ORIGINAL ARTICLE

Deaths Following Cholecystectomy and Herniotomy

An Analysis of Nationwide German Hospital Discharge Data From 2009 to 2013

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SUMMARY

Background: In 2010, 158 000 cholecystectomies and 207 000 herniotomies (without bowel surgery) were performed in Germany as inpatient procedures, generally on a routine, elective basis. Deaths following such operations are rare events. We studied the potential association of death after cholecystectomy or herniotomy with risk factors that could have been detected beforehand, and we examined the types of complications that were documented in these cases.

Methods: Using nationwide hospital discharge data (DRG statistics) for the years 2009–2013, we analyzed the characteristics of patients who died in the hospital after undergoing a cholecystectomy for cholelithiasis or the repair of an inguinal, femoral, umbilical, or abdominal wall hernia. We compared these data with those of patients who survived and studied the impact of the coded comorbidities on the risk of death.

Results: In Germany, in the years 2009–2013, there were 2957 deaths after a total of 731 000 cholecystectomies (in-hospital mortality, 0.4%) and 1316 deaths after a total of 1 023 000 herniotomies without bowel surgery (0.13%). The patients who died were markedly older than those who did not, and they more commonly had comorbidities. Factors associated with a higher risk of death were age over 65 years, and comorbidities such as congestive heart failure, chronic pulmonary or hepatic disease, or poor nutritional status. Complications were coded much more often for the patients who died than for those who did not.

Conclusion: These findings suggest that there is potential for improvement in preoperative risk identification, complication avoidance, and the early recognition and treatment of complications, as well as in safe surgical technique. Measures to lower the mortality associated with herniotomy and cholecystectomy would lessen patients' individual risk and thereby improve patient safety.

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G allbladder removal (cholecystectomy) and surgical repair of an inguinal, femoral, umbilical, or abdominal hernia (herniotomy) are common surgeries. A previous analysis found that approximately 158 000 inpatient cholecystectomies and 207 000 herniotomies without concomitant bowel surgery were performed in Germany in 2010. The median annual case number per hospital was 130 cholecystectomies and 156 herniotomies (1).

Death associated with this usually routine, scheduled surgery is perceived as a rare event. In Germany, the risk of dying in hospital in connection with a cholecystectomy was 0.49% (corresponding to one death per 204 operations) in 2010. For herniotomies the hospital mortality rate was 0.13% (corresponding to one death per 759 operations) (1). This means that, statistically, in an average hospital there is one cholecystectomy-related death every 19 months and one herniotomy-related death only once every five years. This makes it difficult to identify systematic correlations in everyday clinical practice.

Information obtained from peer reviews on quality improvement which analyzed deaths associated with cholecystectomy and herniotomy indicates that there is potential for improvement in indication and in perioperative and postoperative management (2, 3). In particular, patients at increased risk of complications as a result of comorbidities should be identified as high-risk patients before surgery and be provided with appropriate care (2).

The nationwide German hospital discharge data forms a complete dataset and can therefore be used to analyze even rare events. On the basis of this data, this study investigates the characteristics of patients who died in hospital in connection with a cholecystectomy or herniotomy and compares them to the characteristics of surviving patients.

It also analyzes the effect of documented comorbidities illnesses on the risk of death and examines complications and specific interventions during the course of treatment.

Methods

Data

Using controlled remote data processing, we analyzed the nationwide Diagnosis-Related Groups Statistics (DRG Statistics) provided by the German Federal Statistical Office's Research Data Center (4). The nationwide DRG Statistics contain the data records of all acute inpatient hospital cases reimbursed according to the DRG system. This information includes age and sex, diagnoses (coded according to ICD-10-GM International Classification of Diseases, 10th Revision, German Modification) and procedures (coded according to the Surgery and Procedure Coding System [OPS, Operationen- und Prozedurenschlüssel]), hours of mechanical ventilation, and discharge mode for every inpatient case.

In order for analysis to cover sufficient deaths to provide statistical power, data for the years 2009 to 2013 were included and analyzed cumulatively.

Case definition

The units of analysis are inpatient hospital cases in which a patient underwent a cholecystectomy or herniotomy. Cholecystectomies include gallbladder removal for gallstones (cholelithiasis), excluding malignant neoplasias, extended cholecystectomies, and those performed concomitantly with other surgeries were excluded. Herniotomies are defined as surgeries for inguinal, femoral, umbilical, or abdominal hernia, excluding those with concomitant bowel surgery (*eTable 1*). Analyses are limited to patients aged 20 years or over.

Comorbidities, complications, specific interventions

Comorbidities are taken to include conditions that probably existed prior to inpatient admission (e.g. heart failure, chronic lung disease) and that represent potential risk factors for in-hospital death (5–9). Complications include events that are classified as complications in the ICD (e.g. surgical complications such as accidental perforation and suture failure) and serious conditions that would contraindicate the surgery in question (e.g. pulmonary embolism, acute kidney failure) and therefore probably first occurred during treatment. Comorbidities and complications were identified using the coded diagnoses (*eTable 2*).

In addition, specific interventions that indicate complicated patient progress were also investigated. These include, for example, blood transfusions of more than six units and relaparatomies, identified using coded procedures (*eTable 2*). Inpatients receiving mechanical ventilation for longer than 24 hours were also identified, on the basis of documented mechanical ventilation duration.

Analysis

Patient characteristics, comorbidities, complications, and interventions were stratified by survival status. The effects of age, sex, and comorbidities on the in-hospital mortality risk were analyzed using odds ratios that

estimate the risk of death when a characteristic (e.g. a comorbidity) is present in relation to the risk of death when the characteristic is not present. In addition to crude odds ratios, odds ratios adjusted for age, sex, and comorbidities are also provided. These were calculated using generalized logistic regression (10). The adjusted odds ratios quantify the change in risk independently of the effects of other factors in the regression equation. The statistical significance of the odds ratios was assessed using 95% confidence intervals. The discriminatory power of the regression models was assessed using the c-statistic, which is equivalent to the area under the ROC (receiver operating characteristic) curve (11, 12). This measure describes the association of deaths predicted by the regression model and observed deaths. c-values can range between 0.5 (no discrimination) and 1.0 (perfect discrimination). All calculations were performed using SAS version 9.3.

Results

Patient characteristics

Approximately 731 000 cases of cholecystectomy for cholelithiasis and 1 023 000 cases of herniotomy without concomitant bowel surgery were identified during the study period. Between 2009 and 2013, the in-hospital mortality rate for cholecystectomy remained steady at 0.4%. For herniotomy in-hospital mortality was 0.14% from 2009 to 2011, 0.11% in 2012, and 0.13% in 2013. A total of 2957 deaths occurred following cholecystectomy and 1316 following herniotomy during the study period (*Table 1*).

Stratified analysis of the characteristics of surviving and deceased patients shows, unsurprisingly, that for both procedures those who died were substantially older than those who survived. For cholecystectomy the proportion of females was slightly lower among those who died than among those who survived; for herniotomies it was somewhat higher. Almost all comorbidities analyzed were recorded more frequently among those who died than among those who survived. At least one of the analyzed comorbidities had been coded in 99% of deaths following cholecystectomy and 91% of deaths following herniotomy. The mean duration of hospital stay was also substantially longer for patients who died (*Table 2*).

Factors associated with the risk of death following cholecystectomy

For cholecystectomy, the crude figures indicate that ages over 65 years are associated with a risk of death 27 times higher than that of younger patients. After adjustment for sex and comorbidities, the risk of death for patients aged over 65 remains 10 times as high as for younger patients, independently of other factors. According to the crude figures, female sex appears to be associated with a lower risk of death, but this correlation is no longer discernible after adjustment (*Table 3*).

The crude odds ratios of all analyzed comorbidities other than obesity indicate an association with an

TABLE 1

Patient characteristics by year

	2009	2010	2011	2012	2013	Total
Cholecystectomy for cholelithiasis						
No. of cases	145 670	146 041	146 178	146 726	146 811	731 426
No. of deaths	626	576	595	578	582	2957
In-hospital mortality rate	0.43%	0.39%	0.41%	0.39%	0.40%	0.40%
Mean age (years)	55.8	55.9	55.9	56.0	55.9	55.9
Percentage aged 65 years or over	35.3%	34.8%	34.1%	34.1%	33.6%	34.4%
Percentage female	66.9%	66.3%	65.9%	65.4%	65.1%	65.9%
Mean no. of secondary diagnoses coded per case	2.8	2.9	3.1	3.2	3.3	3.1
Mean no. of investigated comorbidities per case	1.3	1.3	1.3	1.4	1.4	1.3
No. of hospitals	1139	1125	1103	1080	1062	1206
Mean no. of cases per hospital	128	130	133	136	138	133
Herniotomy for inguinal, femoral, umbilical, or abdominal hernia						
No. of cases	201 796	200 969	205 699	208 930	205 488	1 022 882
No. of deaths	281	273	281	220	261	1316
In-hospital mortality rate	0.14%	0.14%	0.14%	0.11%	0.13%	0.13%
Mean age (years)	59.7	59.6	59.7	59.7	59.6	59.7
Percentage aged 65 years or over	44.4%	43.5%	43.0%	42.5%	42.0%	43.1%
Percentage female	20.8%	20.5%	20.3%	20.2%	20.0%	20.3%
Mean no. of secondary diagnoses coded per case	2.2	2.2	2.3	2.4	2.5	2.3
Mean no. of investigated comorbidities per case	0.8	0.8	0.8	0.9	0.9	0.8
No. of hospitals	1202	1195	1158	1137	1116	1294
Mean no. of cases per hospital	168	168	178	184	184	176

increased risk of death. After adjustment, an increased risk independent of other factors remains for most comorbidities. The strongest association occurs in patients with heart failure or dilated cardiomyopathy, whose risk of death is 3.6 times higher than that of patients for whom no such comorbidity is coded. Patients with malnutrition and those with coagulation disorders both have a 3.5-fold risk increase. Inflammatory conditions at the surgical site (cholangitis, acute cholecystitis, or biliary pancreatitis) are associated with 3.2-fold increase in the risk of death. In patients with chronic liver disease, chronic pancreatitis, or chronic kidney failure the risk of death is more than twice as high as in patients without these comorbidities. Other comorbidities associated with a significantly increased risk of death according to the adjusted odds ratios are cardiac arrhythmias, chronic ischemic heart disease, atherosclerosis, chronic lung disease, diabetes mellitus, and peritoneal adhesions. For obesity, both the crude and the adjusted analysis actually indicate a protective effect. This means that cholecystectomy patients for whom obesity is coded as a secondary diagnosis have a

lower risk of dying in the hospital. Following adjustment, patients with hypertension also have a lower risk of death than patients for whom it is not coded. Aortic or mitral valve defects and severe kidney disease showed no significant effect on the risk of death after adjustment (*Table 3*).

The *c*-value of the regression model was 0.925. This means that the model has a high power of discrimination and can differentiate very well between patients who died and those who survived on the basis of the variables used here.

Factors associated with the risk of death following herniotomy

In herniotomy patients, after adjustment age over 65 years is associated with a more than 5-fold increase in the risk of death. Women have more than twice the risk of dying in the hospital of men according to both crude and adjusted figures (*Table 3*).

According to the crude figures, all comorbidities appear to be associated with an increased risk of death. After adjustment a greatly increased risk remains for several comorbidities: the risk of death in malnourished

TABLE 2

Patient characteristics by survival status

	Cholecystectomy for cholelithiasis				Herniotomy for inguinal, femoral, umbilical, or abdominal hernia			
	Surviving		Dying		Surviving		Dying	
	Cases	Percentage	Cases	Percentage	Cases	Percentage	Cases	Percentage
Total	728 469	100.0%	2957	100.0%	1 021 566	100.0%	1316	100.0%
Aged 65 years or over	248 841	34.2%	2759	93.3%	439 342	43.0%	1160	88.1%
Female	480 496	66.0%	1540	52.1%	207 576	20.3%	515	39.1%
Investigated comorbidities								
Cardiac arrhythmia	37 261	5.1%	1249	42.2%	64 084	6.3%	468	35.6%
Heart failure/dilated cardiomyopathy	23 478	3.2%	1282	43.4%	34 331	3.4%	500	38.0%
Chronic ischemic heart disease	39 402	5.4%	791	26.8%	80 765	7.9%	306	23.3%
Hypertension (without heart or kidney failure)	251 753	34.6%	1453	49.1%	339 720	33.3%	574	43.6%
Aortic/mitral valve defects	4246	0.6%	130	4.4%	8160	0.8%	58	4.4%
Atherosclerosis of the extremities	4293	0.6%	159	5.4%	8874	0.9%	63	4.8%
Chronic lung disease	32 971	4.5%	426	14.4%	57 997	5.7%	213	16.2%
Chronic liver disease	22 941	3.1%	321	10.9%	11 319	1.1%	164	12.5%
Chronic pancreatitis	1639	0.2%	21	0.7%	991	0.1%	5	0.4%
Severe kidney disease	4723	0.6%	259	8.8%	3849	0.4%	62	4.7%
Chronic kidney failure	26 449	3.6%	1068	36.1%	31 078	3.0%	394	29.9%
Diabetes mellitus	73 727	10.1%	1050	35.5%	88 416	8.7%	307	23.3%
Obesity	90 628	12.4%	259	8.8%	76 266	7.5%	118	9.0%
Cachexia/malnutrition	1320	0.2%	72	2.4%	1337	0.1%	51	3.9%
Coagulation disorder	15 929	2.2%	891	30.1%	13 995	1.4%	265	20.1%
Peritoneal adhesions* ¹	85 749	11.8%	604	20.4%	–	–	–	–
Acute cholecystitis, cholangitis, or biliary pancreatitis	240 599	33.0%	2295	77.6%	–	–	–	–
Malignant neoplasia* ²	–	–	–	–	12 565	1.2%	122	9.3%
At least one investigated comorbidity	485 814	66.7%	2918	98.7%	473 034	46.3%	1200	91.2%
Mean length of hospital stay (days)	5.9		17.4		3.1		11.9	

*¹ As the case definition for herniotomy excludes cases with adhesiolysis (because it excludes concomitant bowel surgery), peritoneal adhesions are not included as a secondary diagnosis.

*² The case definition for cholecystectomy excludes cases with malignant neoplasia as a secondary diagnosis. The corresponding crude mortality rates are shown in eTable 3

patients is eight times higher than in those for whom malnutrition is not coded. Chronic liver disease is associated with an almost six-fold increase in risk. There is a more than four-fold increase in risk associated with coagulation disorders, malignant neoplasias, and heart failure. For patients with chronic kidney failure the risk of death is 2.7 times higher. Other significant increases in risk are found in patients with cardiac arrhythmias, atherosclerosis, chronic lung disease, and diabetes mellitus.

After adjustment, the increase in risk for chronic pancreatitis is no longer significant. No effect on the risk of death was identified for chronic ischemic heart disease, aortic or mitral valve defects, severe kidney

disease, or obesity. The secondary diagnosis hypertension is associated with a reduced risk of death according to adjusted figures (Table 3).

The regression model has a *c*-value of 0.847, indicating a very good power of discrimination.

Complications and specific interventions

All the complications investigated were coded more frequently for patients who died than for those who survived. Sepsis was recorded for 37% of deceased cholecystectomy patients and 17% of deceased herniotomy patients. Other common complications were acute kidney failure (37% and 29% respectively), pneumonia (29% and 27%), cardiogenic shock (17% and 21%),

TABLE 3

Crude and adjusted odds ratios for in-hospital death

	Cholecystectomy for cholelithiasis				Herniotomy for inguinal, femoral, umbilical, or abdominal hernia			
	Crude OR	95% CI	Adjusted OR	95% CI	Crude OR	95% CI	Adjusted OR	95% CI
Aged 65 years or over	26.9	(23.2 to 31.0)	10.0	(8.5 to 11.7)	9.9	(8.3 to 11.6)	5.2	(4.4 to 6.2)
Female	0.6	(0.5 to 0.6)	1.1	(1.0 to 1.2)	2.5	(2.3 to 2.8)	2.3	(2.0 to 2.6)
Comorbidities								
Cardiac arrhythmia	13.6	(12.6 to 14.6)	1.7	(1.6 to 1.9)	8.2	(7.4 to 9.2)	1.7	(1.4 to 2.0)
Heart failure/dilated cardiomyopathy	23.0	(21.3 to 24.7)	3.6	(3.3 to 4.0)	17.6	(15.8 to 19.7)	4.3	(3.6 to 5.0)
Chronic ischemic heart disease	6.4	(5.9 to 6.9)	1.2	(1.1 to 1.3)	3.5	(3.1 to 4.0)	1.1	(0.9 to 1.3)
Hypertension (without heart or kidney failure)	1.8	(1.7 to 2.0)	0.7	(0.6 to 0.8)	1.6	(1.4 to 1.7)	0.7	(0.6 to 0.8)
Aortic/mitral valve defects	7.8	(6.6 to 9.4)	1.2	(1.0 to 1.5)	5.7	(4.4 to 7.5)	1.1	(0.8 to 1.5)
Atherosclerosis of the extremities	9.6	(8.1 to 11.3)	1.7	(1.4 to 2.0)	5.7	(4.5 to 7.4)	1.8	(1.3 to 2.4)
Chronic lung disease	3.6	(3.2 to 3.9)	1.3	(1.2 to 1.5)	3.2	(2.8 to 3.7)	1.5	(1.3 to 1.8)
Chronic liver disease	3.7	(3.3 to 4.2)	2.1	(1.8 to 2.4)	12.7	(10.8 to 15)	5.9	(4.9 to 7.1)
Chronic pancreatitis	3.2	(2.1 to 4.9)	2.1	(1.3 to 3.3)	3.9	(1.6 to 9.5)	1.9	(0.8 to 4.7)
Severe kidney disease	14.7	(12.9 to 16.8)	1.2	(1.0 to 1.4)	13.1	(10.1 to 16.9)	1.0	(0.7 to 1.5)
Chronic kidney failure	15.0	(13.9 to 16.2)	2.2	(2.0 to 2.5)	13.6	(12.1 to 15.3)	2.7	(2.3 to 3.2)
Diabetes mellitus	4.9	(4.5 to 5.3)	1.4	(1.3 to 1.6)	3.2	(2.8 to 3.6)	1.3	(1.1 to 1.5)
Obesity	0.7	(0.6 to 0.8)	0.6	(0.5 to 0.7)	1.2	(1.0 to 1.5)	1.0	(0.8 to 1.2)
Cachexia/malnutrition	13.7	(10.8 to 17.5)	3.5	(2.6 to 4.7)	30.8	(23.1 to 40.9)	8.0	(5.5 to 11.7)
Coagulation disorder	19.3	(17.8 to 20.9)	3.5	(3.1 to 3.9)	18.2	(15.8 to 20.8)	4.7	(3.9 to 5.7)
Peritoneal adhesions ^{*1}	1.9	(1.8 to 2.1)	1.3	(1.2 to 1.5)	to	to	to	to
Acute cholecystitis, cholangitis, or biliary pancreatitis	7.0	(6.4 to 7.7)	3.2	(2.9 to 3.5)	to	to	to	to
Malignant neoplasia ^{*2}	–	–	–	–	8.2	(6.8 to 9.9)	4.1	(3.3 to 5.0)
Association between predicted probability of death and observed mortality			c = 0.925				c = 0.847	

OR: odds ratio; CI: confidence interval

^{*1} As the case definition for herniotomy excludes cases with adhesiolysis (because it excludes concomitant bowel surgery), peritoneal adhesions are not included as a secondary diagnosis.

^{*2} The case definition for cholecystectomy excludes cases with malignant neoplasia as a secondary diagnosis.

other shock (11% and 9%), and cardiovascular or cerebrovascular events such as myocardial infarction or stroke (9% and 11%). Surgical complications (e.g. hemorrhage, accidental perforation, suture failure) were recorded in 19% of deaths following cholecystectomy and 13% of deaths following herniotomy. In total, at least one of the investigated complications was coded for 83% of deaths following cholecystectomy and 78% of deaths following herniotomy (Table 4).

The Figure displays the crude mortality rates for complications. This shows that almost all the analyzed complications are associated with a substantially worse prognosis for survival. Mortality rates of more than 10% were found for patients with thrombotic, cardiovascular, cerebrovascular, or serious cardiac events; acute kidney failure; pneumonia; sepsis; coagulation-related complications; and peritonitis.

The analyzed interventions were also recorded more frequently in patients who died than in those who survived: intensive care was recorded for more than half of cholecystectomy patients who died and 37% of herniotomy patients who died. Ventilation lasting more than 24 hours was administered to 44% of those who died following cholecystectomy and 26% of those who died following herniotomy. Blood transfusions of more than six units, which provide indirect evidence of hemorrhage as a complication, were recorded for 18% of patients who died after cholecystectomy and 10% of patients who died after herniotomy. Relaparotomy or repeat surgery was coded for 11% of deaths following cholecystectomy and 5% of deaths following herniotomy. Resuscitation was performed on 18% of cholecystectomy patients who died and 23% of herniotomy patients who died.

TABLE 4

Complications and specific interventions by survival status

	Cholecystectomy for cholelithiasis				Herniotomy for inguinal, femoral, umbilical, or abdominal hernia			
	Surviving		Dying		Surviving		Dying	
	Cases	Percentage	Cases	Percentage	Cases	Percentage	Cases	Percentage
Total	728 469	100%	2957	100%	1 021 566	100%	1 316	100%
Complications								
Deep vein thrombosis/pulmonary embolism	704	0.1%	106	3.6%	697	0.1%	101	7.7%
Myocardial infarction/TIA/stroke	1577	0.2%	274	9.3%	1260	0.1 %	141	10.7%
Cardiogenic shock/cardiac arrest/ ventricular fibrillation	534	0.1%	512	17.3%	467	0.05%	272	20.7%
Other shock (e.g. hypovolemic, anaphylactic)	1126	0.2%	328	11.1%	1335	0.1%	122	9.3%
Acute kidney failure	3027	0.4%	1088	36.8%	1407	0.1%	377	28.6%
Pneumonia	5045	0.7%	872	29.5%	2199	0.2%	359	27.3%
Wound infection	6905	0.9%	193	6.5%	4132	0.4%	56	4.3%
Sepsis/SIRS	3981	0.5%	1095	37.0%	414	0.04%	222	16.9%
Perioperative or postoperative surgical complication	18 319	2.5%	549	18.6%	28 292	2.8%	168	12.8%
Anesthesia-related complication	5249	0.7%	58	2.0%	6394	0.6%	17	1.3%
Other complication associated with medical procedures	16 572	2.3%	288	9.7%	18 005	1.8%	133	10.1%
Coagulation complication (DIC or HIT II)	371	0.1%	120	4.1%	215	0.02%	27	2.1%
Peritonitis*	–	–	–	–	706	0.1%	82	6.2%
Postoperative intestinal obstruction	664	0.1%	44	1.5%	778	0.1%	22	1.7%
At least one investigated complication	52 826	7.3%	2445	82.7%	60 123	5.9%	1030	78.3%
Specific interventions								
Ventilation for more than 24 hours	2749	0.4%	1 292	43.7%	806	0.1%	342	26.0%
Intensive care	12 783	1.8%	1 491	50.4%	4681	0.5%	481	36.6%
Blood transfusion (at least 6 units)	1481	0.2%	519	17.6%	553	0.1%	132	10.0%
Resuscitation	440	0.1%	542	18.3%	349	0.03%	300	22.8%
Relaparotomy, repeat surgery	3749	0.5%	334	11.3%	8543	0.8%	60	4.6%
Switch from laparoscopic to open surgery	29 655	4.1%	521	17.6%	–	–	–	–
Autopsy	–	–	13	0.4%	–	–	7	0.5%

*Peritonitis is included as a complication in herniotomy only (for cholecystectomy it is unclear whether it was present before surgery or acquired during treatment).

TIA: transient ischemic attack; SIRS: systemic inflammatory response syndrome; DIC: disseminated intravascular coagulation; HIT II: heparin-induced thrombocytopenia, type II

Autopsies were documented for 0.4% of deaths following cholecystectomy and 0.5% of deaths following herniotomy (Table 4).

Discussion

Despite the rarity of these events, the nationwide German database used for this study allowed more than 4000 deaths to be analyzed and compared to 1.75 million surviving patients. This large number of cases made it possible to show common characteristics of patients who died and to investigate the effect of coded comorbidities on the risk of in-hospital death.

In this study comorbidities are identified solely on the basis of corresponding diagnoses being recorded in inpatient data records. As coding of a comorbidity implies that personnel were aware of it during clinical treatment, there may be potential for optimization using a risk-adapted approach in indication, preparation for surgery, and perioperative and postoperative care.

Most comorbidities examined here were associated with a significant increase in the risk of death. The effects of, for example, cardiovascular diseases; chronic lung, liver, or kidney disease; and malnutrition on the

FIGURE

Crude mortality rate stratified by complication. TIA: transient ischemic attack; SIRS: systemic inflammatory response syndrome; DIC: disseminated intra-vascular coagulation; HIT II: heparin-induced thrombocytopenia, type II

*Peritonitis is included as a complication in herniotomy only (for cholecystectomy it is unclear whether it was present before surgery or acquired during treatment)

risk of complications or death following surgery, including visceral surgery, are well documented in the literature (7–9). Identifying such risks is therefore a central part of preoperative preparation (13). Accurate medical history taking and careful physical examination are the basis for identification of diseases that have not previously been detected or have not been adequately treated and affect perioperative risk (14, 15). To the extent that these are factors that can be altered, and if surgery is not so urgent as to make this impossible, preoperative optimization can reduce the risk of complications. This concerns, for example, nutrition therapy for malnourished patients (16, 17) and optimization of treatment for heart failure (18).

Analysis of complications and interventions indicates that there may be potential for optimizing the management of complications (19). This concerns prevention or early identification and adequate treatment of nosocomial infections (20), cardiac events (21), kidney injury (22), and other conditions. In addition, the results of our study suggest that there are further aspects of patient safety in which action is required in German healthcare (23). For example, the frequency of coded surgical complications and blood transfusions in

patients who died indicates that it may be possible to improve safety in surgery still further. An effective tool for preventing intraoperative complications and reducing mortality in patients undergoing surgery is surgical safety checklists (24), comprehensive use of which is recommended for all surgeries (25). Regular morbidity and mortality conferences at which the treatment team analyzes unexpected deaths or complications are also seen as the standard for perioperative medicine (26).

As far as can be determined on the basis of comparable publications, in-hospital mortality following cholecystectomy and herniotomy is no higher in Germany than in other industrialized countries. In-hospital mortality for laparoscopic cholecystectomy is 0.5% in the USA, for example (27). In Denmark, 30-day mortality rates of 0.35% for cholecystectomy (28) and 0.5% in herniotomy (29) were reported. The results of this analysis do indicate, however, that mortality related to these surgeries in Germany could be reduced. This is also suggested by the findings of statutory external quality assurance for cholecystectomy: in 2013 deaths were identified despite a low mortality risk in 169 hospitals (30).

Limitations

The characteristics analyzed here may be biased by erroneous or selective diagnosis coding. It is therefore possible, for example, that comorbidities are more likely to be perceived when treatment is complicated and are therefore coded more frequently in patients who died than in those who survived. This kind of bias would lead to an overestimate of the association between comorbidities and risk of death.

Conclusion

Deaths are strongly associated with coded comorbidities that are usually identifiable before surgery, even for routine surgeries such as cholecystectomy and herniotomy that are low in complexity and usually scheduled. Unlike in high-risk surgeries, because such deaths are rare in individual hospitals awareness of such patient-specific risk factors in such apparently simple surgeries may not always be sufficient. In addition to determining patient-specific risks on the basis of patients' medical history as a requirement for risk-adapted treatment planning, preparation, and execution, there may be potential for improving the management of complications.

Reducing mortality for herniotomy and cholecystectomy would save only a few lives in absolute terms. For the patients, however, who usually consider a herniotomy or cholecystectomy low risk surgery, appropriate steps would contribute substantially to reducing their individual risk. In addition, measures to prevent deaths might reduce complication rates as well as mortality and therefore improve overall patient safety.

KEY MESSAGES

- Between 2009 in 2013 in Germany, there were 2957 deaths following cholecystectomy for gallstones (mortality: 0.4%) and 1316 deaths following herniotomy without concomitant bowel surgery (mortality: 0.13%).
- In addition to higher age, coded comorbidities such as cardiovascular disease; chronic lung, liver, or kidney disease; and compromised nutritional status are associated with an increased risk of death.
- Unsurprisingly, complications are coded substantially more frequently for patients who died than for survivors.
- There may be potential for optimization in preoperative risk identification, prevention or early identification and treatment of complications, and safe surgery technique.
- Reducing mortality for herniotomy and cholecystectomy would save only a few lives in absolute terms. However, appropriate steps would contribute substantially to reducing individual patient risk and thereby improve patient safety.

Conflict of interest statement

The Department of Structural Advancement and Quality Management in Health Care, for which the authors work, is an endowed professorship of Helios Kliniken GmbH.

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[Supplementary material
eTables:
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Supplementary material to:

Deaths Following Cholecystectomy and Herniotomy

An Analysis of Nationwide German Hospital Discharge Data From 2009 to 2013

by Ulrike Nimptsch and Thomas Mansky

Dtsch Arztebl Int 2015; 112: 535–43. DOI: 10.3238/arztebl.2015.0535

eTABLE 1

Case definition*

	Criterion	Principal diagnosis (ICD-10)	Secondary diagnosis (ICD-10)	Procedure (OPS)
Cholecystectomy for cholelithiasis; excluding extended cholecystectomies or cholecystectomies performed concomitantly with other surgeries	Inclusion	K80		5–511.0, 5–511.1, 5–511.2, 5–511.x, 5–511.y
	Exclusion		C00–C97	5–511.3, 5–511.4, 5–511.5
Herniotomy for inguinal, femoral, umbilical, or abdominal hernia without concomitant bowel surgery	Inclusion	K40, K41, K42, K43		5–530, 5–531, 5–534, 5–535, 5–536
	Exclusion			5–451, 5–452, 5–453, 5–454, 5–455, 5–456, 5–458, 5–459, 5–460, 5–461, 5–462, 5–463, 5–464, 5–465, 5–466, 5–467, 5–468, 5–469, 5–484, 5–485, 5–530.4, 5–530.8, 5–531.4, 5–531.8

*The analyses performed for this study are limited to patients aged 20 years or over.

OPS: Classification of Operations and Procedures (the German modification of the International Classification of Procedures in Medicine)

eTABLE 2
Definition of variables

Comorbidity	ICD-10 code	Comments
Cardiac arrhythmia	I44.2, I48, Z45.0, Z95.0	
Heart failure/cardiomyopathy	I50, I11.0, I13.0, I13.2, I42.0, I42.6, I42.7, I42.8, I42.9	
Chronic ischemic heart disease	I25	
Hypertension (without heart or kidney failure)	I10, I11.9, I12.9, I13.9, I15	
Aortic/mitral valve defects	I34.0, I34.2, I35.0, I35.1, I35.2, I05.0, I05.1, I05.2, I06.0, I06.1, I06.2, Q23.1, Q23.2, Q23.3	
Atherosclerosis of the extremities	I70.2	
Chronic lung disease	J41, J42, J44, J45, J47	
Chronic liver disease	B18, I86.4, I98.2, K70, K73, K74, K76.0, K76.1, K76.5, K76.6, K76.7	
Chronic pancreatitis	K86.0, K86.1	
Severe kidney disease	N03, N04, N05, N07, N08, N11, N12, N14, N15, N16	
Chronic kidney failure	I12.0, I13.1, I13.2, N18, N19, Z99.2	
Diabetes mellitus	E10, E11, E12, E13, E14	
Obesity	E66	
Cachexia/malnutrition	R64, R63.4, E43, E44	
Peritoneal adhesions	K66.0	Cholecystectomy only
Coagulation disorder	D66, D67, D68, D69.1, D69.3, D69.4	
Acute cholecystitis, cholangitis, or biliary pancreatitis	K80.0, K80.3, K81.0, K83.0, K85.1	Cholecystectomy only
Malignant neoplasia	C00-C97	Herniotomy only
Complication	ICD-10 code	Comments
Deep vein thrombosis/pulmonary embolism	I80.1, I80.2, I80.3, I82.2, I26	
Myocardial infarction/TIA/stroke	I21, I22, G45, I60, I61, I63, I64	
Cardiogenic shock/cardiac arrest/ventricular fibrillation	R57.0, I46, I49.0	
Other shock (e.g. hypovolemic, anaphylactic)	R57.1, R57.8, R57.9, T81.1, T88.2, T88.6	
Acute kidney failure	N17, N99.0	
Pneumonia	A48.1, J10.0, J11.0, J12, J13, J14, J15, J16, J17, J18, J69	
Wound infection	T81.4	
Sepsis/SIRS	A40, A41, R57.2, R65	
Postoperative intestinal obstruction	K91.3	
Perioperative or postoperative surgical complication	T81.7, T81.8, T81.9, T88.7, Y57.9	
Anesthesia-related complication	T88.3, T88.4, T88.5, T41	
Other complications associated with medical procedures	I97.8, I97.9, T80, T81.8, T81.9, T88.7	
Coagulation complication	D65.1, D69.53	
Peritonitis	K65	Herniotomy only
Intervention	Classification of Operations and Procedures (OPS) code	Comments
Intensive care	8-980	
Blood transfusion (whole blood or red cell concentrate, six units or more)	8-800.1, 8-800.c1 bis 8-800.cr, 8-800.70 bis 8-800.7e, 8-800.7g, 8-800.h	Change in OPS 2010
Resuscitation	8-771, 8-772, 8-773	
Relaparotomy, repeat surgery	5-541.2, 5-983	
Switch from laparoscopic to open surgery	5-511.21, 5-511.22	Cholecystectomy only
Clinical or quality-assurance autopsy	9-990	

eTABLE 3

Crude mortality rates stratified by patient characteristics

	Cholecystectomy for cholelithiasis			Herniotomy for inguinal, femoral, umbilical, or abdominal hernia		
	Total cases	Deaths	Crude mortality rate	Total cases	Deaths	Crude mortality rate
Total	731 426	2957	0.40 %	1 022 882	1316	0.13%
Aged 65 years or over	251 600	2759	1.10%	440 502	1160	0.26%
Female	482 036	1540	0.32%	208 091	515	0.25%
Investigated comorbidities						
Cardiac arrhythmia	38 510	1249	3.24%	64 552	468	0.72%
Heart failure/dilated cardiomyopathy	24 760	1282	5.18%	34 831	500	1.44%
Chronic ischemic heart disease	40 193	791	1.97%	81 071	306	0.38%
Hypertension (without heart or kidney failure)	253 206	1453	0.57%	340 294	574	0.17%
Aortic/mitral valve defects	4376	130	2.97%	8218	58	0.71%
Atherosclerosis of the extremities	4452	159	3.57%	8937	63	0.70%
Chronic lung disease	33 397	426	1.28%	58 210	213	0.37%
Chronic liver disease	23 262	321	1.38%	11 483	164	1.43%
Chronic pancreatitis	1660	21	1.27%	996	5	0.50%
Severe kidney disease	4982	259	5.20%	3911	62	1.59%
Chronic kidney failure	27 517	1068	3.88%	31 472	394	1.25%
Diabetes mellitus	74 777	1050	1.40%	88 723	307	0.35%
Obesity	90 887	259	0.28%	76 384	118	0.15%
Cachexia/malnutrition	1392	72	5.17%	1388	51	3.67%
Coagulation disorder	16 820	891	5.30%	14 260	265	1.86%
Peritoneal adhesions ^{*1}	86 353	604	0.70%	–	–	–
Acute cholecystitis, cholangitis, or biliary pancreatitis	242 894	2295	0.94%	–	–	–
Malignant neoplasia ^{*2}	–	–	–	12 687	122	0.96%

^{*1} As the case definition for herniotomy excludes cases with adhesiolysis (because it excludes concomitant bowel surgery), peritoneal adhesions are not included as a secondary diagnosis.

^{*2} The case definition for cholecystectomy excludes cases with malignant neoplasia as a secondary diagnosis.