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ORIGINAL SCIENTIFIC REPORT

Emergency Abdominal Operations in the Elderly: A Multivariate Regression Analysis of 430 Consecutive Patients with Acute Abdomen

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Abstract

Background This study is intended to ascertain if outcome of acute abdominal surgery among elderly patients with acute abdominal pain have improved.

Methods Altogether 456 patients aged >65 years underwent emergency abdominal surgery between the years 2007 and 2009 in our hospital. After excluding emergency reoperations of elective surgery, a total of 430 consecutive patients were included in this retrospective audit. The key factors under analysis in this study were the occurrence of major complications and death from any cause within 30 days after the operation. In addition, we compared our results to our previously published data some 20 years ago.

Results The most common diagnoses were cholecystitis ($n = 139$, 32.3 %, incidence of 125 per 100,000 elderly persons), incarcerated hernia ($n = 60$, 13.9 %, 54/100,000), malignancy related ($n = 50$, 11.6 %, 45/100,000), or acute appendicitis ($n = 46$, 10.7 %, 41/100,000). The majority of operations (80.7 %) were performed using open technique. Of all 112 laparoscopic procedures, 25.9 % were converted to open surgery. Reoperations were rare and postoperative surgical complications were not associated with statistically significant increase in mortality, even if reoperation was needed. The 30-day mortality and morbidity rates were 14.2 and 31.9 %, respectively. Logistic regression analysis showed that patient's age ($p = 0.014$), atrial fibrillation ($p = 0.017$), low body mass index ($p = 0.001$), open surgery ($p = 0.029$), ASA grade III or more ($p < 0.001$), and previous history of malignancies ($p = 0.010$) were likely to increase mortality.

Conclusions Despite modern diagnostics and improved surgical techniques, the results of emergency abdominal surgery still have relatively high morbidity and mortality as reported in earlier studies.

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Introduction

The world population is ageing rapidly [1]. This is a global issue, and both developed and developing countries will face a significant increase in the proportion of elderly people. The number of people worldwide over 65 years of age is estimated to rise from 524 million in 2010 to 1.5 billion in 2050 [2]. Not surprisingly, an ageing world poses social, economic and health care challenges. We can study these forthcoming challenges in countries where the demographic change has already occurred or is rapidly advancing. For example, in Finland during the past two decades, the percentage of people over 65 years of age has already increased from 13.5 to 19.4 [3]. As the proportion of people older than 65 years of age has increased and the proportion of younger people has diminished, ageing has emerged as one of this country's fundamental problems.

The demographic change in the population has changed the profile of emergency abdominal surgery, where typical diagnoses in elderly patients include acute cholecystitis, incarcerated hernia, bowel obstruction and acute appendicitis [4, 5]. Of these only the last one is considered less common in older patients [6]. In addition to a rise in the number of procedures required, the recovery from surgery is also considered more often complicated in the elderly [7, 8]. Complications are more common and hospital stays are longer. Altogether, it is reasonable to assume that the demand for surgical resources will grow [9].

Despite the urgent need for knowledge in the treatment of the elderly surgical patients with acute abdomen, there are surprisingly few population-based studies [4, 5, 7, 10–12]. Our former study from one district hospital some 20 years ago reported overall morbidity (26 %) and mortality (22 %) in emergency abdominal surgery of patients >65 years of age [5]. In the present study, we were interested to ascertain whether the diagnoses or the outcomes of emergency abdominal surgery in the elderly have changed apace with the development of laparoscopic surgery, advanced diagnostic imaging and intensive care medicine.

Materials and methods

All patients over 65 years of age who underwent emergency abdominal surgery between 2007 and 2009 at the study hospital (central hospital) in Finland (annual catchment area of approximately 193,500 inhabitants, of which approximately 37,000 were elderly inhabitants) were included in this study. All emergency cases from the catchment area were referred to this hospital. The data were collected retrospectively from the electronic medical records used in the emergency department, on the surgical ward and in the intensive care unit. Endoscopic procedures and emergency reoperations after elective surgery (26 patients) were excluded. Therefore, out of 456 patients operated on, a total of 430 patients were included in the study.

Outcome

Primary outcome variables were the following: 30-day mortality and morbidity. Secondary outcome variables were time spent in hospital (days), rate of conversion from laparoscopic to open surgery and rate of reoperations required. Complications were defined and classified by using Clavian-Dindo (C-D) classification [13]. The key factors under analysis in this study were the occurrence of major complications and death from any cause within 30 days after the operation.

Statistical analysis

All statistical analyses were performed using SPSS Statistics version 22 for Windows (IBM Corp, Armonk, NY, USA). The analysis of the categorical variables was calculated with the χ^2 test and of the continuous variables with the Mann–Whitney U test. The ANOVA and Kruskal–Wallis tests were used for multiple statistical comparisons. To estimate risk factors, all the variables significant in univariate analysis were inserted into a cox regression analysis. Hazard risk (HR) and their 95 % confidence intervals (CI) were derived from the multivariate analyses. Statistical significance was set at $p < 0.05$.

Results

The clinical characteristics of patients with or without complications are summarized in Table 1. 1. A total of 430 patients were included in the study (with a median age of 76 years (range 65–96), 50.9 % men). The most common comorbidities were hypertension ($n = 221$, 51.4 %), coronary artery disease ($n = 100$, 23.3 %) and atrial fibrillation ($n = 70$, 16.3 %). Only 113 patients (26.3 %) had no co-existing diseases. Patients with complicated (either death or serious complication) and uncomplicated outcome were compared. Older age ($p = 0.007$, $p < 0.001$) and polypharmacy ($p = 0.001$, $p < 0.001$) were associated with higher risk of death and complications. The patients who died had more often a history of previous malignancies ($p < 0.001$, especially gastrointestinal malignancy $p < 0.001$), coronary artery disease ($p = 0.001$) or atrial fibrillation ($p < 0.001$, with warfarin therapy $p < 0.001$).

Table 1 Baseline characteristics according to surgical outcome

Variable	Morbidity			Mortality			Total	
	n	(%)	*p* value[a]	*n*	(%)	*p* value[b]	($n = 430$)	
Age, mean (years, range)	77.8	± 7.2	0.007	79.9	± 6.6	<0.001	76.4	± 7.2
Sex, f/m	75	62	NS	29	32	NS	211	/219
BMI (kg/m^2)	26.8	± 4.5	NS	24.2	± 5.0	<0.001	26.4	± 4.7
Underweight (<18.50)	3	(33.3)	NS	7	(77.8)	<0.001	9	(2.1)
Normal weight (18.50–24.99)	47	(28.1)	NS	26	(15.6)	NS	167	(38.8)
Overweight (≥25.00)	57	(34.3)	NS	22	(13.3)	NS	166	(38.6)
Obese (≥30.00)	30	(34.1)	NS	6	(6.8)	0.026	88	(20.5)
Comorbidities								
None	28	(24.8)	NS	13	(11.5)	NS	113	(26.3)
Cardiac comorbidities[c]	101	(34.8)	NS	45	(15.5)	NS	290	(67.4)
Respiratory comorbidities[d]	16	(34.0)	NS	4	(8.5)	NS	47	(10.9)
Diabetes mellitus	24	(36.9)	NS	9	(13.8)	NS	65	(15.1)
Chronic rheumatic disease	7	(25.0)	NS	5	(17.9)	NS	28	(6.5)
Chronic kidney disease	5	(62.5)	NS	3	(37.5)	NS	8	(1.9)
Malignancies	20	(27.4)	NS	22	(30.1)	<0.001	73	(17.0)
Medication								
No medication	9	(18.4)	0.031	2	(4.1)	0.031	49	(11.4)
No anticoagulants	66	(29.3)	NS	28	(12.4)	NS	225	(52.3)
Acetylsalicylic acid	39	(33.1)	NS	10	(8.5)	0.037	118	(27.4)
Warfarin	29	(39.2)	NS	20	(27.0)	0.001	74	(17.2)
Other anticoagulants	5	(23.8)	NS	3	(14.3)	NS	21	(4.9)
Insulin therapy	11	(37.9)	NS	6	(20.7)	NS	29	(6.7)
Corticosteroids (per oral)	7	(25.9)	NS	7	(25.9)	NS	27	(6.3)
Polypharmacy (≥6 drugs)	76	(55.5)	0.001	42	(22.3)	<0.001	188	(43.7)
Previous abdominal surgery	37	(32.7)	NS	23	(20.4)	0.029	113	(26.3)

All the numbers in brackets are percentages

[a] Univariate analysis of patients with complications compared to patients without complications

[b] Univariate analysis of patients who died compared to patients who survived

[c] Atrial fibrillation ($n = 70$, 32.9 % mortality, $p < 0.001$), congestive heart disease, coronary artery disease ($n = 100$, 24 %, $p = 0.001$), hypertension and other cardiac comorbidities

[d] Asthma, chronic pulmonary disease, other respiratory disease

The absence of comorbidities did not statistically decrease mortality ($p = 0.341$). However, patients with no previous medication had both lower mortality ($p = 0.031$) and morbidity ($p = 0.031$). Mortality was also significantly lower in patients with acetylsalicylic acid medication ($p = 0.037$). Obesity was not associated with higher mortality; instead the surgical outcomes on underweight patients were significantly poorer ($p < 0.001$).

The most common diagnoses were cholecystitis ($n = 139$, 32.3 %, incidence of 125 per 100,000 elderly inhabitants), incarcerated hernia ($n = 60$, 13.9 %, 54 per 100,000) and malignancy related ($n = 50$, 12.0 %, 45 per 100,000). Acute appendicitis was the fourth most common reason for surgery. Of 59 patients, 46 had positive histology for acute appendicitis, while remaining 13 had normal histology ($n = 46$, 10.7 %, 41 per 100,000). Outcome varied between diagnoses. Figure 1 and Table 2 demonstrates the distribution of diagnoses.

In the 57 patients (13.3 %) who were misdiagnosed in the emergency department, the risk of complications was found to be higher. Higher ASA classification indicated higher morbidity ($p = 0.003$) and mortality ($p < 0.001$). The surgeon's experience had no effect on the outcome. Of all 112 laparoscopic procedures, 29 (25.9 %) required conversion to open surgery. Mortality in open surgery was statistically significantly higher ($p = 0.002$). Only four patients died after laparoscopic operation, all of them after cholecystectomy. The perioperative data are presented in Table 3.

Fig. 1 Emergency abdominal operations performed between 2007 and 2009

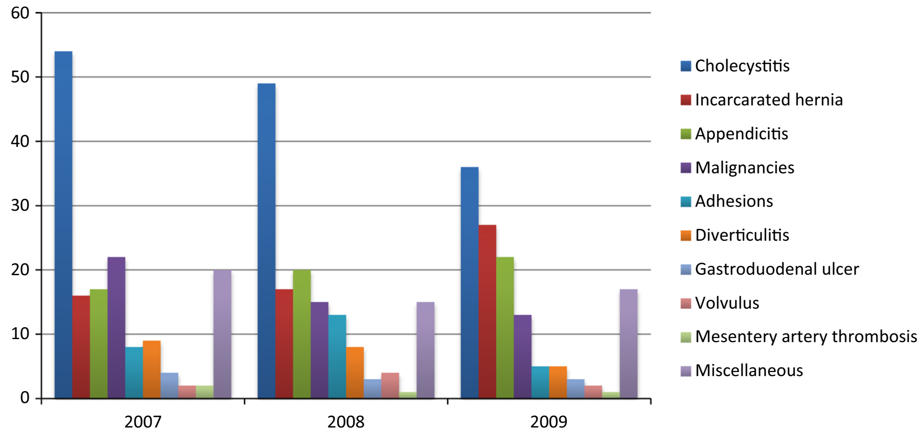

Table 2 Major outcome and complications by procedure

Surgical diagnosis	*n*	(%)	*n*/100,000	Morbidity (%)	Mortality (%)
Acute cholecystitis	139	(32.3)	125	28.1	5.8
Incarcerated hernia	60	(13.9)	54	30.0	13.3
Inguinal	24	(5.6)	22	29.2	12.5
Femoral	18	(4.2)	16	22.2	5.6
Other	18	(4.2)	16	38.9	22.2
Malignancies	50	(11.6)	45	28.0	28.0
Large bowel	25	(5.8)	23	36.0	20.0
Palliative	20	(4.7)	18	15.0	40.0
Acute appendicitis	46	(10.7)	41	23.9	0.0
Intestinal obstruction caused by adhesions	26	(6.0)	23	61.5	15.4
Acute diverticulitis	22	(5.1)	20	50.0	36.4
Gastro-duodenal ulcer	10	(2.3)	9	60.0	10.0
Volvulus	8	(1.9)	7	62.5	25.0
Mesentery artery thrombosis	4	(0.9)	4	0.0	100
Miscellaneous	65	(15.1)	58	26.2	18.5
Total	430	(100)	387	31.9	14.2

All numbers in brackets are percentages

The overall mortality and morbidity were 14.2 and 31.9 %, respectively. Medical complications (17.2 %, C-D $\geq$ III 55.6 %) were more common than surgical complications (14.9 %, C-D III $\geq$ 59.4 %). There were no complications directly associated with anaesthesia. In univariate analysis, patients with complicated outcome were compared to patients without complications. Medical complications ($p < 0.001$) including postoperative heart failure ($p = 0.011$), pneumonia ($p = 0.001$) and sepsis ($p = 0.003$) were associated with higher mortality. Conservative treatment was sufficient in most cases. Reoperations were rare (30 patients, 7.0 %), with no associated significant rise in mortality. Of the mortalities, one patient died during the operation and the rest during the 30-day follow-up. Most common causes of death were infections and malignancy related. Tables 2, 4 and 5 presents the prevalence of postoperative complications and death.

The results were compared to those of our earlier study. The mean age was 76 years in both studies (with 49 % being female in the new data and 50 % in the older study). In the older study, more patients were considered to be ASA classes three or more. Four of the most common diagnoses were the same. Incidence of cholecystitis was higher (32 vs. 18 %) and the incidence of gastro-duodenal ulcer disease was lower (2 vs. 10 %). Overall mortality in earlier study was 22 % and morbidity 26 %. The mortality of patients aged 65–69, was 6 % in both studies. In older patients, the older study reported a higher risk of dying,

Table 3 Perioperative data and outcomes

Variable	n	(%)	Morbidity		Mortality	
			(%)	p value[a]	(%)	p value[b]
Misdiagnosed when admitted to hospital	57	(13.3)	(56.1)	$p < 0.001$	(19.3)	NS
Preoperative ASA						
ASA I–II	255	(59.3)	(26.3)	$p = 0.003$	(5.5)	$p < 0.001$
ASA ≥III	175	(40.7)	(40.0)	$p = 0.003$	(26.9)	$p < 0.001$
Preoperative antibiotics	409	(95.1)	(32.5)	NS	(14.7)	NS
Surgeon's experience						
Specialist	241	(56.0)	(34.9)	NS	(15.8)	NS
Other subspeciality	75	(17.4)	(33.3)	NS	(17.3)	NS
Resident	114	(26.5)	(24.6)	NS	(8.8)	NS
Surgical technique						
Open surgery	347	(80.7)	(33.7)	NS	(16.7)	$p = 0.002$
Laparoscopic surgery	83	(19.3)	(24.1)	NS	(3.6)	$p = 0.002$
Conversion required	29	(6.7)	(37.9)	NS	(3.4)	NS
Postoperative anticoagulation	302	(70.2)	(39.7)	$p < 0.001$	(18.5)	$p < 0.001$
Treatment in the ICU	48	(11.2)	(62.5)	$p < 0.001$	(31.3)	$p < 0.001$

All the numbers in brackets are percentages

[a] Univariate analysis of patients with complications compared to patients without complications

[b] Univariate analysis of patients who died compared to patients who survived

Table 4 Postoperative complications and mortality

Variable	n	(%)	Mortality within group	
			(%)	p value[a]
Morbidity	137	(31.9)		
Medical complication	74	(17.2)	(28.4)	$p < 0.001$
Heart failure	35	(8.1)	(28.6)	$p = 0.011$
Pneumonia	23	(5.3)	(39.1)	$p < 0.001$
Sepsis	5	(1.2)	(60.0)	$p = 0.003$
Surgical complication	64	(14.9)	(12.5)	NS
Wound dehiscence	17	(4.0)	(50.0)	$p = 0.001$
Conservatively treated	111	(25.8)	(19.8)	$p = 0.048$
Reoperation required	30	(7.0)	(23.3)	NS
30-days mortality	61	(14.2)		

All numbers in brackets are percentages

[a] Univariate analysis of patients who died compared to patients who survived

especially in the oldest age group (21 vs. 43 %). The mortality in ASA classes II, III or more was almost the same. The comparison between the two studies is presented in Table 6.

To estimate the risk factors behind higher mortality, a multivariate analysis was performed after bivariate correlation analysis. All the statistically significant variables (age, BMI, previous history of malignancies, coronary artery disease, atrial fibrillation (warfarin therapy), acetylsalicylic acid medication and history of no previous medication, surgical technique, ASA classification) were inserted into a cox regression analysis. The results of the multivariate analysis are shown in Table 7. Patients with increased mortality were older ($p = 0.014$), had atrial fibrillation more often ($p = 0.017$), had a previous history of malignancy ($p = 0.010$) or were underweight ($\mathrm{BMI} \leq 18.50$, $p = 0.001$). ASA grade III or more ($p < 0.001$) was associated with poor outcome, as there was also an association with higher mortality after open surgical procedures ($p = 0.029$).

Discussion

The main result of this study was that regardless of technical progress, mortality and morbidity among elderly patients requiring emergency abdominal surgery is still surprisingly high. Patient's age, low body mass index, atrial fibrillation, previous history of malignancy and the surgical technique chosen were found to increase mortality. In contrast to postoperative surgical complications, medical complications were associated with higher mortality. ASA class three or more predicted higher morbidity and mortality.

Table 5 Postoperative mortality and causes of death following surgery

Variable	65–69 years ($n = 98$)		70–84 years ($n = 270$)		Over 85 years ($n = 62$)		All patients ($n = 430$)	
	n	(%)	*n*	(%)	*n*	(%)	*n*	(%)
Malignancy related	6	(6.1)	10	(3.7)	1	(1.6)	17	(4.0)
Systemic infection	0	(0.0)	17	(6.3)	4	(6.5)	21	(4.9)
Pneumonia	0	(0.0)	5	(1.9)	3	(4.8)	8	(1.9)
Other infection	0	(0.0)	1	(0.4)	0	(0.0)	1	(0.2)
Cardiovascular	0	(0.0)	3	(1.1)	1	(1.6)	4	(0.9)
Other	0	(0.0)	3	(1.1)	3	(4.8)	6	(1.4)
Unknown	0	(0.0)	3	(1.1)	1	(1.6)	4	(0.9)
30-days mortality	6	(6.1)	42	(15.6)	13	(21.0)	61	(14.2)
In-hospital mortality	2	(2.0)	27	(10.0)	10	(16.1)	39	(9.1)
90-days mortality	7	(7.1)	61	(22.6)	18	(29.0)	86	(20.0)
360-days mortality	9	(9.2)	73	(27.0)	23	(37.1)	105	(24.4)

All numbers in brackets are percentages

Table 6 The results of surgery compared to the previous study

Variable	Kettunen et al. [5] ($n = 201$)	Our present study ($n = 430$)
Age, year (mean, range)	76 (65–98)	76 (65–96)
Sex, female	50 %	49 %
Cardiovascular disease	52 %	67 %
Diabetes mellitus	12 %	15 %
Chronic pulmonary disease	11 %	11 %
Previous history of malignancies	12 %	17 %
ASA 1–2	24 %	59 %
ASA ≥3	76 %	41 %
Diagnose: Acute cholecystitis	18 %	32 %
Diagnose: Acute appendicitis	16 %	11 %
Diagnose: Incarcerated hernia	11 %	14 %
Diagnose: Malignancy	11 %	12 %
Diagnose: Gastro-duodenal ulcer	10 %	2 %
Morbidity, *n* (%)	22 %	32 %
Mortality	22 %	14 %
Mortality in patients aged 65–69	6 %	6 %
Mortality in patients aged 70–84	22–27 %	16 %
Mortality in patients aged over 85 years	43 %	21 %
Mortality in patients with ASA I–II	4.8 %	6 %
Mortality in patients with ASA ≥III	28 %	27 %

As our study showed, fewer surgeries were required for complicated gastro-duodenal ulcer disease. In addition to incidence, deaths were also less frequent in our series. In comparison to other newer data, Soreide et al. reported similar incidence (3.8–14/100,000) and mortality (10–25 %) in their study [14]. The lower risk of complicated peptic ulcer disease might be explained by the increased use of Helicobacter pylori eradication therapy and PPI-medication.

Our study reported high mortality in patients with diverticular disease. In comparison, Lidsky et al. reported 9.7 and 17.8 % mortality and 45.5 and 44.1 % morbidity in elderly (aged 65–79) and super-elderly (aged over 80) patients [15]. Zingg et al. reported higher mortality,

Table 7 Predictors of 30-days mortality according to operation performed

Variable	Mortality		
	HR	95.0 % CI	p value
Age	1.05	1.01–1.10	0.014
Atrial fibrillation	2.12	1.14–3.93	0.017
Malignancies	2.22	1.21–4.09	0.010
BMI			
Normal weight	Reference group		
Underweight (BMI $\leq$ 18.50)	4.80	1.87–12.3	0.001
ASA grade III or more	4.28	2.00–9.18	<0.001
Surgical technique (open surgery)	3.23	1.13–9.24	0.029

especially after Hartmann's procedure (29.2 %) [16]. In our study, only 22 patients were operated on due to diverticulitis (incidence of 20 per 100,000 elderly persons) and all were operated on with Hartmann's procedure.

In our study, surgical treatment of acute appendicitis was safe. There were no mortalities and the complication rate in appendectomy was 23.9 %. There was no significant difference in comparison to the earlier study. Instead, it is noteworthy that 77.8 % of patients had positive histology for appendicitis, the rest being normal. The use of CT might improve diagnostic accuracy in elderly patients [17].

Although age was found to be significantly and independently associated with higher mortality, its real significance is debatable (HR 1.05, with 95 % CI 1.01–1.10). If compared to the earlier study, the results for extremely old patients seem to be getting better. This may in part be due to higher life expectancy. From 1990 to 2009, life expectancy at the age of 65 rose from 13.7 years in males and 17.7 years in females to 17.2 and 21.2 years, respectively [18]. Nevertheless mortalities occur, and they are more common in older patients. In contrast to younger patients, the importance of proper diagnosis and the treatment of post-operative infections seem to be critical, as we can see in the causes of deaths.

In our present study, more than half of the patients were considered obese, which is a much higher percentage than among general elderly population in Finland [19]. Increasing obesity may explain the higher prevalence of cholecystitis compared to that reported in the earlier study, as described in the preceding paragraphs [20]. In addition, the mortality of elderly patients undergoing cholecystectomy was surprisingly high. Kuy et al. reported 3.2 % mortality after cholecystectomy in patients aged 80 or more [21]. However, they stated that reported mortality may have been too low, because readmissions and post-discharge mortality were not captured. In another epidemiologic study on Scottish population, mortality was especially high in the elderly population and in patients who had acute causes for surgery [22]. We focused especially on emergency admissions, and mortalities were precisely documented, also including post-discharge deaths.

In addition to obesity, surprisingly polypharmacy and warfarin therapy were also more common than in general elderly population [23]. In our data, 43.7 % of patients had six or more, and 16.7 % of patients ten or more medications. In the univariate analysis, polypharmacy was associated with poorer results, but in the multivariate analysis no such association was found. Most patients with multiple medications had a disease independently associated with higher mortality, such as atrial fibrillation. Furthermore, instead of counting the total amount of medication taken we believe we should focus on medication with systematic effect, as some of the drugs used could be classified as a risk-reducing medications (for example statins) and some most likely have little to no systematic effect (for example vitamins). In our study, we did a separate analysis only for corticosteroids, different anticoagulatives and insulin therapies. More studies on this subject are needed.

As initially noted, postoperative medical complications were more common than surgical complications. Only wound dehiscence was linked to higher mortality in the univariate analysis, but in the multivariate analysis no association was found. Nevertheless, it was the most common reason for reoperation. Mortality was highest in and after open surgeries. However, there was a significant patient selection bias because laparoscopic surgery was not initially chosen for patients with the highest preoperative risk or for those with assumed complicated diagnoses.

This study was a retrospective analysis of the results of emergency abdominal surgery on the elderly. Due to the retrospective nature of the study, we were unable to gather some data, for example, on patients' lifestyles. There were also problems with documentation. Surgical complications were accurately documented, medical complications, on the other hand, were not. To gather more reliable data on medical complications for our analysis, we had to go through all the perioperative imaging and nursing reports. The mortalities, however, were precisely documented. As we discovered, the results of emergency abdominal surgery vary not only between diagnostic groups but also by the surgical technique used. There were many surgeons who were highly experienced and some with less experience of emergency abdominal surgery on the elderly. Due to this, the surgical technique chosen may have varied between patients. The same variation was also seen in the quality of perioperative treatment.

Conclusions

In conclusion, this study shows that, regardless of technical progress, postoperative morbidity is still an important problem in emergency abdominal surgery performed on elderly. Even though we had more complications in our study than in our earlier study, fewer patients died in our series.

Compliance with ethical standards

Conflict of interest The authors declare that there are no conflicts of interest.

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