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Cause-specific Mortality Risks of Anesthesiologists

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Background: **The health-related effects of the operating room environment are unclear. The authors compared mortality risks of anesthesiologists to those of internal medicine physicians between 1979 and 1995.**

Methods: **The Physician Master File database, a listing of all US physicians, was used to identify anesthesiologists and general internists. The cohort of internists (n = 40,211) was a stratified random sample of all internists, frequency-matched to the cohort of anesthesiologists (n = 40,242) by gender, decade of birth, and US citizenship. The National Death Index was used to confirm death status and to determine specific causes of death. Mortality risks, adjusted for age, gender, and race, were compared using the Cox proportional hazards regression model.**

Results: **The standardized mortality ratios for all physicians were well below 1.0, except for suicide. The all-cause mortality ratios, and the risks of death caused by cancer and heart disease, did not differ between anesthesiologists and internists. Anesthesiologists had an increased risk of death from suicide (rate ratio [RR] = 1.45, 95% confidence interval [CI] = 1.07 − 1.97), drug-related death (RR = 2.79, 95% CI = 1.87 − 4.15), death from other external causes (RR = 1.53, 95% CI = 1.05 − 2.22), and death from cerebrovascular disease (RR = 1.39, 95% CI = 1.08 − 1.79). Male anesthesiologists had an increased risk of death from HIV (RR = 1.82, 95% CI = 1.09 − 3.02) and viral hepatitis (RR = 7.98, 95% CI = 1.0 − 63.84). Although the risk to anesthesiologists of drug-related deaths was highest in the first 5 years after medical school graduation, it remained increased over that of internists throughout the career.**

Conclusions: **Substance abuse and suicide represent significant occupational hazards for anesthesiologists. New methods to combat substance abuse among anesthesiologists should be developed. (Key words: National Death Index; occupational mortality; physicians; substance abuse; suicide.)**

ANESTHESIOLOGISTS work in an environment that is characterized by chronic exposure to trace concentrations of anesthetic gases, chronic low-dose radiation exposure, and psychological stresses that are different from those encountered by physicians who work outside of the operating room. The health-related effects of these exposures are unclear. Although some early studies suggested an increased mortality rate from leukemia and lymphoma, especially among female anesthesiologists and operating room nurses,[1,2] subsequent studies found no excess risk of death caused by cancer.[3–5] In contrast, up to a twofold increase in risk of death by suicide was observed.[4]

During the past 20 years, the practice of anesthesiology has changed considerably because of the widespread scavenging of waste anesthetic gases and changes in anesthetic agents. However, there remain a number of potential health hazards that are different from those encountered by physicians who work outside of the operating room, including radiation exposure, exposure to blood and body fluids, psychological stresses such as irregular working hours, sleep deprivation, need for sustained vigilance, and easy access to opioids and cocaine.

A formal evaluation of mortality risks to US anesthesiologists has not been undertaken since 1976. The mortality rate in physicians is lower than in the general population, primarily because of the low prevalence of cigarette smoking in these individuals, their higher frequency of health-oriented behaviors and practices, and the "healthy worker effect" (*i.e.*, a person must be relatively healthy to be working).[6–11] Therefore, the mortality rate of anesthesiologists was compared to that of general internists, a group of physicians who practice outside of the operating room environment. Also, internists are not exposed to chemicals and radiation that might influence mortality rate, such as may be experienced by pathologists and radiologists.

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Materials and Methods

The cohort was assembled from the Physician Master File (PMF) maintained by the American Medical Association. The association keeps a record of all medical students and physicians in the country, independent of membership in the association. These data are primarily available for human resources estimates for the medical profession, and for verification of physician credentials. The PMF, one of the most complete central sources of information on physicians in the United States, contains demographic data and information pertaining to the individual's professional qualifications and training. The database includes an individual's name, date and place of birth, gender, race, citizenship and visa status, medical

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school graduated, date of graduation, dates of residencies, self-designated specialty, major professional activity, vital status, date of death for decedents, and last known address.

All physicians identified in the PMF with a self-designated primary specialty of anesthesiology or general internal medicine who were alive as of January 1, 1979, and who graduated from medical school before June 1, 1995, were eligible for inclusion in the cohort. Internists were chosen as a comparison specialty population because they have fairly similar training requirements but are not likely to spend significant amounts of time in the operating room. The PMF registered more than three times as many internists as anesthesiologists. Study resources did not permit the follow-up of all internists; thus, a stratified random sample of internists was chosen. The stratified random sample was selected by stratifying the internists by gender, decade of birth, and citizenship (US or non-US). The sample was chosen to match the distribution of anesthesiologists on these factors. The US citizenship category included native-born and naturalized citizens. Within each stratum a random number was assigned to each individual, and the stratum then was sorted by the random numbers. The targeted number of internists, equal to the number of anesthesiologists in the corresponding stratum, then was selected in sequence from this list.

Vital status for all cohort members was determined using the PMF designation. The PMF continually updates and confirms the vital status of physicians using multiple sources of information, including death certificate data, direct notification from families, copies of obituaries, state licensing boards, and local medical associations. Maintaining an updated vital status is an important function for the PMF in order to verify physician credentials. The underlying and contributing causes of death were obtained from the National Death Index (NDI) maintained by the National Center for Health Statistics. Since 1979, the NDI has gathered mortality statistics from vital registries in all 50 states and New York City, providing a mechanism by which vital status and cause of death can be determined for health research purposes. An individual is linked to the NDI using a probabilistic matching scheme based on name, gender, marital status, race, date and place of birth, and social security number.[12,13] Because the PMF provided vital status and dates of death, but not social security number, the decedents in the anesthesiology–internist cohort were linked to the NDI Plus database. The NDI Plus database is a newer service that provides cause of death information for known decedents, obviating the need to request all death certificates from the individual states.[14] The PMF provided the date of death, which improved the reliability of the matches to NDI Plus. NDI Plus gave the cause of death only for the best probabilistic match. A copy of the death certificate was requested from the state if the cause of death was not clear from NDI Plus. If the initial match did not seem plausible, the death certificate for the next most probable match was requested. The underlying cause of death reported by the individual states to NCHS was used to classify cause of death in this study. If a link to NDI was not made, but the individual was reported as deceased with a date of death in the PMF, the cause of death was recorded as unknown.

The follow-up period for this cohort study began on January 1, 1979, the earliest date for which the NDI data are available, and continued through December 31, 1995. Follow-up for cohort members who graduated after January 1, 1979, began on their dates of medical school graduation. Date of graduation was estimated to be on June 1 of the reported year of graduation in the PMF. Pre-1979 graduates began follow-up period on January 1, 1979. Person-time was accrued until December 31, 1995, or the date of death for decedents. If only month and year of death were available, the date of death was coded to be on the first day of that month. If only the year of death was available the date of death was coded as January 1 of that year. Possible losses to follow-up, including physicians who moved out of the country and thus the reporting area of the NDI and PMF, were not identifiable.

Statistical Analysis

The all-cause and cause-specific mortality rate of anesthesiologists was compared to that of internists using methods for cohort studies.[15,16] The specific causes of death of prior interest included all malignant neoplasms (International Classification of Diseases, 9th Revision [ICD-9] 140–208), malignant neoplasms of the brain (ICD-9 191) and pancreas (ICD-9 157), leukemias (ICD-9 204–208), other hematopoietic malignancies (ICD-9 200–203), suicides (ICD-9 E950–E959), drug-related suicides (ICD-9 E950.0–950.5), and drug-related deaths (ICD-9 304, E930–E949, E950.0–950.5, E980.0–E980.5).

Cause-specific and all-cause standardized mortality ratios (SMRs) were computed for each specialty by gender using the Life Table Analysis System (Occupational Safety and Health, Cincinnati, OH) for personal computers.[17] This program tabulates the underlying causes of death and person-time of follow-up into age-, gender- and race-specific strata. SMRs and 95% confidence intervals (CIs) were calculated using US cause-specific mortality rates as a reference. The classifications of specific cause of death were limited to those available in the reference data.

Rate ratios comparing the mortality rates of anesthesiologists to internists were estimated using Cox proportional hazards regression models.[15] The proportional hazards model is a mathematic model that directly compares the survival experience of two or more groups over time (internists and anesthesiologists, in this case), adjusting for potentially confounding variables. The ef-

fects of potentially confounding variables, including the matching criteria, decade of birth, gender, and US citizenship status, and race (white, nonwhite, missing), were included in the model if they changed the rate ratio estimates by more than 10%. Ninety-five percent CIs were computed to estimate sampling error. The proportional hazards model assumes that the hazard ratios are constant (proportional) over time for all strata. Because anesthesiologists are more validly compared with internists than with the US general population, and the methods for follow-up and cause of death determination are equivalent for internists and anesthesiologists, we place the most emphasis on results comparing anesthesiologists to internists.

To determine if the hazard ratios varied with the duration of the time in the profession, a surrogate measure of cumulative exposure in the operating room environment, the final Cox models for the brain and pancreatic cancers and leukemia were fit with year of graduation as an interaction term with the indicator for specialty, to determine whether the hazard ratios varied by the time since graduation. To evaluate the effect of drug abuse prevention programs in anesthesiology initiated in the 1980s,[18] the mortality rates from drug-related suicides and all drug-related deaths were compared for the periods before and after January 1, 1987. Poisson regression models[15] were fit to estimate the age-, gender-, and race (white *vs.* nonwhite)–adjusted rate ratios comparing anesthesiologists and internists before and after that date. Years of life lost before age 65 for both cohorts were calculated for all causes, suicides, drug-related suicides, and all drug-related deaths.

Results

The PMF database identified 40,285 anesthesiologists who were alive as of January 1, 1979, and who had graduated from medical school before December 31, 1995. The same database identified 136,834 general internists who met the same criteria. The stratified random sample of internists yielded 40,269 for inclusion in the cohort. Excluded from the cohort were individuals with incompatible dates of birth, death, and graduation, leaving 40,242 anesthesiologists and 40,211 internists for the analysis (table 1). The distributions of age, gender, and race were similar for the anesthesiologists and the sampled general internists in the cohort (table 1). Women comprised approximately 18% of the entire cohort, but only 8.6% of the deaths in anesthesiologists and 9.1% of the deaths in internists, reflecting the relatively younger age of female physicians. Thirty-four percent of the total cohort was not classified by race because race was not always recorded in the PMF. The mean years of follow-up were nearly the same for anesthesiologists and internists (table 1). There were 2,458 deceased anesthesiologists and 2,376 deceased internists. The age at death

Table 1. Characteristics of Anesthesiologists and Internal Medicine Physicians Included in the Cohort

	Anesthesiologists		Internists	
	N	%	N	%
Total	40,242	100	40,211	100
Gender				
Men	33,040	82.1	33,044	82.2
Women	7,202	17.9	7,167	17.8
Race				
White	20,507	51.0	20,094	50.0
Black	769	1.9	805	2.0
Hispanic	958	2.4	1,130	2.8
Asian	3,751	9.3	3,612	9.0
Native American	13	<1.0	11	<1.0
Other	539	1.3	712	1.8
Missing	13,705	34.1	13,847	34.4
Deceased	2,458	6.1	2,376	5.9
Cause of death known	2,326	94.6	2,183	91.9
Year of birth (mean)	1944		1944	
Men	1944		1944	
Women	1947		1947	
Age at end of follow-up (mean)	50.3		50.3	
Men	50.7		50.9	
Women	48.0		47.7	
Years of follow-up (mean)	13.7		13.9	
Age at death for decedents (mean)	66.5†		69.0	

*Percent of deceased. † $P < 0.01$ anesthesiologists compared with internists.

for decedents was slightly lower for anesthesiologists (66.5 ± 14.7 years) compared with internists (69.0 ± 14.5 years, $P < 0.01$; table 1). The cause of death was determined for 2,326 (94.6%) of the anesthesiologists and 2,183 (91.9%) of the internists.

The SMRs for major causes of death for male and female anesthesiologists and internists were nearly all well below 1, indicating the overall better health states experienced by physicians than the US general population (data for anesthesiologists are shown in table 2; data for internists are not shown). Exceptions were accidental poisoning and suicide. Male anesthesiologists experienced a 34% excess risk of death from an accidental poisoning compared with the general population (SMR = 1.34, 95% CI = 0.92–1.87; table 2). Female anesthesiologists did not experience an excess of accidental poisonings but did show an elevated risk of suicide (SMR = 1.68, 95% CI = 0.82–3.00; table 2), and the SMR for suicide in female internists also exceeded unity (SMR = 1.11; 95% CI = 0.44–2.27).

The proportional distribution of selected causes of death, including the causes of death of prior interest, are displayed in table 3. Heart disease, cancer, and other diseases of the circulatory system were the most frequent causes of death for both anesthesiologists and internists. There were no striking differences in the proportion of any type of cancer for anesthesiologists compared with internists.

Table 2. Standardized Mortality Ratios for Major Causes of Death in Male and Female Anesthesiologists: 1979–1995

Cause of Death	OBS	EXP*	SMR	95% CI
Men				
All causes of death	2,247	4,654.3	0.48	0.46–0.50
All cancers	563	1,187.3	0.47	0.43–0.51
Neoplasms of lymphatic and hematopoietic tissue	85	109.5	0.78	0.61–0.95
Accidents	130	260.1	0.50	0.41–0.59
Accidental poisoning	34	25.3	1.34	0.92–1.87
Violence	98	193.3	0.51	0.41–0.61
Suicide	92	115.0	0.80	0.64–0.98
Women				
All causes of death	211	437.4	0.48	0.41–0.55
All cancers	84	136.5	0.62	0.49–0.76
Neoplasms of lymphatic and hematopoietic tissue	5	11.5	0.43	0.14–1.01
Accidents	10	18.0	0.55	0.26–1.01
Accidental poisoning	1	1.8	0.54	0.01–2.97
Violence	14	11.6	1.20	0.65–2.01
Suicide	11	6.5	1.68	0.82–3.00

* Based on rates for United States 1979–95.

CI = confidence interval; EXP = expected; OBS = observed; SMR = standardized mortality ratios.

The all-cause mortality rates for anesthesiologists and internists did not differ (RR = 1.03; table 3). The rate ratios for all cancers, brain cancer, and hematopoietic neoplasms did not differ from unity. The rate ratios for leukemia (RR = 1.26, 95% CI = 0.78–2.09) and pancreatic cancer (RR = 1.31, 95% CI = 0.84–2.00) were modestly elevated; however, the CIs were wide and overlapped unity. No variation in rate ratios by length of time in the profession was observed for any of these outcomes.

In contrast, mortality rates resulting from suicide, drug-related deaths, HIV-related deaths, and cerebrovascular disease were higher for anesthesiologists compared with internists (table 3). Anesthesiologists had a nearly 50% excess risk of suicide (RR = 1.45, 95% CI = 1.07–1.97, $P = 0.016$), and the rate ratio for drug-related suicide was more than doubled (RR = 2.21, 95% CI = 1.33–3.66, $P = 0.002$). Furthermore, if all drug-related deaths were combined, the difference between anesthesiologists and internists was even greater (RR = 2.79, 95% CI = 1.87–4.15, $P < 0.001$). Anesthesiologists had a 50% increased risk of death from other external causes (RR = 1.53, 95% CI = 1.05–2.22, $P = 0.021$). These included deaths caused by boating, bicycle, and airplane accidents; drowning; fire; and falls and other miscellaneous injuries. Anesthesiologists had an 80% higher risk of HIV-related deaths than internists (RR = 1.78, 95% CI = 1.08–2.94, $P = 0.023$). The risk of death from viral hepatitis also was increased (RR = 4.06, 95% CI = 0.86–19.11), but this finding was based on a small number of deaths (n = 8). Compared with internists, anesthesiologists were more likely to die from cerebrovascular disease (ICD-9 430–438) and unspecified heart failure; however, death rates among anesthesiologists from other heart and circulatory disease were slightly lower than among internists. The majority of the difference in the rates for cerebrovascular disease was in "acute but ill-defined" cerebrovascular disease (ICD-9 436)—67 deaths in anesthesiologists and 35 in internists.

The gender-specific mortality differences in anesthesiologists and internists were similar to those of the entire cohort (table 4). Male anesthesiologists had higher relative rates of drug-related deaths (RR = 3.00, 95% CI = 1.96–4.62, $P < 0.001$), HIV-related deaths (RR = 1.82, 95% CI = 1.09–3.02, $P = 0.033$), viral hepatitis (RR = 7.98, 95% CI = 1.0–63.84, $P = 0.05$), and other external causes (RR = 1.47, 95% CI = 1.00–2.15, $P = 0.05$). The rate ratios for suicide were similar for males and females. Because there were only 211 and 217 deaths among women anesthesiologists and internists, respectively, the cause-specific analyses for women relied on sparse data; the estimates were unstable, resulting in large CIs.

Suicide and drug-related death rates are described further by years since graduation in figures 1 and 2. For all suicides and all drug-related deaths, the rates in anesthesiologists were higher compared with corresponding rates among internists, except for suicides in the first 5 years after graduation. Suicide rates also generally increased with increasing years since graduation—that is, increasing age, a pattern seen for suicides in the general population (fig. 1). Conversely, the differences in rates for drug-related deaths (fig. 2) were greatest in the first 5 years after graduation, and the rates generally declined for both specialties over time. There was no indication that the relative risk of death from drug-related causes among anesthesiologists changed after the education attempts in the 1980's. The relative risk for drug-related suicides and drug-related deaths in anesthesiologists compared with internists remained elevated for both time periods (table 5).

Anesthesiologists had a greater number of years of life lost before age 65 because of suicides, drug-related suicides, and drug-related deaths and a higher all-cause mortality rate than internists. The anesthesiologist cohort had 1,583 life-years lost because of suicide, compared with 994 life-years lost in the internist cohort. There were 2,108 life-years lost because of premature deaths from all drug related causes in anesthesiologists, compared with 715 life-years lost in internists. The excess in suicide and drug-related deaths accounted for most of the differences in years of life lost because of all-cause mortality in anesthesiologists (12,956 life-years lost) compared with internists (9,936 life-years lost).

Discussion

In this cohort study of anesthesiologists and general internal medicine physicians, exposure to the operating

Table 3. Age, Gender, and Race-adjusted Rate Ratios Comparing Anesthesiologists with Internists for All Causes and Selected Causes of Death

	Anesthesiologists		Internists			
	N	(%)	N	(%)	RR	95% CI
All deaths	2,458	(100)	2,376	(100)	1.03	0.97–1.09
All cancer	647	(26.3)	641	(27.0)	0.99	0.89–1.11
Pancreatic cancer	49	(2.0)	37	(1.6)	1.31	0.84–2.00
Brain cancer	28	(1.1)	28	(1.2)	1.00	0.59–1.69
Respiratory cancer	115	(4.7)	121	(5.1)	0.95	0.73–1.22
Digestive cancer	189	(7.7)	166	(7.0)	1.13	0.92–1.39
Leukemia	37	(1.5)	29	(1.2)	1.26	0.78–2.09
Hematopoietic	53	(2.2)	63	(2.7)	0.82	0.57–1.19
All heart disease	749	(30.5)	794	(33.4)	0.94	0.85–1.04
Ischemic heart disease	549	(22.3)	611	(25.7)	0.90	0.80–1.01
Hypertensive heart disease	13	(0.5)	19	(0.8)	0.71	0.35–1.45
Cardiomyopathy	23	(0.9)	28	(1.2)	0.81	0.47–1.41
Heart failure	30	(1.2)	18	(0.8)	1.70	0.95–3.06
Cerebrovascular disease	147	(6.0)	107	(4.5)	1.39†	1.08–1.79
Other diseases of circulatory system	50	(2.0)	55	(2.3)	0.94	0.64–1.37
HIV-related	43	(1.8)	24	(1.0)	1.78*	1.08–2.94
Diseases of digestive system	39	(1.6)	29	(1.2)	1.3	0.81–2.11
COPD	52	(2.1)	55	(2.3)	0.97	0.34–1.24
Pneumonia, influenza, bronchiolitis	51	(2.1)	37	(1.6)	1.44	0.94–2.19
Chronic liver disease	28	(1.1)	21	(0.9)	1.30	0.74–2.29
Viral hepatitis	8	(0.3)	2	(0.1)	4.06	0.86–19.1
Diabetes	41	(1.7)	40	(1.7)	1.02	0.66–1.57
Renal disease	11	(0.4)	11	(0.5)	1.01	0.44–2.34
Mental disorders	17	(0.7)	17	(0.7)	1.05	0.54–2.06
Diseases of nervous system and sense organs	56	(2.3)	56	(2.3)	0.99	0.68–1.44
Alzheimer disease	20	(0.8)	21	(0.9)	1.03	0.56–1.90
Motor vehicle accidents	38	(1.6)	35	(1.5)	1.08	0.68–1.70
Suicide	103	(4.2)	71	(3.0)	1.45*	1.07–1.97
Drug-related suicide	48	(2.0)	22	(0.9)	2.21†	1.33–3.66
All drug-related deaths	91	(3.7)	33	(1.4)	2.79‡	1.87–4.15
Homicide	9	(0.4)	11	(0.5)	0.80	0.33–1.92
Other external causes	69	(2.8)	45	(1.9)	1.53*	1.05–2.22

* $P \leq 0.05$. † $P < 0.01$. ‡ $P < 0.001$.

CI = confidence interval; COPD = chronic obstructive pulmonary disease; RR = rate ratio (an RR of unity [1.0] means no difference in death rate between anesthesiologists and general internists).

room environment was not found to increase the risk of death from cancer. Compared to internists, anesthesiologists had an increased risk of death from suicide, particularly suicide by drug overdose, drug-related death, cerebrovascular disease, and other external causes. The rates of drug-related death appear to be highest in more recent graduates. In addition, the risk of death from HIV and viral hepatitis also was increased in male anesthesiologists.

Methodologic Issues

Although the study results were drawn from a very large cohort that purportedly included all self-designated anesthesiologists, the results should be interpreted with reference to a number of limitations. The main limitation of the study is the relatively young age and short follow-up of the cohorts. The mean year of birth was 1944, with a mean follow-up of 13.7 years to a mean age of 50.3 years (table 1). As the risk of death from cancer increases with advanced age, further follow-up to the typical cancer death ages (>65 years) is necessary to assess the true cancer risks of anesthesiologists.

The cohort of all anesthesiologists was compared with the cohort of a subset of general internists randomly sampled and matched for gender, decade of birth, and citizenship status. The randomization procedure was performed using standard techniques and resulted in a population with identical demographic characteristics as the anesthesiologist cohort (table 1). The study's general results would be similar if the entire internist cohort were studied, although statistical precision would be expected to be modestly improved with additional subjects.

Another limitation of this cohort mortality study is the ambiguity in identifying all decedents and classifying their causes of death correctly. The study relied on the PMF designation of vital status, which may be incomplete. The PMF designation of vital status was used (instead of searching the entire cohort using NDI) because of the absence of a unique identifier (i.e., social security number) for each member of the cohort. NDI

Table 4. Gender-specific Frequency Distribution and Age and Race-adjusted Rate Ratios for All Causes and Selected Causes of Death Comparing Anesthesiologists with Internists

	Men				Women			
	Anesthesiologists N	Internists N	RR	95% CI	Anesthesiologists N	Internists N	RR	95% CI
All deaths	2,247	2,159	1.03	0.97–1.10	211	217	0.99	0.82–1.20
All cancer	563	563	0.98	0.88–1.11	84	78	1.03	0.76–1.40
Pancreatic cancer	45	36	1.24	0.80–1.92	4	1	4.01	0.45–35.92
Brain cancer	24	26	0.93	0.54–1.63	4	2	1.92	0.35–10.48
Respiratory cancer	103	111	0.92	0.70–1.20	12	10	1.23	0.53–2.85
Digestive cancer	177	151	1.16	0.94–1.44	12	15	0.80	0.37–1.72
Leukemia	33	26	1.26	0.76–2.12	4	3	1.30	0.29–5.83
Hematopoietic	52	62	0.83	0.57–1.20	1	1	0.99	0.06–5.84
Heart disease	713	751	0.94	0.85–1.05	36	43	0.93	0.60–1.45
Ischemic heart disease	528	581	0.91	0.81–1.02	21	30	0.78	0.44–1.36
Hypertensive heart disease	10	17	0.60	0.28–1.32	3	2	1.90	0.32–11.47
Cardiomyopathy	22	26	0.84	0.47–1.48	1	2	0.50	0.05–5.53
Heart failure	28	18	1.57	0.87–2.85	2	0	§	
Cerebrovascular disease	131	92	1.43†	1.10–1.87	16	15	1.19	0.59–2.41
Other diseases of circulatory system	46	52	0.91	0.61–1.35	4	3	1.53	0.34–6.89
HIV-related disease	42	23	1.82*	1.09–3.02	1	1	0.99	0.06–15.86
Diseases of digestive system	38	27	1.36	0.83–2.23	1	2	0.49	0.44–5.43
COPD	49	48	1.03	0.69–1.54	3	7	0.47	0.12–1.81
Pneumonia, influenza, bronchiolitis	49	33	1.54	0.99–2.39	2	4	0.55	0.10–2.99
Chronic liver disease	27	19	1.38	0.77–2.48	1	2	0.51	0.05–5.69
Viral hepatitis	8	1	7.98*	1.0–63.84	0	1	§	
Diabetes	40	38	1.04	0.67–1.63	1	2	0.49	0.04–5.34
Renal disease	10	10	1.02	0.42–2.45	1	1	0.99	0.06–15.79
Mental disorders	14	17	0.86	0.43–1.75	3	0	§	
Diseases of nervous system and sense organs	52	52	1.04	0.71–1.53	4	4	1.03	0.26–4.12
Alzheimer disease	17	21	0.87	0.46–1.65	3	0	§	
Motor vehicle accidents	33	30	1.09	0.67–1.79	5	5	0.98	0.28–3.39
Suicide	92	64	1.44*	1.05–1.98	11	7	1.50	0.58–3.88
Drug-related suicide	42	18	2.37†	1.37–4.12	6	4	1.43	0.40–5.08
All drug-related deaths	83	28	3.00‡	1.96–4.62	8	5	1.53	0.50–4.67
Homicide	6	9	0.65	0.23–1.82	3	2	1.47	0.25–8.8
Other external causes	65	44	1.47*	1.00–2.15	4	1	4.01	0.45–35.95

* $P \leq 0.05$. † $P < 0.01$. ‡ $P < 0.001$. § RR not calculated because of n = 0 in either group.

CI = confidence interval; COPD = chronic obsructive pulmonary disease; RR = rate ratio (an RR of unity [1.0] means no difference in death rate between anesthesiologists and general internists).

searches result in a large number of false positives, especially in the absence of a social security number.[12,13] It is likely that vital status classification using the PMF may be less reliable for physicians who trained or once practiced in the United States but are no longer in the country and thus are not tracked actively for the PMF. Furthermore, information from the NDI would not be available for those who died outside of the United States. The extent to which this differed between anesthesiologists and internists, if at all, is unknown. Drawing a sample of internists matched on US citizenship was done to minimize this effect.

The proper classification of cause of death relied on a positive match with the NDI. The availability of the NDI Plus and an estimated date of death improved the probability of finding an exact match. The NDI has a high sensitivity (92–98%) with matches, even in the absence of a social security number, as long as name and complete date of birth are used.[12,13] The availability of NDI Plus and an estimated date on death improved the probability of an exact match. In our study, differentiation between true and false positives was made by manual review of each record and their matches (comparing name, birth date, sex, birth place, date of death, and state of death). Death certificate requests were sent to the state vital statistics offices to confirm questionable matches identified during the manual review.

Although matching of known decedents by the NDI was quite successful, 132 anesthesiologists (5.4%) and 193 internists (8.1%) were not coded for cause of death. Had these been correctly classified, the observed rate ratios may have been reduced modestly, if the distribu-

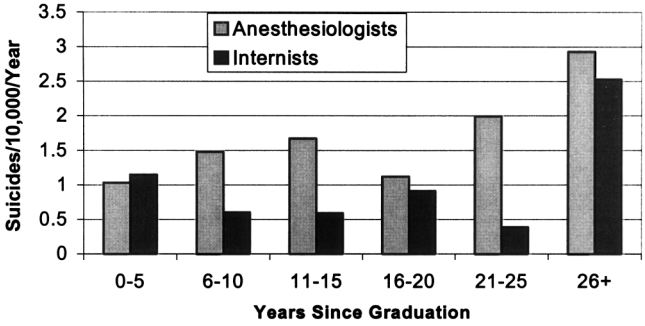

Fig. 1. Suicides per 10,000 person-years by years since graduation for anesthesiologists and internal medicine physicians.

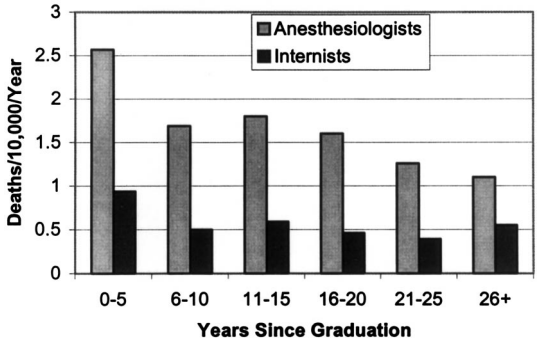

Fig. 2. All drug-related deaths per 10,000 person-years by years since graduation for anesthesiologists and internal medicine physicians.

tion of causes of the uncoded deaths were different for deaths of known causes (because of the greater number of uncoded deaths of internists).

It is also important to recognize that the complexities of the operating room environment make it difficult to identify specific causative agents or work conditions. We classified exposure by the surrogate measure of the duration of time within the profession and evaluated whether the hazard ratio for several cancers and suicide varied with time since graduation. We were unable to quantify specific exposures to trace anesthetic gases, stress and irregular hours, radiation, and other hazards that might be present within the operating room environment. In addition, differences in personal habits, lifestyle, and psychological profiles between anesthesiologists and internists could not be evaluated in this study. There also may be a bias related to ethnic background. The only available measure of ethnicity was self-designated race. This information was missing for about 34% of the cohort; however, in those for whom it was reported, the racial distribution between the two specialties was similar (table 1). An increased risk in anesthesiologists may be caused by these personal factors rather than occupational exposure.

Finally, this study reports comparisons of the mortality experience between anesthesiologists and general internal medicine specialists for a number of diseases. It is possible that because of the number of comparisons made some of the differences in mortality risks occurred by chance.

Mortality Risk

Comparison with General Population. Overall, anesthesiologists and general internists had lower mortality rates than the general population, as evidenced by SMRs well below unity (table 2). The only exceptions were increased rates of suicide in female anesthesiologists and accidental poisonings among male anesthesiologists. Although the low SMRs may result partially from the incomplete ascertainment of deaths in the cohorts, the SMR findings are consistent with prior studies.[6–11] The low mortality rates primarily reflect the higher socioeconomic class of physicians, a better health-related lifestyle, and the "healthy worker effect."[6–11] The rate of cigarette smoking–related diseases was especially low in the physician population, as has been reported in the past.[6–11]

Comparison of Anesthesiologists with General Internists. The comparison of mortality risks of anesthesiologists *versus* general internists did not show an increase in risk of death in anesthesiologists caused by cancer. This finding is also consistent with older studies of US anesthesiologists[3,4] and more recent studies of anesthesiologists in the United Kingdom.[9,10] However, the incidence of cancer generally increases with advanced age and a longer length of exposure to potential carcinogens. Therefore, it is possible that the modest increased risk of death from pancreatic cancer (31%) and leukemia (26%) observed in this study might become

Table 5. Relative Rate Ratios for Drug and Suicide Deaths Comparing Anesthesiologists with Internists before and after January 1, 1987

		Anesthesiologists (N)	Internists (N)	RR*	95% CI
All drug-related deaths	<1987	36	14	2.65	1.42–4.91
	≥1987	55	19	2.87	1.71–4.84
Drug-related suicides	<1987	16	11	1.48	0.69–3.20
	≥1987	32	11	2.88	1.45–5.71
Suicides	<1987	41	33	1.25	0.79–1.97
	≥1987	62	38	1.60	1.07–2.39

* Ratio (RR) of anesthesiologists compared with internists for that time period. RR is adjusted for age, gender, and race.

CI = confidence interval.

more pronounced, or possibly vanish, if the cohort were followed for another 10 to 20 years.

Male anesthesiologists had increased risks of death from HIV (RR = 1.82) and viral hepatitis (RR = 7.98) compared with internists (table 4). The increase in risk of death from hepatitis is consistent with earlier studies suggesting an increased rate of hepatic disease in anesthesiologists.[2,5,9] Although our study is not able to determine whether these deaths resulted from lifestyle or occupational exposures because the 80% increase in HIV occurred primarily in males (42/43 cases) and the eightfold increase in hepatitis occurred exclusively in males, it is likely that these cases represented a lifestyle exposure. However, anesthesiologists are believed to be at higher occupational risk for HIV and hepatitis than physicians with lower exposure rates to blood and body secretions because percutaneous injuries are common among anesthesiologists.[19,20]

Our finding of increased rates of suicide and drug-related suicides in anesthesiologists compared with the general US population is consistent with the results of prior mortality studies comparing anesthesiologists with socioeconomic control subjects or the general population.[1,3,4,9,10] Physicians, especially female physicians, have increased rates of suicide compared with the general population.[7,9,11,21,22] Our study also showed an increased risk of suicide (RR = 1.45), especially drug-related suicide (RR = 2.21), in anesthesiologists compared with internists (table 3). In addition, the 2.8-fold increase risk in all drug-related deaths in anesthesiologists compared with internists may represent additional suicides because suicide may have been concealed.

Although anesthesiologists and internists have similar rates of use of psychoactive substances,[23,24] anesthesiologists may be more likely to use parenteral opioids and more frequently obtained drugs from the workplace than other physicians.[25] The prevalence of opioid drug abuse among anesthesiology residents and practitioners was estimated at 1–3%.[26,27] Anesthesiologists were estimated to represent between 9 and 13% of the physicians in drug treatment programs; fewer than 4% of all physicians are anesthesiologists.[25,27,28] The success rate for resident reentry into anesthesiology among parenteral opioid abusers was poor, with death occurring as the initial relapse symptom in 16% (13/79) of parenteral opioid users who were allowed to reenter the training.[29]

Differences in rates of drug-related deaths and drug-related suicides between anesthesiologists and internists were greatest during the first 5 years after graduation; the rates generally declined for both specialties over time (fig. 2). This may reflect the increased use of fentanyl and parenteral opioids in anesthesiology residents, in contrast to the more slowly addicting sedatives and oral opioids used by older general internists. Substance abusers in anesthesiology have been found to be younger than other physician abusers.[23] Premature deaths of younger anesthesiologists from all drug-related causes resulted in over 2,000 years of life lost before age 65, compared with 715 life-years lost in internists. The lower age of death of anesthesiologist decedents (table 1) also is attributed to the excess mortality rate from suicide and drug-related deaths in anesthesiologists. Our results therefore suggest that substance abuse and suicide represent significant occupational risks for anesthesiologists.

Despite increased awareness of the potential for substance abuse and education efforts,[18] our study found that the relative risk for drug-related deaths for anesthesiologists remained elevated after 1987 despite the introduction of educational programs in academic medical centers (table 5). This result suggests that current preventive and educational efforts concerning drug abuse should be evaluated. Because the mortality rate does not include many nonfatal cases of drug abuse and therefore represents only the "tip of the iceberg," enhanced preventive measures are especially important.

Our study found modestly increased rates of death from cerebrovascular disease (RR = 1.39; table 3). Most of the cerebrovascular disease represented "acute but ill-defined" disease. Increased mortality rates from cerebrovascular disease have not been observed in prior mortality studies of anesthesiologists[1,3,4,9,10] and are unlikely to be related to the operating room environment. Death rates from other heart and circulatory disease, including ischemic heart disease, hypertensive heart disease, and cardiomyopathy were lower in anesthesiologists; thus the mortality rate from all types of heart disease was not different from that in internists (table 3). The small increase in unspecified heart failure may represent a misclassification of these other disorders.

Conclusions

The risk of cancer was not increased in anesthesiologists compared with internists. However, further follow-up to the typical cancer death ages is needed to assess the true cancer risks. Compared with internists, anesthesiologists had an increased risk of death from suicide, particularly suicide by drug overdose, and drug-related death. Male anesthesiologists had a higher risk of death from HIV and viral hepatitis, which may be related to lifestyle. The results suggest that continued attention to substance abuse among anesthesiologists is warranted.

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