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Mortality After Appendectomy in Sweden, 1987–1996

Paul G. Blomqvist, PhD,* Roland E. B. Andersson, PhD,† Fredrik Granath, PhD,* Mats P. Lambe, PhD,* and Anders R. Ekbom, PhD*

*From the *Karolinska Institutet, Department of Medical Epidemiology, Stockholm, Sweden, and the †Department of Surgery, Ryhov County Hospital, Jönköping, Sweden*

Objective
To study mortality after appendectomy.

Summary Background Data
The management of patients with suspected appendicitis remains controversial, with advocates of early surgery as well as of expectant management. Mortality is not known.

Methods
The authors conducted a complete follow-up of deaths within 30 days after all appendectomies in Sweden (population 8.9 million) during the years 1987 to 1996 (n = 117,424) by register linkage. The case fatality rate (CFR) and the standardized mortality ratio (SMR) were analyzed by discharge diagnosis.

Results
The CFR was 2.44 per 1,000 appendectomies. It was strongly related to age (0.31 per 1,000 appendectomies at 0–9 years of age, decreasing to 0.07 at 20–29 years, and reaching 164 among nonagenarians) and diagnosis at surgery (0.8 per 1,000 appendectomies after nonperforated appendicitis, 5.1 after perforated appendicitis, 1.9 after appendectomies for nonsurgical abdominal pain, and 10.0 for those with other diagnoses).

The SMR showed a sevenfold excess rate of deaths after appendectomy compared with the general population. The relation to age was less marked (SMR of 44.4 at 0–9 years, decreasing to 2.4 in patients aged 20–29 years. and reaching 8.1 in nonagenarians). The SMR was doubled after perforation compared with nonperforated appendicitis (6.5 and 3.5, respectively). Nonsurgical abdominal pain and other diagnoses were associated with a high excess rate of deaths (9.1 and 14.9, respectively). The most common causes of deaths were appendicitis, ischemic heart diseases and tumors, followed by gastrointestinal diseases.

Conclusions
The CFR after appendectomy is high in elderly patients. The excess rate of death for patients with nonperforated appendicitis and nonsurgical abdominal pain suggests that the deaths may partly be caused by the surgical trauma. Increased diagnostic efforts rather than urgent appendectomy are therefore warranted among frail patients with an equivocal diagnosis of appendicitis.

Acute appendicitis is one of the most common abdominal emergencies in the industrialized world. Suspected appendicitis remains a diagnostic challenge because of the similarity of symptoms to other gastrointestinal, gynecologic, and nonspecific functional diseases. Recent aids to improve the diagnostic workup, such as ultrasound, computed tomography, and diagnostic scoring systems, have not gained wide acceptance.[1–4]

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Correspondence: Dr. Roland Andersson, Department of Surgery, Ryhov County Hospital, SE-551 85 Jönköping, Sweden.
E-mail: roland.andersson@ryhov.ltjkpg.se
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The preferred management of patients with suspected appendicitis has been clinical assessment and a liberal attitude to early surgical exploration, with a subsequently high proportion of surgical procedures where the appendix is unaffected.[5,6] A proportion of negative appendectomies of 20% to 25% has been considered an acceptable level.[7] One reason for this policy has been the increased rates of death and complications after perforation, and the notion that early surgery could prevent perforation. This assumption has not been supported: most perforations probably have occurred by the time the patient arrives at the hospital, and the rate of exploration has not been found to have any influence on the incidence of perforation.[8–11] There are indications that spontaneous resolution occurs more frequently than is commonly thought, and recent studies have

shown smaller differences than expected in the long-term complication rate among patients with perforated appendicitis versus those with nonperforated appendicitis.[11,12]

The death and complication rates after perforated appendicitis have decreased over the years as a result of improved perioperative routines and postoperative care, including treatment with antibiotics. Parallel to the decrease in the death rate has been a decreasing rate of appendectomies, indicating a more conservative attitude to early surgical exploration.[11,13]

The aims of this study are to analyze the case-fatality rate (CFR), the standardized mortality ratio (SMR), and causes of death among patients undergoing appendectomy in Sweden during a 10-year period, and to analyze the association with age, gender, and the underlying cause of the abdominal pain.

METHODS

Setting

Sweden (population 8.9 million) has a national healthcare system based on administratively independent county councils. The private hospital sector is small and provides only elective care. Healthcare is mainly funded by local taxes. Since 1964, the Swedish National Board of Health and Welfare has compiled data on individual hospital discharges in the National Inpatient Register, and since 1987 the register has covered all Swedish hospitals. Besides a national registration number (uniquely identifying every resident of Sweden), each record contains medical data including surgical procedures performed (coded according to the Swedish Classification of Operations and Major Procedures, sixth edition) and diagnoses at discharge (coded according to Swedish version of the International Classification of Diseases, ninth Revision [ICD9] during 1987–1996).

Patients

All patients discharged during the years 1987 through November 1996 with a procedure code of appendectomy, performed as open surgery or by laparoscopy (procedure codes 4510, 4511, and 4517), were identified in the National Inpatient Register. Perforated appendicitis was defined as patients having an ICD9 discharge diagnosis of 540A (acute appendicitis with perforation or rupture) or 540B (acute appendicitis with peritoneal abscess). Nonperforated appendicitis was defined as patients having an ICD9 diagnosis of 540X (acute appendicitis without peritonitis), 541 (appendicitis, not specified), or 542 (appendicitis, otherwise not specified). In this study all diagnoses 289C (mesenterial lymphadenitis) and 789A (abdominal pain) were categorized as nonsurgical abdominal pain (NSAP). All other diagnoses were categorized as "other."

All postoperative deaths were analyzed by linking information on date of death and underlying cause of death through 1996 from the Swedish Death Register to the National Inpatient Register, using the personal identification number. Date of surgery was not recorded in the National Inpatient Register during this study period. Therefore, the time between surgery and death was calculated as the difference between the date of admission and the date of death, assuming that the patient had undergone surgery immediately after admission. Underlying causes of death were coded by the ICD9 classification. To enable a minimum follow-up of 30 days after admission, only patients undergoing surgery between January 1, 1987, and November 30, 1996, were included.

Data Analysis

Descriptive analyses of the characteristics of all patients undergoing surgery and of the fatal cases to and including 30 days after admission were performed, considering age, gender, discharge diagnoses, underlying causes of death, and time of death after admission. CFR per 1,000 appendectomies was computed by categories of discharge diagnosis and age. The 30-day standardized mortality ratio (SMR) was calculated using age-, calendar year-, and sex-specific expected survival estimates from the Swedish population. Ninety-five percent confidence intervals (CI) were calculated assuming a Poisson-distributed number of events.[14]

Multivariate analyses of the SMR patterns as a function of age, diagnosis group, sex, and calendar period were performed by Poisson regression using SAS software.[15] The statistical significance of influential factors and interactions was assessed by likelihood ratio tests.

RESULTS

Basic Data

The study cohort consisted of 117,424 patients (Table 1). The median age at surgery was 23 years (quartile range 15–38), and the gender distribution was almost even (male patients 50.7% vs. female patients 49.3%). Four fifths of the patients (80.9%) had a discharge diagnosis of appendicitis, 11.9% had NSAP (nonspecific abdominal pain or lymphadenitis), and the remaining 6.8% had a wide range of other diagnoses. The proportion of appendicitis patients with perforation was 20.2%. Most procedures were conventional appendectomies: only 2.0% of the appendectomies were performed by laparoscopy, increasing from 0.01% in 1986 to 7.6% in 1996. The annual incidence of appendectomies decreased by 17.5% during the study period. The decrease was confined to patients between 20 and 29 years (37%) and 30 to 39 years (23%), and to the patients with nonperforated appendicitis (9%) and negative appendectomy (48%). The incidence of perforated appendicitis remained stable.

During the study period, 287 of the patients died within 30 days after admission for a CFR of 2.44. For the patients with a final diagnosis of appendicitis, the CFR was 1.63, or 0.2 per

Table 1. APPENDECTOMY IN SWEDEN 1987–1996

Age group	Operations	Deaths within 30 days		Case fatality rate per 1000 operations	Standardised Mortality	
		Observed	Expected		Ratio	95% CI
0–9	9,756	3	0.07	0.31	44.4	9.2–129.7
10–19	37,098	3	0.40	0.08	7.6	1.6–22.1
20–29	27,054	2	0.82	0.07	2.4	0.3–8.8
30–39	15,664	3	1.04	0.19	2.9	0.6–8.4
40–49	10,937	9	1.95	0.82	4.6	2.1–8.8
50–59	6,534	14	2.86	2.14	4.9	2.7–8.2
60–69	5,160	37	6.22	7.17	5.9	4.2–8.2
70–79	3,757	97	12.26	25.86	7.9	6.4–9.6
80–89	1,407	96	12.21	68.23	7.9	6.4–9.6
90–99	140	23	2.84	164.29	8.1	5.1–12.2
Total	117,424	287	40.67	2.44	7.1	6.2–7.9

Age distribution, observed and expected number of deaths, case fatality rate per 1000 operations and standardised mortality ratios with 95% confidence intervals (CI) by age group.

100,000 population and year during the study period. The median age of those who died was 77.0 years (quartile range 69–84). Slightly more than a third of the patients died during the first 7 days (40.0%), and two thirds died within the first 2 weeks (68.3%). Most patients died in the hospital during the same admission as when the surgery was performed (68.4%).

Case Fatality Rate

The CFR was strongly influenced by patient age, forming a J-shaped curve (Tables 1 and 2). For those 9 years of age or younger, the CFR was 0.31. It was 0.07 for patients 20 to 29 years of age. From age 40 to 49 years, an almost threefold increase was found for each decade of age, reaching more than 16% in the nonagenarians. Gender had only a marginal influence on CFR (2.2 in female patients vs. 2.7 in male patients).

Patients with nonperforated appendicitis had the lowest CFR (0.76). Perforated appendicitis increased the rate six times to 5.08 (see Table 2). However, the difference between perforated and nonperforated appendicitis was only roughly doubled when analyzed by age interval. Patients with NSAP had a CFR of 1.87; those with other diagnoses had the highest CFR of all, 9.89.

Standardized Mortality Ratio

The SMR showed a sevenfold rate of excess deaths within 30 days after appendectomy compared with the general population (see Table 1). The relation to age was less marked than for CFR. Despite the few deaths in children younger than 10 years of age, the SMR reached 44.4 (95% CI 9.2–129.7) because of the low number of expected deaths. Patients aged 20 to 29 years had the lowest rate of excess deaths (SMR 2.4, 95% CI 0.3–8.8).

The multivariate analysis showed a significantly higher

Table 2. CASE FATALITY RATES PER 1,000 OPERATIONS (CFR) WITHIN 30-DAYS AFTER APPENDECTOMY BY DIAGNOSES AND AGE GROUPS

Age	Perforated appendicitis			Non-perforated appendicitis			Non-surgical abdominal pain			Other diagnoses		
	Operations	Deaths	CFR	Operations	Deaths	CFR	Operations	Deaths	CFR	Operations	Deaths	CFR
0–9	1,965	1	0.51	5,397	2	0.37	1,798	0	0.00	519	0	0.00
10–19	4,172	0	0.00	24,625	1	0.04	5,911	0	0.00	2,390	2	0.84
20–29	2,660	0	0.00	18,331	1	0.05	3,523	1	0.28	2,540	0	0.00
30–39	2,138	1	0.47	10,452	1	0.10	1,432	1	0.70	1,642	0	0.00
40–49	2,185	1	0.46	6,550	2	0.31	815	2	2.45	1,387	4	2.88
50–59	1,708	4	2.34	3,614	3	0.83	388	1	2.58	824	6	7.28
60–69	1,697	8	4.71	2,441	8	3.28	252	5	19.84	770	16	20.78
70–79	1,397	36	25.77	1,446	18	12.45	207	6	28.99	701	37	52.78
80–89	542	33	60.89	434	17	39.17	112	9	80.36	319	37	115.99
90–99	55	10	181.82	36	3	83.33	22	2	90.91	27	8	259.30
All	18,519	94	5.08	73,326	56	0.76	14,460	27	1.87	11,119	110	9.89

Table 3. STANDARDIZED MORTALITY RATIOS (SMR) WITH 95% CONFIDENCE INTERVAL (CI) AFTER APPENDECTOMY BY DIAGNOSES, AGE GROUPS AND GENDER

	Perforated appendicitis				Nonperforated appendicitis				Nonsurgical abdominal pain				Other diagnoses			
Age	Obs	Exp	SMR	95% CI	Obs	Exp	SMR	95% CI	Obs	Exp	SMR	95% CI	Obs	Exp	SMR	95% CI
0–19	1	0.10	9.8	0.2–54.9	3	0.20	15.3	3.2–44.6	0	0.09	0.0	0.0–39.8	2	0.07	27.2	3.3–98.2
20–59	6	1.51	4.0	1.5–8.6	7	3.90	1.8	0.7–3.7	5	0.47	10.5	3.4–2.4.6	10	0.78	12.8	6.1–23.5
60–79	44	6.84	6.4	4.7–8.6	26	7.49	3.5	2.3–5.1	11	0.95	11.6	5.8–20.8	53	3.20	16.6	12.4–21.7
80+	43	5.94	7.2	5.2–9.7	20	4.31	4.6	2.8–7.2	11	1.46	7.6	3.8–13.5	45	3.34	13.5	9.8–18.0
All	94	14.40	6.5	5.3–8.0	56	15.90	3.5	2.7–4.6	27	2.97	9.1	6.0–13.2	110	7.39	14.9	12.2–17.9
All men	51	9.14	5.6	4.2–7.3	31	10.00	3.1	2.1–4.4	14	1.44	9.7	5.3–16.3	62	3.92	15.8	12.1–20.3
All women	43	5.26	8.2	5.9–11.0	25	5.90	4.2	2.7–6.3	13	1.53	8.5	4.5–14.5	48	3.48	13.8	10.2–18.3

death rate for patients with perforated appendicitis versus nonperforated appendicitis, with an SMR of 1.73 (95% CI 1.24–2.43) ($P = .001$). There was a significant U-shaped relation with age ($P = .02$): SMRs relative to the age group 80+ years as follows (with 95% CI): 60 to 79 years, 0.88 (0.62–1.24); 20 to 59 years, 0.49 (0.27–0.90); and 0 to 19 years, 2.79 (1.00–7.73).

For NSAP and other diagnoses, the risk was increased in all age intervals, with an almost 9-fold excess rate of deaths for NSAP and a 15-fold excess rate for other diagnoses. There was a significantly higher SMR for female patients than for male patients, with an SMR of 1.39 (95% CI 1.00–1.92) ($P = .05$). No difference between the periods 1987 to 1991 and 1992 to 1996 was found.

Causes of Death

Cardiovascular disease was the most common cause of death (25.8%), followed by perforated appendicitis (19.9%), nonperforated appendicitis (14.3%), and tumors (12.9%) (Table 4). The patterns of causes of death varied by discharge diagnosis. Appendicitis and peritonitis accounted for 64% of the deaths among patients with perforated appendicitis, 45% of the deaths among the patients with nonperforated appendicitis, 19% of the deaths among the patients with NSAP, and 12% among the patients with other diagnoses. Among the NSAP patients, 70% were assigned a cause of death that was localized outside the abdomen. In these patients, neither the discharge diagnosis nor the cause of death motivated an abdominal exploration.

DISCUSSION

The CFR and the death rate after appendectomy for appendicitis in this study are among the lowest that have been reported.[16–20] Appendectomy is not, however, a harmless procedure; rather, it is associated with a sevenfold excess 30-day rate of death compared with the general population. The death rate after appendectomy is related to age and to the diagnosis at surgery. The highest CFR was found among elderly patients and the highest SMR among children younger than 10 years of age, showing a high risk in frail patients. Perforation of the appendix was associated with an almost doubled rate of death compared with non-

Table 4. UNDERLYING CAUSES OF DEATH AFTER APPENDECTOMY BY DISCHARGE DIAGNOSIS

	Appendicitis:									
	Perforated		Non-perforated		Nonsurgical abdominal pain		Other diagnoses		Total	
Causes of death	Number	%	Number	%	Number	%	Number	%	Number	%
Perforated appendicitis	49	52.1	5	8.9			3	2.7	57	19.9
Non-perforated appendicitis	11	11.7	20	35.7	4	14.8	6	5.5	41	14.3
Cardiovascular disease	29	30.9	15	26.8	8	29.6	22	20.0	74	25.8
Tumours	2	2.1	6	10.7	2	7.4	27	24.6	37	12.9
Splancnic circulatory disease					1	3.7	17	15.5	18	6.3
Intestinal obstruction	1	1.0					6	5.4	7	2.4
Cholecystitis							6	5.4	6	2.1
Peritonitis					1	3.7	4	3.6	5	1.7
Other	2	2.1	10	17.8	11	40.7	19	17.3	42	14.6
Total	94	100.0	56	100.0	27	100.0	110	100.0	287	100.0
(%)	32.8		19.5		9.4		38.3		100.0	

perforated appendicitis, but the difference was smaller among the very young and the very old. This is in accordance with the studies of Addiss et al[19] and Luckmann,[16] but the difference is smaller than reported by others who did not take the effect of age into account.[6,21,22]

Death after appendectomy is not caused by appendicitis only but is also related to comorbidity and the trauma of anesthesia and surgery.[20,23] For perforated appendicitis, the excess rate of death is likely to be explained by peritonitis or sepsis. Similarly, the death rate among patients with other diagnoses is also expected, because this group includes patients with other potentially fatal diseases that were diagnosed at surgery.

However, the causes of the excess death rate in the patients with a discharge diagnosis of nonperforated appendicitis and NSAP are not evident. In a few patients, the cause of death indicated a fatal disease that was not noted among the discharge diagnoses and therefore may have been undetected at the time of surgery. In many patients, however, the cause of death was a disease that is normally not fatal, such as nonperforated appendicitis and urinary tract infection. Many died of cardiovascular diseases. Some of these deaths may have been caused by the trauma of anesthesia and surgery in patients with low physiologic reserves as a result of age or comorbidity.[24] The excess death rate after appendectomy for nonperforated appendicitis and NSAP therefore suggests that the surgical trauma itself may in fact be an important cause of death, as proposed in 1971 by Lichtner and Pflanz.[25] An alternative interpretation is that frail patients are more prone to develop nonperforated appendicitis or to be subjected to appendectomy for NSAP. Unfortunately, comorbidity could not be assessed from the available data.

Our study is one of the largest population-based analyses performed on this subject. Unlike other studies, we also included deaths after appendectomy for causes other than appendicitis. The study design, with linkage of the National Inpatient Register to the Swedish Death Register, had the advantage of including all discharges after appendectomy in Sweden during a decade, and enabled a complete follow-up of both dates of death and underlying causes of death. This made it possible to include all deaths that had occurred within 30 days after surgery and also after the patient was discharged from the hospital.

Register studies may give biased results as a result of misclassification. The accuracy of an appendicitis diagnosis in the National Inpatient Register was assessed in one previous local study.[11] The appendicitis diagnosis was falsely positive in 10% and falsely negative in 6% of the patients when the registered diagnoses were compared with the pathologic anatomical diagnoses. These figures are probably representative of the whole register. Misclassification of the date of death is less likely because the reporting from the Swedish Death Register is virtually complete and is of high quality.[26] Misclassification of the causes of death is probably more of a problem because an autopsy has been performed in only some of the patients. However, it seems less likely that misclassification and undiagnosed fatal disease could explain all of the excess deaths after nonperforated appendicitis and NSAP.

Our results have implications for healthcare providers because of the changing panorama of appendectomies in industrialized countries. Longitudinal studies repeatedly have three main findings in common. The first is a decreasing incidence rate of appendectomies, in the range of two to five percentage points per year. The second is an increasing proportion of appendectomies among older patients, and the third is an improved diagnostic accuracy, particularly among women. With fewer patients undergoing surgery and successively older patients coming from an aging population, efforts to monitor outcomes are indeed relevant, but they need to be placed in a proper perspective. Appendectomy is associated with a low absolute number of deaths, only 3 per 1 million population per year. However, appendectomy is still associated with a rather high excess death rate, and our results suggest that some of these deaths may be avoidable.

It may be argued that a certain level of adverse events when operating on patients with suspected appendicitis is a calculated risk to be taken to prevent perforations, thereby reducing an even higher rate of death. However, the natural history of nonperforated appendicitis is not known, but there are indications that spontaneous resolution is common.[11] Others have shown that most perforations have already occurred before the patient arrives at the hospital, with no relation to in-hospital delay.[10,27,28] The strategy to prevent perforations by liberal and early exploration of patients with suspected appendicitis is therefore not supported.

Our results shed additional light on this practice because they suggest that the surgical trauma itself may cause deaths among patients who undergo appendectomy. Avoiding unnecessary surgery by making a correct preoperative diagnosis and minimizing surgical trauma by proper timing of surgery, with preoperative optimization of physiologic reserves, may therefore be more important to reduce the death rate from appendicitis than performing urgent appendectomy in patients with an equivocal diagnosis of appendicitis. Nonsurgical treatment with antibiotics and percutaneous drainage of abscesses may also be considered in selected patients.[29] The historical maxim, "the right to being wrong in the diagnosis of appendicitis is the only sure means to avoid mortality from an essentially benign disease," therefore no longer seems valid.[30]

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