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Cause-specific mortality among neurosurgeons

Clinical article

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Object. The authors sought to determine a cause-specific mortality profile for US neurosurgeons during the period 1979–2005.

Methods. Neurosurgeons who died during the study period were identified from the Physician Master File database. Using the National Death Index, the reported cause of death was identified for 93.7% of decedents. Standardized mortality ratios were used to compare mortality risk in the study cohort to that of the US population.

Results. There was a marked reduction in mortality from virtually all causes in comparison with the control population. This finding is consistent with prior studies of mortality in physicians. The small number of deaths among female neurosurgeons precluded meaningful analysis for this group. Increased mortality risk for male neurosurgeons was seen from leukemia, nervous system disease (particularly Alzheimer disease), and aircraft accidents. Deaths from viral hepatitis and HIV infection, considered to be occupational hazards for surgeons, were less frequent than in the general population. Suicide, drug-related deaths, and alcohol-related deaths were less frequent than in the general population.

Conclusions. Neurosurgeons may be at higher risk for death from leukemia, aircraft accidents, and diseases of the nervous system, particularly Alzheimer disease; however, the mortality profile of neurosurgeons is favorable when compared with the general population. *(DOI: 10.3171/2010.1.JNS091740)*

Key Words • cause of death • mortality • neurosurgeon • occupational hazard • neurosurgeon mortality

Studies of mortality are an important tool in the identification of occupational hazards. Previous studies of mortality in physicians have found increased death from brain tumors and suicide in pathologists;[17] leukemia, pancreatic cancer, lung cancer, and skin cancer in radiologists;[32] and suicide, accidental death, and drug-related death in anesthesiologists.[1] In the case of radiologists, the recognition of increased cancer risk associated with occupational exposure to ionizing radiation led to institution of fundamental radiation safety practices. In the case of anesthesiologists, the recognition of increased risk of drug-related death and suicide led to institution of intervention programs aimed at identification and rehabilitation of at-risk physicians.[4,10]

Abbreviations used in this paper: AMA = American Medical Association; ICD-9 = International Classification of Diseases, 9th revision; ICD-10 = ICD, 10th revision; NDI = National Death Index; PMF = Physician Master File; SMR = standardized mortality ratio.

We undertook an investigation of cause-specific mortality risk in neurosurgeons practicing in the US between 1979 and 2005. Study methodology was modeled on a well-known study of cause of death in anesthesiologists by Alexander et al.[1] Our null hypothesis was that the cause-of-death profile of neurosurgeons is similar to that of the population at large. Prospectively defined causes of particular interest were: cardiovascular disease, brain neoplasm, leukemia and other hematopoietic neoplasms, HIV-related causes, viral hepatitis, suicide, and accidental death.

Methods

The Committee for the Protection of Human Subjects was approached for approval prior to the beginning of the study. Because this is a study of deceased subjects, it was deemed outside the scope of human experimentation and therefore exempt from review.

This study was performed using 2 databases: the

AMA Physician Master File (PMF) and the Centers for Disease Control and Prevention National Death Index (NDI). The PMF is a database of all practicing physicians in the US; to prevent use of deceased physicians' identities for fraudulent credentialing, it includes an updated entry of each subject's vital status (alive/dead). Information on vital status is obtained based on quarterly cross-referencing with the Social Security Death Index as well as more frequent screening of an online obituary service, screening of other online databases, communication with medical specialty societies, and in some cases, direct communication with families, friends, and colleagues of the deceased (Sellers J, 2009, personal communication). Physicians are included in the PMF whether they were AMA members or not. The PMF includes both residents and attending-level physicians and both US medical graduates and foreign medical graduates. Entries in the PMF include: name, medical school, year of graduation, sex, birth place, birth date, residency training, state licensure, board certification, practice location, and practice specialty.

The NDI is a central, computerized index of death record information on file in each state's vital statistics office. Information is available from 1979 to the present time. Users submit entries for each subject that include as much identifying information as possible. Submissions may include a combination of the following fields: last name, first name, middle initial, social security number, date of birth, year of birth, state of birth, father's surname, age at death, sex, race, marital status, and state of residence at death. When a social security number is not available, a full name and month/year of birth must be included. A probabilistic matching scheme is then used to identify the most likely match. Standard NDI results include only the date of death and the state from which the death record was obtained; however, using the NDI Plus service, cause of death is also available as an ICD-9 or ICD-10 code.

For this study, we identified all physicians with the specialty of neurosurgery or pediatric neurosurgery who practiced as attending-level or resident physicians during the period of 1979 through 2005 and who died during that same period. Identifying data obtained from the PMF included each decedent's full name, birth date, birth state, and date of death. Cause of death for each decedent was then obtained from the NDI. Standardized mortality ratios (SMR) were generated for each cause of interest, using de-identified data of neurosurgeons practicing within the specified period who were still living as of December 31, 2005. The SMR is the ratio of observed to expected deaths. Expected deaths are calculated using a reference population, in this case US cause-specific mortality rates, 1979–1998.[7] Because death rates in the reference population are subdivided into age- and sex-specific strata for each cause, the expected number of deaths can be calculated for a study group of a particular age and sex composition. Thus, SMRs permit comparison between the study group's mortality rates and the mortality rates of a hypothetical reference group that possesses the same demographic characteristics.

We prospectively identified certain causes of interest, which included: cardiovascular disease, brain neoplasm, leukemia and other hematopoietic neoplasms, HIV-related causes, viral hepatitis, suicide, and accidental death. Cardiovascular death was chosen because of the established link between work-related stress and death from cardiovascular causes.[5,18,20,21] Brain neoplasm was chosen because of its implication in excess mortality in pathologists,[17] its link with viral infection,[25] and anecdotal reports of patient-to-surgeon transmission of malignant tumor.[15] Leukemia and other hematopoietic neoplasms were chosen because of the frequent use of fluoroscopy in the operating room and the increased incidence of these neoplasms in radiologists during the early 20th century.[31] Viral hepatitis and HIV infection are established occupational hazards for surgeons.[8,9,12] Suicide and accidental death have previously been cited as causes of excess mortality in anesthesiologists.[1,23]

Results

A total of 7562 neurosurgeons practiced in the US during the period from 1979 through 2005. Of these, 755 died during the study period. The population was markedly skewed with regard to sex: 7163 (94.7%) of the practicing neurosurgeons were male, and 750 (99.3%) of the dead neurosurgeons were male. For men who had died, the mean age at death (± SD) was 71.2 ± 13.8 years. For women who had died, the mean age at death was 45.8 ± 13.5 years. A successful match for cause of death from NDI was obtained in 708 (93.7%) of deaths.

Because only 5 female neurosurgeons died during the study period, inferences about cause of death in this group are limited; this analysis is therefore aimed primarily at cause of death among male neurosurgeons. Table 1 depicts SMR data for major medical causes of death among male neurosurgeons, comparing the neurosurgery experience with the US population. For almost all causes, SMRs are substantially less than 1, reflecting fewer than expected deaths among neurosurgeons; however, death from nervous system disease was notably more frequent in the neurosurgery population. For purposes of this study, nervous system disease includes Alzheimer disease and other dementias, Parkinson disease, as well as other hereditary and degenerative diseases of the nervous system and sensory organs; it does not include brain tumor, other nervous system cancer, or cerebrovascular disease. Excess mortality from nervous system disease was related to higher than expected mortality from Alzheimer disease and to a lesser degree, Parkinson disease.

Table 2 depicts SMR data for various cancers. Leukemia was more frequent in the neurosurgery group, overcoming a general trend toward fewer than expected cancer deaths among neurosurgeons.

Table 3 depicts SMR data for external causes as well as other, prespecified causes of interest. With the exception of aircraft accidents, SMRs for accidental and nonaccidental trauma remained substantially below 1, reflecting the trend toward decreased mortality risk in neurosurgeons compared with the general population. Occupational risks notwithstanding, death from HIV infection or viral hepatitis was uncommon, as were drug and alcohol-related deaths.

Table 4 depicts cause of death among female neurosurgeons. Because of the small number of female neuro-

TABLE 1: Standardized mortality ratio mortality data for male neurosurgeons: general*

Cause	Observed	Expected†	SMR (95% CI)
all causes	750	1811	0.35 (0.11–0.81)
cancer	231	465	0.50 (0.43–0.57)
heart disease	229	641	0.36 (0.31–0.41)
cerebrovascular disease	38	96	0.40 (0.28–0.55)
digestive system disease	18	71	0.25 (0.15–0.40)
COPD	14	78	0.18 (0.1–0.3)
pneumonia, influenza, bronchiolitis	13	49	0.27 (0.14–0.45)
renal disease	6	20	0.30 (0.11–0.66)
mental disorders	6	20	0.30 (0.11–0.64)
disease of the nervous system & sense organs	33	27	1.2 (0.85–1.7)
Alzheimer disease	14	6.0	2.4 (1.3–3.9)
Parkinson disease	7	6.0	1.2 (0.47–2.4)
other hereditary & degenerative diseases of the nervous system	5	5.4	0.93 (0.30–2.2)

* COPD = chronic obstructive pulmonary disease.
† Based on rates for US 1979–1998.

surgeons, particularly among the older generations, there were few deaths among female neurosurgeons. However, it is notable that 2 of the 5 deaths were due to homicide.

Table 5 depicts age at death, stratified by cause. Neurosurgeons who died of chronic disease were most likely to die in the 8th decade of life. Those who died of accidental, HIV-related, or alcohol-related causes died, on average, 2 decades earlier.

Discussion

This study was notable for a substantially decreased mortality risk among neurosurgeons, compared with the general population, for virtually all causes. To a degree, this decreased risk is consistent with other studies of physician mortality. Recent studies in the US, the United Kingdom, Korea, and Taiwan report all-cause SMRs for physicians ranging from 0.47 to 0.63.[1,6,24,30] Some of this reduction can be attributed to a healthy-worker effect. People who are working have a decreased mortality risk when compared with the population at large. Because participation in a job requires a certain degree of health and disabled people are excluded from the analysis, there is a bias toward greater life expectancy and decreased mortality from all causes. This is likely to be especially pronounced in the physician population, which represents a well-educated, socioeconomically advantaged, and presumably health-conscious segment of society.

However, the all-cause SMR of 0.35 reported in this study is lower than all other studies of physician mortality to date. This raises the possibility that ascertainment bias resulted in underreporting of physician deaths. We used the PMF as our source of information about physician vital status. As described above, the PMF methodology for ascertaining physician deaths is robust and should represent an accurate source of this information. Alexander et al.[1] also used the PMF as a source of vital status and reported an all-cause mortality of 0.48. This SMR is consistent with findings from other studies of physician mortality from a variety of countries, using a variety of methodologies. Although it is possible that dead neurosurgeons were "missed," repeated reviews of methodology with the staff of PMF have failed to uncover any such event.

TABLE 2: Standardized mortality ratio mortality data for male neurosurgeons: cancer

Cause	Observed	Expected*	SMR (95% CI)
pancreatic cancer	17	22	0.78 (0.45–1.2)
brain cancer	8	11	0.74 (0.32–1.46)
respiratory cancer	49	167	0.29 (0.22–0.39)
digestive cancer	57	91	0.63 (0.48–0.82)
leukemia	20	16	1.2 (0.75–1.9)
other hematopoietic cancer	22	26	0.85 (0.53–1.3)
other cancer	58	132	0.44 (0.33–0.57)

* Based on rates for US 1979–1998.

TABLE 3: Standardized mortality ratio mortality data for male neurosurgeons: external causes and other areas of interest*

Cause	Observed	Expected†	SMR (95% CI)
all external causes	55	148	0.37 (0.28–0.48)
MVA	11	39	0.28 (0.14–0.51)
suicide	20	37	0.54 (0.33–0.83)
homicide	2	22	0.09 (0.01–0.33)
aircraft accident	9	1.7	5.3 (2.4–10)
HIV-related	3	27	0.11 (0.02–0.32)
viral hepatitis	1	2.2	0.45 (0.01–2.5)
all drug-related	1	12	0.08 (0–0.46)
all alcohol-related	3	30	0.10 (0.02–0.30)

* MVA = motor vehicle accident.
† Based on rates for US 1979–1998.

TABLE 4: Standardized mortality ratio mortality data for female neurosurgeons

Cause	Observed	Expected*	SMR (95% CI)
all deaths	5	14	0.35 (0.11–0.81)
all cancer	2	4.3	0.47 (0.06–1.7)
homicide	2	0.33	6.0 (0.73–22)

* Based on rates for US 1979–1998.

TABLE 5: Mean age at death for male neurosurgeons, by cause

Cause	Median Age (95% CI)
cancer	72 (71–73)
heart disease	75 (73–76)
cerebrovascular disease	77 (75–79)
digestive system disease	80 (71–85)
COPD	79 (77–83)
pneumonia, influenza, bronchiolitis	82 (70–86)
renal disease	80 (72–83)
mental disorders	85 (80–92)
HIV-related	56 (39–61)
external causes	56 (48–62)
alcohol-related	55 (37–69)

Increased risk of death from leukemia, nervous system disease, Alzheimer disease, Parkinson disease, and aircraft accidents were noted. In the case of leukemia, nervous system disease, and Parkinson disease, the CIs cross unity. Traditionally, results which cross unity are considered not statistically significant; however, these results must be considered in the context of the group's overall, marked reduction in all-cause mortality. When considered against an all-cause SMR of 0.35, a cause-specific SMR of 1 is notable; it means that the forces driving up mortality from that cause were sufficient to overcome the forces driving down mortality generally.

Any explanation of etiology for specific mortality risks is speculative. Multiple mutagenic hazards in the operating room have been identified, including electrocautery smoke, x-rays, and waste anesthetic gases. In addition to containing organic compounds such as hydrogen cyanide, butadiene, and acetylene,[27] electrocautery smoke has been shown to transmit viral infection[14] as well as viable tumor cells.[13] One study demonstrated its ability to mutate DNA.[16] Exposure to x-rays is a known risk factor for the development of cancer, and a dose-dependent effect has been shown in both patients and health care personnel exposed to medical x-rays (including through fluoroscopy).[2,26,28,31] In a study of mortality of radiologists in the early part of the 20th century, prior to the institution of radiation safety precautions, the greatest excess mortality was seen from leukemia and skin cancer.[31] Some studies suggest an abortifacient or teratogenic effect of waste anesthetic gases, but no carcinogenic effects have been shown to date.[3,22,32,33] With regard to Alzheimer disease and other degenerative neurological disease, it is difficult to associate the increased incidence with any known environmental exposure.[29] There is a direct correlation between age and risk of Alzheimer disease.[11] A cohort with decreased mortality from other causes is likely to be older and therefore, may have a higher incidence of Alzheimer disease. However, the calculation of SMR is stratified by age, so this is not a potential source of confounding within this cohort. The higher frequency of aircraft accidents is most likely attributable to a higher than average prevalence of small plane ownership and amateur piloting among neurosurgeons.

Some attention should be paid to relatively increased SMRs, that is, SMRs that are substantially greater than the all-cause SMR of 0.35, even if they are not greater than 1. These may reflect real associations or hazards that are being concealed by the overall favorable mortality profile of the group. Brain cancer, pancreatic cancer, and nonleukemic hematopoietic cancer fall into this category. Other than the carcinogenic hazards described above, the authors are unaware of any risk factors for these diseases that are specific to the operating room environment or the demographic patterns of neurosurgery.

It is striking that 2 of 5 female deaths were the result of homicide. It is difficult to draw conclusions from this, given the small number of cases involved. However, it is interesting that other studies have reported a statistically significant increase in the risk of violent death among female physicians, not only relative to their male counterparts, but also relative to the population at large.[6,19]

The principal weakness of this study is the lack of a nonneurosurgeon, physician control group. Although the study by Alexander et al.[1] used a virtually identical methodology, the raw data from that study is no longer available. A rudimentary comparison with analyzed data in its published form is possible, but this cannot account for confounding by inherent differences between the groups. Were a physician control group available for direct statistical comparison, it would mitigate issues of the healthy-worker effect, ascertainment bias, and the inherent difficulty of assessing statistical significance in the setting of globally decreased mortality ratios.

In calculating SMRs, we elected to use reference US population mortality data only for the years 1979 through 1998, though the neurosurgeon population under study involved a period from 1979 through 2005. In 1998, coding for cause of death transitioned from ICD-9 to ICD-10. Because of changes in the categorization of disease, it is difficult to accurately synthesize data from the 2 different coding formats. We felt that large-scale changes in the patterns of mortality from 1998 to 2005 were unlikely, and therefore that utilization of the earlier time period was valid. However, it is possible that for specific diseases, such as HIV infection, institution of new methods of prevention and treatment during the later period resulted in decreased mortality rates for the general population that were not reflected in our data analysis; this may have resulted in artifactually decreased SMRs.

Conclusions

Neurosurgeons were more likely to die of Alzheimer disease, other nonneoplastic nonvascular nervous system disease, leukemia, and aircraft accidents, when compared with the general population. Further interpretation of neurosurgeons' mortality profile is complicated by inherent differences between neurosurgeons and the population at large. In general, neurosurgeons benefited from significantly reduced all-cause mortality.

Disclosure

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Author contributions to the study and manuscript preparation include the following. Conception and design: SS Lollis, PA Ball. Acquisition of data: SS Lollis, PA Valdes. Analysis and interpretation of data: SS Lollis. Drafting the article: SS Lollis. Critically revising the article: SS Lollis, PA Valdes, PA Ball, DW Roberts. Reviewed final version of the manuscript and approved it for submission: SS Lollis, PA Valdes, Z Li, PA Ball, DW Roberts. Statistical analysis: Z Li. Administrative/technical/material support: DW Roberts. Study supervision: SS Lollis.

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