals are troubling, and should prompt an evaluation of how appendicitis is managed in our hospitals, and who should be performing appendectomy.

Figure 1 Morbidity (%) of Appendectomy over time

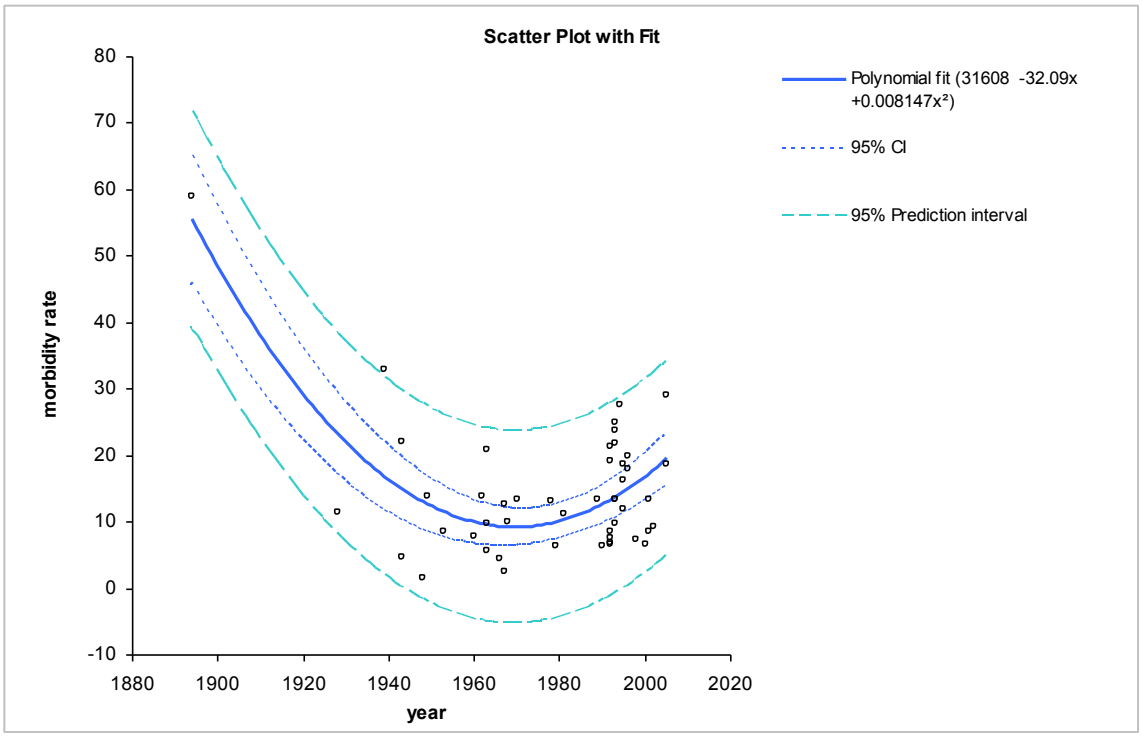

Table 1 Appendectomy Morbidity and Mortality Peer reviewed literature

Article	Location	years studied	mid year	# app's	# morbid	% morbid	# died	% died
Fowler [4]	Brooklyn, NY	1892-1895	1894	127	76	58.9	42	33.1
Beckett [5]	Los Angeles, CA	1899-1903	1901	54			6	11.1
Deaver [6]	Philadelphia, PA	1904-1909	1907	105			2	1.9
Dowd [7]	New York, NY	1907-1909	1908	100			0	0
Brinsmade [8]	Brooklyn, NY	1908-1914	1911	110			0	0
Guerry [9]	Columbia, SC	1909-1925	1917	2584			12	0.5
MacLaren [10]	St. Paul, MN	1915-1920	1918	255			13	5.1
Morse [11]	Brooklyn, NY	1915-1924	1920	4133			113	2.7
Nassau [12]	Frankford, PA	1904-1939	1922	3450			145	4.2
Schullinger [13]	New York, NY	1916-1935	1926	3058			144	4.7
Cutler [14]	Boston, MA	1913-1940	1927	2192			96	4.4
Eliason [15]	Philadelphia, PA	1928	1928	675	77	11.4	37	5.3
McKenna [16]	Chicago, IL	1922-1935	1929	3187			78	2.5
Morse [11]	Brooklyn, NY	1925-1934	1930	4594			75	1.6
Cantrell [17]	Baltimore, MD	1928-1931	1930	85			16	18.8
Schullinger [13]	New York, NY	1916-1945	1931	5405			193	3.6
Slattery [18]	Boston, MA	1928-1933	1931	391			25	6.3
Young [19]	Anderson City, SC	1923-1939	1932	3611			110	3
Smith [20]	New York, NY	1929-1937	1933	793			25	3.2
Rumbold [21]	Genessee, NY	1925-1939	1933	2013			66	3.3
Bower [22]	Philadelphia, PA	1928-1937	1933	22873			949	4.15
Slattery [23]	New York, NY	1928-1939	1934	677			35	5.1
Jennings [24]	Borrklyn, NY	1930-1938	1935	1680			32	1.9
Ray [25]	New York, NY	1932-1937	1935	886			19	2.1
Rogers [26]	Boston, MA	1929-1940	1935	3301			101	3.1
Grey Turner [27]	London, UK	1933-1937	1935	7329			298	4.1
Cantrell [17]	Baltimore, MD	1931-1939	1935	479			48	10
Stafford [28]	Baltimore, MD	1931-1939	1936	1317			47	3.6
Boyce [29]	New Orleans, LA	1930-1941	1936	4963			253	5.1
Slattery [23]	Boston, MA	1934-1939	1937	286			10	3.4
Hathaway [30]	Cleveland, OH	1930-1942	1937	19401			931	4.8
Reid [31]	Cincinnati, OH	1934-1938	1937	921			55	6
Aud [32]	Lousiville, KY	1939	1939	1161			45	3.9
Babcock [33]	Danville, PA	1936-1940	1939	382	126	33		5.5
Mueller [34]	New York, NY	1935-1944	1940	1481			24	1.6
Aycock [35]	Baltimore, MD	1935-1944	1940	1151			40	3.5
Tashiro [36]	Cincinnati, OH	1939-1943	1941	865			30	3.5
McGraw [37]	Detroit, MI	1938-1947	1943	1365	63	4.6	7	0.5
Babcock [33]	Danville, PA	1941-1945	1943	360	79	22		1
Schullinger [13]	New York, NY	1941-1945	1943	146			2	1.4
Cantrell [17]	Baltimore, MD	1939-1947	1943	325			23	7
Slattery [23]	Boston, MA	1940-1947	1944	265			4	1.5
Maynard [38]	New York, NY	1941-1948	1945	1334			64	4.8
Anderson [39]	Unites States Army Hospital	1947-1949	1948	680	10	1.5	0	0
Babcock [33]	Danville, PA	1946-1950	1949	519	73	14		1
Cantrell [17]	Baltimore, MD	1947-1954	1951	219			6	2.7
Babcock [33]	Danville, PA	1951-1955	1953	401	34	8.5	4	0.5
Howie [40]	Scotland, UK	1954-1963	1959	47467			805	1.7
Campaigne [41]	Duluth, MN	1956-1965	1960	2336	185	7.92	10	0.43

Mittelpunkt [42]	Chicago, IL	1960-1964	1962	1000	140	14	14	1.4
Kazarian [43]	New York, NY	1961-1965	1963	539	113	21	1	0.18
Seremetis [44]	France	1955-1970	1963	59655	5795	9.7	241	0.4
Seremetis [44]	United States	1955-1970	1963	27241	1531	5.62	120	0.4
Peltokallio [45]	Helsinki, Finland	1953-1974	1964	9652			16	0.2
Howorth [46]	Oxford, MS	1963-1968	1966	270	12	4.4	0	0
Crawford [47]	Brisbane, Australia	1965-1970	1967	200	5	2.5	0	0
Janik [48]	Chicago, IL	1957-1976	1967	1640	210	12.8	4	0.24
Lewis [49]	San Francisco, CA	1963-1973	1968	1000	101	10.1	8	0.8
Stuart [50]	Portland, ME	1967-1973	1970	675	90	13.3	5	0.8
Hauswald [51]	Lexington, KY	1966-1973	1970	944			12	1.3
Detmer [52]	Milwaukee, WI	1978	1978	1048	137	13.1	2	0.2
Linz [53]	Cleveland, OH	1978-1980	1979	107	7	6.5	0	0
Detmer [54]	Milwaukee, WI	1981	1981	924	104	11.3	1	0.1
Linz [53]	Cleveland, OH	1988-1990	1989	90	12	13.3	0	0
Attwood [55]	Dublin, Ireland	1990	1990	62	4	6.5	0	0
Franz [56]	Tampa, FL	1987-1992	1990	100			8	8
Nguyen D.	Boston, MA	1991-1993	1992	321	22	6.9	0	0
Richards [57]	Salt Lake City, UT	1990-1993	1992	720	62	8.6	0	0
Frazee [58]	Temple, TX	1992	1992	75	5	6.7	0	0
Tate [59]	Dublin, Ireland	1992	1992	140	30	21.4	0	0
Blomqvist [60]	Sweden	1987-1996	1992	117424			287	0.2
Baigrie [61]	Wales, GB	1992	1992	6595	508	7.7	16	0.24
Martinez-Mas [62]	Valencia,I Spain	1992	1992	249	48	19.3	1	0.4
Firilas [63]	Little Rock, AK	1993	1993	68	17	25	0	0
Ortega [64]	United States consortium	1993	1993	253	60	23.7	0	0
Hansen [65]	Brisbane, Australia	1992-1994	1993	158	21	13.3	0	0
Martin [66]	Miami, FL	1993	1993	169	37	21.9	0	0
Williams [67]	Mobile, AL	1992-1993	1993	75	10	13.3	0	0
Wagner [68]	Aarberg, Switzerland	1991-1995	1993	267	26	9.7	1	0.4
Long [69]	Rochester, MN	1992-1995	1994	202	56	27.7	0	0
Minne [70]	Denver, CO	1994-1995	1995	50	6	12	0	0
Margenthaler [71]	United States VA hospitals	1991-1999	1995	4163	679	16.3	74	1.8
Cox [72]	Bedford Park, Australia	1995	1995	64	12	18.8	2	3.1
Firilas [63]	Little Rock, AK	1995-1997	1996	42	8	20	0	0
Cheever [73]	Milwaukee, WI	1995-1996	1996	61	11	18	0	0
Lee [74]	Los Angeles, CA	1995-2000	1998	954	71	7.4	1	0.1
Ball [75]	Calgary, Alberta, CA	1995-2003	2000	332	22	6.6	0	0
Earley [76]	Philadelphia, PA	1999-2002	2001	294	39	13.3	0	0
Hoehne [77]	Bakersfield, CA	1999-2003	2002	216	20	9.3	0	0
Katkhouda [78]	Los Angeles, CA	2005	2005	247	46	18.6	0	0
Simpson [79]	Nottingham, UK	2004-2005	2005	199	58	29.1	1	0.5

Figure 2 Mortality from appendicitis/appendectomy (%) over time

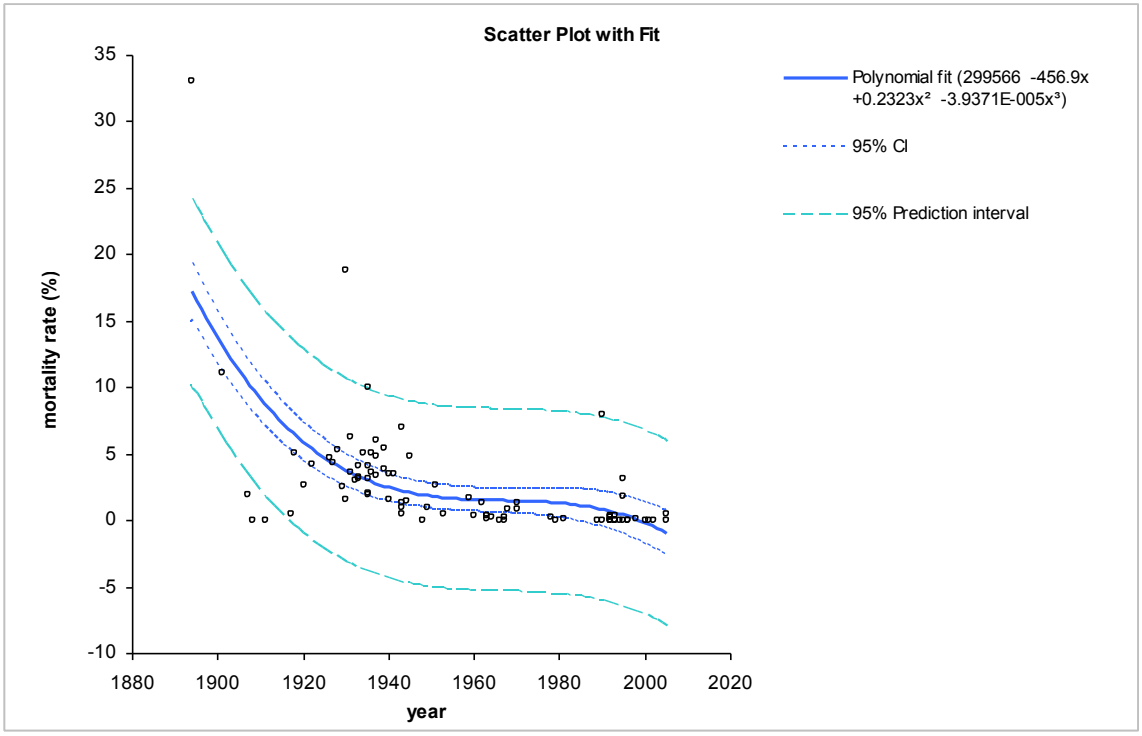

Table 2 Morbidity by time and type of institution

n	294584

	Groups		
morbidity of teaching	morbidity	no morbidity	Total
teaching hospitals > 1960	1591 (979.0)	9200 (9812.0)	10791
Teaching Hospitals 1989-2008	1070 (619.6)	5760 (6210.4)	6830
non-teaching hospitals > 1960	7312 (8548.5)	86913 (85676.5)	94225
all hospitals before 1960	538 (409.1)	3971 (4099.9)	4509
all hospitals before 1950	504 (372.7)	3604 (3735.3)	4108
All Hospitals before 1940	279 (107.4)	905 (1076.6)	1184
All Hospitals 1950-1981	8430 (8767.2)	88205 (87867.8)	96635
All Hospitals 1989-2008	7002 (6922.5)	69300 (69379.5)	76302
Total	26726	267858	294584

Pearson's X^2 statistic	1389.65
DF	7
p	<0.0001

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