

Neoplastic Disease in a Medicolegal Autopsy Material

A Retrospective Study in Northern Sweden

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Summary. Only a small fraction of sudden unexpected deaths are caused by neoplastic disease and thus subject to medicolegal autopsy. The medicolegal autopsy forms an opportunity to study not only medically diagnosed and treated neoplasms, but also the natural evolution of untreated disease. In a series of 7,020 consecutive medicolegal autopsies in northern Sweden, we found 171 cases with malignant and/or intracranial neoplasms.

In 41 cases, sudden death was caused by previously unknown tumors. The most common mechanisms of death in this group were disseminated cancer, intracranial tumors, pulmonary thromboembolism, hemoptysis, and aspiration of blood, and the most common locations were the bronchi and the lung. In some of these cases, the mechanism was sometimes dramatic, raising a question of violent death or intoxication. In 30 cases, sudden unexpected death was caused by previously known tumors, and also in this group disseminated cancer was the most common cause of death, and the most common locations were the bronchi and the lung.

In 22 cases, tumors were found in suicidal cases; in 14 of these, the tumor was considered to be a major causative factor to the suicide, while in eight cases the tumor was considered to be an incidental finding. The expected number of cancers in the 1,060 suicides investigated in this series was 27, according to the official cancer prevalence data. Thus, a possible overrepresentation of suicides among persons with cancer seems doubtful and needs further exploration.

Key words: Neoplastic disease, medicolegal autopsy – Sudden unexpected death, caused by unknown tumors – Suicide, tumors in suicidal cases

Zusammenfassung. Nur ein geringer Teil plötzlicher und unerwarteter Todesfälle ist Folge einer neoplastischen Erkrankung. Die in diesem Zusammenhang vorgenommenen rechtsmedizinischen Obduktionen geben damit Gelegenheit, nicht nur diagnostizierte und behandelte Tumor-Erkrankun-

gen, sondern auch deren natürliche Entwicklung bei unbehandelten Erkrankungen zu untersuchen. Unter insgesamt 7020 rechtsmedizinischen Obduktionen im nördlichen Schweden haben wir in 171 Fällen maligne und/oder intrakranielle Tumore gefunden.

In 41 Fällen war der Tod durch den zuvor unbekannten Tumor verursacht worden. Die häufigsten Todesursachen waren in diesen Fällen Tumormetastasen, intrakranielle Tumore, Lungenembolie, Hämoptysis, Blutaspiration, am meisten waren Bronchien und Lunge betroffen. In einigen Fällen waren die Todesumstände derart dramatisch verlaufen, daß der Verdacht eines gewaltsamen Todes oder einer Vergiftung aufkam. In 30 Fällen war der plötzliche Tod durch bereits bekannte Tumor-Erkrankungen verursacht, wobei Bronchien- und Lungenmetastasen die häufigsten Todesursachen waren.

Bei 22 Suizidfällen wurden Tumore gefunden, wobei in 14 Fällen der Tumor als Grund für den Suizid anzusehen war; in acht Fällen stellten Tumore nur einen Nebebefund dar. Nach der offiziellen Krebsstatistik würden 27 Tumorträger unter den 1060 Suizidfällen zu erwarten sein. Die Annahme einer Überrepräsentation von Suiziden bei Personen mit einer Krebserkrankung erscheint daher zweifelhaft und bedarf weiterer Untersuchungen.

Schlüsselwörter: Geschwülste bei rechtsmedizinischen Obduktionen – Plötzlicher Tod, durch unbekannte Tumore – Selbsttötung, bei Tumorerkrankung

Introduction

The forensic autopsies are largely those of sudden, unexpected death due to natural disease, which frequently is not diagnosed ante mortem. Most of these deaths are caused by ischemic heart disease, but a small percentage is caused by neoplasms. Critical localization, hemorrhagia, or advanced disease may trigger these latter deaths.

The present paper reports an analysis of a forensic autopsy material where malignant and/or intracranial neoplasms were found.

Materials and Methods

We have reviewed the findings in 7,020 consecutive forensic autopsies performed at the State Institute of Forensic Medicine of Umeå during the 8-year period from 1978 to 1985. This institute serves a population of about 907,000; and according to official statistics, about 46,500 males and about 35,800 female deaths were recorded during the period. This makes a medicolegal necropsy index of about 8.5% of all deaths. Of these 7,020 autopsies, about 3,940 were caused by disease, 1,060 were suicides, 70 homicides, 1,550 accidents, and 400 were unnatural deaths of undetermined origin. The mean age (\pm SD) of all 7,020 autopsies was 55 ± 20 years for men and 58 ± 21 years for women, and in the suicide fraction 45 ± 17 and 47 ± 16 years, respectively.

All neoplasms found were evaluated macro- and microscopically and classified according to the WHO classification. Basal cell carcinomas of the skin and all extracranial benign tumors were excluded.

Results

In all, 171 cases with malignant and/or intracranial neoplasms were found. These cases were subdivided into fractions I–V according to the following. Seventy-one cases represented sudden deaths directly caused by unknown (fraction I) or previously diagnosed (fraction II) neoplastic disease, giving an average number of 8.9 cases per year, or 1.0% of the autopsied cases.

Twenty-three cases were suicides caused by (fraction III) or with incidental finding of (fraction IV) tumor disease (including one homicide for euthanasic reasons, a so-called “extended suicide”), thus constituting 2.2% of all investigated suicides.

In the remaining 77 cases, the cause of death was not directly attributed to the presence of tumor (fraction V).

Death Caused by Previously Unknown Tumors (41 Cases; Table 1)

This group contained 14 women and 27 men, with a mean age (\pm SD) of 71 ± 9 and 63 ± 17 years, respectively. The most common tumor was carcinoma of the bronchi and lung (12 cases), and the histological type was in most cases spinocellular carcinoma. The mechanisms of death was hemoptysis and aspiration of blood in four cases and disseminated cancer in five cases. Two cases had no metastases whatsoever, and in seven other cases the records did not indicate any symptoms of neoplastic disease in spite of disseminated cancer. Three of these seven individuals were alcoholics.

The second most common cancer in this group was gastric cancer where the mechanism of death was disseminated cancer in three cases, gastric stenosis and retention in one case, and aspiration of blood in one case. Meningioma was present in four cases, hypernephroma of the kidney in three cases, and pancreatic tumor in another three cases. Among the latter, there was one insulinoma which may have caused the death through acute severe hypoglycemia. The remaining cases represented various types of cancer, causing the death in most cases through disseminated disease or through pulmonary thromboembolism.

Case Report (No. 8). A 68-year-old single alcoholic was found dead, showing several bruises. The police authority was informed by an anonymous person that the deceased had been assaulted before his death. A medicolegal autopsy was performed as the suspicion of homicide was raised. The autopsy findings included aspiration of gastric contents and a bronchial cancer with distant metastases.

Case Report (No. 14). A 33-year-old man was admitted to a neurologic ward due to acute severe seizures and aggravating coma. The neurologic symptoms were thought to be caused by intoxication. The man died and a medicolegal autopsy was performed, showing a poorly differentiated gastric adenocarcinoma with distant metastases. These included severe infiltration of the meninges, explaining the neurologic symptoms.

Table 1. Sudden, unexpected deaths caused by unknown tumors ($n = 41$)

Case no.	Age	Sex	Cause of death	Primary tumor			Symptoms of neoplastic disease
				Location	Diam. ^a (cm)	Microscopic type	
1	72	M	Pneumonia	Lobar bronchus	3	Spinoecellular carcinoma	Dyspnea
2	81	M	Hemoptysis	Lobar bronchus	3	Spinoecellular carcinoma	Hemoptysis
3	76	M	Disseminated carcinoma	Lobar bronchus	12	Adenocarcinoma	Distant
4	58	M	Aspiration of blood	Lobar bronchus	7	Spinoecellular carcinoma	Regional nll
5	67	M	Pneumonia	Lobar bronchus	3	Spinoecellular carcinoma	Regional nll
6	48	M	Brain metastases	Lung	4	Oat cell carcinoma	Distant
7	68	M	Disseminated carcinoma	Lung	12	Spinoecellular carcinoma	Distant
8	68	M	Aspiration	Bronchus	?	Adenosquamous carcinoma	Distant
9	63	M	Aspiration of blood	Main bronchus	3.5	Spinoecellular carcinoma	Regional nll
10	63	M	Disseminated carcinoma	Main bronchus	7	Spinoecellular carcinoma	Distant
11	83	M	Disseminated carcinoma	Main bronchus	8	Spinoecellular carcinoma	Distant
12	52	M	Aspiration of blood	Main bronchus	4	Spinoecellular carcinoma	Regional nll
13	68	F	Disseminated carcinoma	Ventricle	4	Carcinoid	Distant
14	33	M	Meningeal metastases	Ventricle	5	Adenocarcinoma	Stomach ache
15	63	F	Disseminated carcinoma	Ventricle	5	Adenocarcinoma	Headache, seizures
16	70	F	Aspiration of blood	Ventricle	20	Anaplastic carcinoma	Anxiety, dyspnea
17	69	F	Gastric stenosis	Ventricle	15	Adenocarcinoma	Regional nll
18	80	M	Disseminated carcinoma	Kidney	8	Hypernephroma	Regional nll
19	66	M	Disseminated carcinoma	Kidney	10	Hypernephroma	Distant
20	64	M	Brain metastases	Kidney	7	Hypernephroma	Distant
21	74	F	Aspiration	Skull base	5	Meningioma	Distant
22	81	M	Pulmonary thromboembolism	Frontal vault	6	Meningioma	Distant
23	61	M	Intracranial tumor	Skull base	6	Meningioma	Distant
24	55	M	Intracranial tumor	Skull base	5	Meningioma	Distant

25	7	M	Intracranial tumor	4th ventricle	3	Medulloblastoma	—	Nausea, vomiting, unconsciousness
26	75	F	Intracranial tumor	Temporal lobe	4	Astrocytoma	—	—
27	65	M	Intracranial tumor	Occipital lobe	5	Hemangioblastoma	—	—
28	81	F	Disseminated carcinoma	Pancreas	?	Adenocarcinoma	Distant	—
29	78	F	Hypoglycemia?	Pancreas	4	Insulinoma	Ingrowth to the spleen	—
30	61	M	Disseminated carcinoma	Pancreas	5	Adenocarcinoma	Distant	—
31	52	F	Disseminated carcinoma	Ovary	17	Endometroid carcinoma	Distant	—
32	76	F	Pulmonary thromboembolism	Ovary	6	Papillary cystadenocarcinoma	Distant	Weakness
33	71	M	Liver insufficiency	Rectum	6	Adenocarcinoma	Distant	—
34	77	F	Pulmonary thromboembolism	Appendix	6	Adenocarcinoma	Distant	Weakness, nausea
35	83	F	Pulmonary thromboembolism	Colon ascendens	5	Adenocarcinoma	—	—
36	34	M	Hemorrhage in brain metastases	Retroperitoneal region	10	Choriocarcinoma	Distant	Coughing, infirm
37	57	F	Disseminated carcinoma	Extrahepatic bile duct	?	Adenocarcinoma	Liver and regional nll	Shoulder ache
38	83	M	Disseminated carcinoma	Liver	3	Hepatocellular carcinoma	Distant	Weight loss
39	64	F	Pulmonary thromboembolism	Corpus uteri	3	Adenocarcinoma	Regional nll	Tiredness, weight loss
40	78	M	Cerebral hemorrhage	Bone marrow	—	Preleukemia	—	Infections
41	57	M	Disseminated tumor	Abdominal lymph nodes	—	Malignant lymphoma	Distant	—

^a Denotes size of tumor at autopsy

Table 2. Sudden deaths caused by known tumors (*n* = 30)

Case no.	Age	Sex	Cause of death	Primary tumor		Diam. ^a (cm)	Microscopic type	Metastases
				Location				
42	39	M	Disseminated carcinoma	Lung		0	Oat cell carcinoma	Distant
43	71	M	IHD + lung tumor	Lung		6	Spino-cellular carcinoma	—
44	56	M	Aspiration of blood	Lung		4	Spino-cellular carcinoma	Distant
45	67	M	Disseminated carcinoma (+ IHD)	Lung		4	Adenocarcinoma	Distant
46	54	F	Aspiration of blood	Main bronchus		4	Adenocarcinoma	—
47	59	M	Disseminated carcinoma	Main bronchus		4	Adenosquamous carcinoma	Distant
48	55	M	Disseminated carcinoma	Main bronchus		4	Spino-cellular carcinoma	Distant
49	73	M	Disseminated carcinoma	Main bronchus		6	Spino-cellular carcinoma	Regional nll
50	55	M	Disseminated carcinoma	Ventricle		8	Adenocarcinoma	Distant
51	61	F	Hemorrhage from liver metastasis	Ventricle		9	Adenocarcinoma	Distant
52	69	M	Disseminated carcinoma	Ventricle		5	Adenocarcinoma	Distant
53	64	M	Disseminated carcinoma	Ventricle		8	Adenocarcinoma	Distant
54	64	F	Disseminated carcinoma	Ovaries		15	Endometroid carcinoma	Distant
55	73	F	Disseminated carcinoma	Ovary		0.5	Papillary cystadenocarcinoma	Distant
56	60	F	Disseminated carcinoma	Ovary		8	Mesonephroid carcinoma	Distant
57	80	M	Urosepsis	Prostate		?	Adenocarcinoma	—
58	84	M	Pneumonia	Prostate		?	Adenocarcinoma	Distant
59	65	M	Disseminated carcinoma	Kidney		6	Adenocarcinoma	Distant
60	79	F	Disseminated tumor	Lymph nodes		4	Reticle cell sarcoma	Distant
61	61	F	Aspiration of blood	Hypopharynx		4	Spino-cellular carcinoma	Distant
62	41	M	Liver insufficiency	Liver		14	Cholangiocellular carcinoma	—
63	77	F	Polycytemia verae	Bone marrow		—	Polycytemia verae	—
64	16	F	Cerebral tumors	Cerebellum		5	Medulloblastoma	Cerebral + spinal

65	60	M	Intracranial tumor	Hypophysis	3	Craniopharyngeoma	—
66	57	F	Disseminated tumor	Small intestine	3	Carcinoid	Distant
67	90	M	Disseminated carcinoma	Colon	?	Adenocarcinoma	Distant
68	66	M	Pulmonary thromboembolism	Anus	4	Spinocellular carcinoma	Distant
69	82	M	Disseminated carcinoma	Lip	2	Spinocellular carcinoma	Distant
70	66	F	Cardiac amyloidosis ^b	Skeleton	—	Myeloma	Skeletal
71	41	F	Pneumonia	Mammary gland	10	Cystosarcoma phyllodes	Distant

^a Denotes size of tumor at operation in cases treated surgically and at autopsy in the other cases

^b See [1] for a detailed description of this case

Case Report (No. 25). A 7-year-old boy was found dead in his bed. The day before he had fallen from a seesaw on a playground nearby and was examined by a physician who did not find any signs of trauma, although an X-ray of the skull was never performed. During the following night, the boy vomited a few times. When the boy was found dead, it was thought that the death was caused by the trauma and that the physician had missed this diagnosis. At autopsy, it was revealed that the death was caused by a medulloblastoma of the fourth ventricle.

Case Report (No. 34). A 77-year-old woman died suddenly and unexpectedly. According to the son of the deceased, his mother had become weaker and weaker during the last few months. He associated this progression with the occasions when his sister had visited his mother and told the police that he was convinced that his sister had poisoned their mother to death. At autopsy, a moderately differentiated adenocarcinoma of the appendix vermiformis with extensive mucin formation and distant metastases was found.

Deaths Caused by Previously Known Tumors (30 Cases; Table 2)

In this group there were 12 women and 18 men, with mean ages (\pm SD) of 59 ± 17 and 65 ± 14 years, respectively. Also in this group, lung and bronchial carcinoma predominated, comprising altogether eight cases. Of these, two deaths were caused by aspiration of blood and most of the other by disseminated tumor. Gastric cancer caused four deaths and ovarian cancer three. The remaining cases represented a variety of tumors.

In this group, advanced cancer was the most common cause of death (18 cases). Sudden unexpected deaths were seen in nine cases – in four cases caused by a sudden hemorrhage (nos. 44, 46, 51, and 61), in two cases by intracranial tumors (nos. 64 and 65), and in one case each by pulmonary thromboembolism (no. 68), by cardiac amyloidosis with engagement of the conduction system (no. 70; see [1] for a detailed description of this case), and by urosepsis (no. 57).

Not included in Table 2 was a case of fatal iatrogenic hemorrhage caused by lung perforation of a drain during the treatment of a lung adenocarcinoma with distant metastases in a 73-year-old woman.

Suicides Due to Tumor (15 Cases; Table 3)

All available records were studied in detail to classify the suicides with respect to the “cause” of the suicide. In questionable cases, additional information was obtained from close relatives of the deceased. Although the suicides often had multifactorial causes, they were classified into this group when the data available clearly indicated that the malignant disease was a major causative factor.

This group contained a great variety of tumors; however, cancer of the colon and rectum was the most common type with four cases, all having distant metastases. Only three cases had a previously known psychiatric disease, including one alcoholic. Most cases had been treated for the neoplastic disease, only two cases had not. In one of these two latter cases, the neoplasm was not medically diagnosed ante mortem, but the man was convinced that he suffered from a malignant disease (see case report no. 74 below). While it was obvious in all these cases that the suicide was committed due to the neoplastic disease, physical symptoms of this disease were mentioned in only four cases.

Table 3. Suicides due to tumors (n = 15)

Case no.	Age	Sex	Cause of death	Primary tumor		Diam. ^a (cm)	Microscopic type	Metastases	Psychiatric disease	Treatment for neoplasm ^b	Symptoms of neoplasm ^b
				Location							
72	60	M	Drug intoxication	Colon	Colon	4	Adenocarcinoma	Distant	Alcoholism	S	—
73	59	F	Drug intoxication	Colon	Colon	?	Adenocarcinoma	Distant	—	SC	Itching
74	78	M	Hanging	Colon	Colon	6	Carcinoid	Distant	—	—	Nausea, diarrhea
75	60	M	Firearm wound of brain	Rectum	Rectum	?	Adenocarcinoma	Distant	—	S	—
76	76	M	CO intoxication	Prostate	Prostate	6	Adenocarcinoma	—	—	—	—
77	74	M	Hanging	Prostate	Prostate	—	Adenocarcinoma	—	—	S	—
78	52	F	Multiple injuries ^c	Skull base	Skull base	2	Meningioma	—	—	S	—
79	52	M	Hanging	Parasagittal	Parasagittal	5	Meningioma	—	Psychosis	SR	Hallucination, depression, epilepsy
80	63	F	Drowning	Ovary	Ovary	7	Anaplastic carcinoma	Distant	—	C	—
81	64	F	Drowning	Corpus uteri	Corpus uteri	?	Adenocarcinoma	—	Depression	RS	—
82	55	F	Drug intoxication	Mammary gland	Mammary gland	4	Ductal carcinoma	Distant	—	SR	Weakness
83	66	M	Firearm wound of face	Vestibulum nasi	Vestibulum nasi	?	Spinocellular carcinoma	—	—	SR	—
84	64	M	Firearm wound of brain	Abdominal nll, liver, spleen	Abdominal nll, liver, spleen	—	Mb. Hodgkin	Liver, spleen	—	SC	—
85	57	M	Hanging	Ventricle	Ventricle	Diffuse	Adenocarcinoma	Distant	—	P	—
86	64	F	Firearm wounds of brain ^d	Papilla Vateri	Papilla Vateri	2	Adenocarcinoma	Distant	—	SC	Aphasia, epilepsy, apraxia, coma

^a Denotes size of tumor at operation in cases treated surgically and at autopsy in the other cases
^b S = surgery, C = chemotherapy, R = radiotherapy, P = palliative only
^c Thrown herself in front of a train
^d Case of euthanasia (so-called extended suicide)

In this group we also included one homicide case as this case represented a so-called extended suicide or homicide-suicide (see case report no. 86 below). The mean age (\pm SD) of the men ($n = 9$) in this group was 65 ± 9 years and of the women ($n = 6$) 60 ± 5 years.

Not included in Table 3 was a 21-year-old man without previous psychiatric disease who, slightly inebriated by alcohol, drowned himself because he feared he had cancer as he had observed blood in the urine. The autopsy revealed no malignancy whatsoever.

Case Report (No. 74). A 78-year-old man, previously physically healthy, visited his physician because of nausea and diarrhea, and the preliminary diagnosis was gastroenteritis. Four days later, he again consulted his physician, and in spite of the fact that all laboratory tests were normal, the man himself was convinced that he suffered from cancer, although this was denied by his physician. Ten days later he hanged himself. At autopsy, a disseminated carcinoid of the colon was confirmed.

Case Report (No. 79). A 52-year-old man was found hanged. One year previously he had been surgically treated for a meningioma, which could not be excised radically. The months preceding his suicide, he developed a psychosis with depression, which was considered to have a purely somatic basis, i.e., caused by the intracranial tumor.

Case Report (No. 86). A 64-year-old woman was assassinated by her husband by several firearm wounds through her brain. During the last 6 months before the homicide, the woman developed aggravating neurologic symptoms with dysphasia, epilepsy, apraxia, deterioration, etc., due to brain metastases from a papillary adenocarcinoma of the papilla Vateri, operated upon 4 years previously. Due to the aggravating deterioration her husband killed her for euthanasic reasons and afterward killed himself. He left detailed notes explaining his reasons for doing what he did.

Suicides with Incidental Finding of Tumor (8 Cases; Table 4)

Eight cases (five men, three women; mean age (\pm SD) 64 ± 12 years) were found where the suicide could not be directly correlated to the presence of neoplastic disease. In five of these cases there was a previously recognized psychiatric disease. None of these had any known symptoms of the tumor, while two of the remaining three cases had had.

Traumatic and Natural Deaths with Incidental Finding of Tumor (77 Cases)

Seventy-seven cases were found where neoplastic disease was not correlated to the cause of death nor to suicidal cases. Also in this group, only intracranial neoplasms were included of the benign tumors. There were 55 men and 22 women, with a mean age (\pm SD) of 72 ± 11 and 66 ± 13 years, respectively. An additional eight cases had previously been treated for malignant tumors, but in these cases no tumor was found at autopsy.

Carcinoma of the kidney ($n = 21$), and the prostate ($n = 11$), were the most common localizations. Meningiomas ($n = 7$), leukemias ($n = 6$), thyroid cancer ($n = 5$), lung cancer ($n = 5$), ovarian cancer ($n = 4$), and primary hepatic cancer ($n = 3$) were the next in order, while the remaining cancers constituted only one

Table 4. Suicides with incidental finding of tumor (*n* = 8)

Case no.	Age	Sex	Cause of death	Primary tumor		Metastases	Psychiatric disease	Treatment for neoplasm ^b	Symptoms of neoplasm ^b
				Location	Diam. ^a (cm)	Microscopic type			
87	42	M	Hanging	Ventricle	3	Adenocarcinoma	Cycloid psychosis	S	—
88	72	F	Drowning	Ventricle	Diffuse	Scirrous adeno-carcinoma	Anxiety neurosis	—	—
89	75	M	Esophageal and gastric erosions ^c	Liver	4	Cholangiocellular carcinoma	Alcoholism	—	—
90	79	M	Drug intoxication	Pancreas	3.5	Adenocarcinoma	—	—	—
91	57	F	Multiple injuries ^d	Parasagittal	2.5	Meningioma	Depression	—	—
92	57	M	Multiple injuries ^e	Left kidney	6	Hypernephroma	Depression	—	—
93	71	M	Hanging	Prostate	—	Adenocarcinoma	—	S	Nausea, weakness
94	57	F	Morphine intoxication	Vertebrae	?	Small cell carcinoma	—	C	Severe pain

^a Denotes size of tumor at autopsy
^b S = surgery, C = chemotherapy
^c Ingestion of ammonia
^d Thrown herself in front of a train
^e Thrown himself in front of a passenger car

or two cases each. Six cases suffered accidental deaths, while the rest were natural deaths, mostly due to ischemic heart disease.

In this group, a few cases could be related to the treatment of the tumor, i.e., indirectly related to the tumor. In one case, a 75-year-old woman died of myocardial fibrosis, probably at least partially due to adriamycin treatment of an ovarian cancer. In another case, a 22-year-old man died of sepsis after having undergone splenectomy a few years previously due to Hodgkin's disease [2–4].

Discussion

Malignant neoplasms may produce a general, "malignant" symptomatology, including weight loss, fever, anemia, and cachexia, finally resulting in death. Although malignant tumors in this way usually kill slowly, this review of cases of malignant and/or intracranial tumors found in a medicolegal autopsy material illustrates that tumors may also present as incidental findings, and just as often as the immediate or precipitating cause of death. The forensic autopsy forms an opportunity to study not only medically diagnosed and treated neoplasms, but also the natural evolution of untreated disease. Clinically occult or misdiagnosed cancer is not uncommon [5–8] and may eventually present in an unusual fashion, sometimes as a cause of sudden, unexpected death.

Hirvonen and Rinne [9] reported 27 sudden deaths caused by tumors, amounting to 0.12% of all deaths in an area in Northern Finland, in which they had a medicolegal autopsy index of about 16% of all deaths. In our region we have a lower medicolegal autopsy index (8.5%), and we found cancer in 171 cases during an 8-year period, amounting to 0.2% of all deaths or 2.4% of all medicolegal autopsies. The latter figure can be compared to the figure of 1.7% found by Murphy [10], and 4.1% by Huntington [11], who, however, included a significant number of hospital deaths in his material. No corresponding figure was given in the material from northern Finland [9], but from the figures given in this paper, it can be estimated that they detected sudden deaths due to tumors in approximately 0.7% of all medicolegal autopsies. This figure would correspond to fractions I and II in our material, or a percentage of 1.0. Of all cancers found by us, 49.7% were considered as incidental findings (fractions IV and V), while among Murphy's 22 cases [10], nine (41%) were incidental.

In the present material, the tumors which caused sudden unexpected death in males were mostly bronchial or lung carcinomas (cf. also [9]). Although primary bronchial and lung carcinoma is only the second most common tumor in the Swedish male population after prostate carcinoma [12], the critical localization in a vital organ explains the predominance of this tumor in sudden deaths. In females the most common types of tumor causing sudden unexpected death were gastric cancer, intracranial tumors, and ovarian cancer. Contrary to the findings of Murphy [10], our material did not include any breast tumor, which was the most common cancer in his material and which is by far the most common cancer among Swedish women [12]. As pointed out previously [9], such a difference can probably be explained by the earlier detection of this type of tumor in our population (cf. also [5, 7]), as well as by the fact that most terminal

breast cancer cases are treated in hospital and thus do not become medicolegal cases.

It is a little astonishing that so many of the sudden unexpected deaths were caused by (undiagnosed) tumors which had not given any notable symptoms ante mortem (19 cases) in spite of the fact that in quite a number of these cases there was distant spread of the tumor. In fact, distant metastases were noted in 21/41 cases in fraction I (undiagnosed tumors) as compared to 21/30 cases in fraction II (diagnosed tumors). Also Hirvonen and Rinne [9] detected a large proportion (4/9) of asymptomatic cases among cases of undiagnosed tumors causing sudden death, as well as a large proportion of metastatic disease among these (5/9). This finding is not easily explained, but high age, alcoholism, and mental disease may in some cases have aided to the missing diagnosis. Although it is possible that some symptoms could have been explored by directive questioning, it seems probable that even vigorous health screening of the population could not have discovered the disease in more than a few of these cases. Furthermore, the disease would have been medically curable in probably only a few instances.

The main mechanism of sudden natural death in the overall material was disseminated cancer, followed by intracranial tumors. The third most common mechanism was hemorrhage from the tumor, in turn causing aspiration or hemoptysis (cf. [9]). In these cases, the mechanism was sometimes dramatic, raising a question of violent death or intoxication, as illustrated by some of the case reports. Other frequent mechanisms of sudden death were pulmonary thromboembolism and pneumonia. More spectacular mechanisms were, e.g., dysrhythmia of the heart through cardiac amyloidosis caused by advanced myeloma (cf. [1]) and, presumably, disturbances in glucose metabolism via insulin-induced hypoglycemia (cf. [13]). There were however, no sudden deaths from tumor embolization in the present material, a death mechanism previously reported in sarcomas [14], which were lacking here. Neither were any cardiac tumors seen, except for one case of cardiac metastases from a spinocellular carcinoma of the lip.

Intracranial tumors were seen in quite a number of cases. A few previous investigations have analyzed deaths due to primary intracranial neoplasms in medicolegal autopsy materials, and have detected frequencies of 0.17% (15), 0.31% (16), 0.54% (17), and 0.6% (11). We found in our material altogether 11 cases of primary intracranial neoplasm in the fractions I + II + III, i.e., among those altogether 86 cases where the neoplasm had caused the death. Primary intracranial neoplasms thus caused the death in 0.16% of our series of 7,020 consecutive medicolegal autopsies. Of all deaths in Sweden, 0.55% are caused by primary intracranial neoplasms [18]. The discrepancy between our figures and those of DiMaio et al. [15] and the considerably higher figures reported by Huntington et al. [11, 17], may stem from the fact that the latter materials contained a majority of hospital cases – cases which are not normally subject to medicolegal investigation in Sweden unless there is a suspicion of unnatural death. On the other hand, the reasons for performing an autopsy were similar, i.e., suspicion of trauma, intoxication, alcoholism, or unknown cause of death. Also among these tumor cases, many had developed without obvious symptoms

– six of our 11 cases were asymptomatic before death as compared with five of 19 [15], and eight of 32 ([16]; also including eight angiomatous malformations and four cysts) in previous publications.

Of the 11 cases of primary intracranial neoplasm causing the death in our material, only one was an astrocytoma but six were meningiomas. This is in contrast to the materials previously presented containing 3/6 astrocytomas [11], 9/19 astrocytomas [15], 9/20 astrocytomas [16], and 8/19 astrocytomas [17], while only 1/6 [11], 1/19 [15], 3/20 [16], and 2/19 [17] were meningiomas. This discrepancy cannot easily be explained, but it can be observed that the diameter of the fatal meningiomas in our series was large, in most cases 5 cm or more, as compared with the diameter of meningiomas incidentally found at autopsy [19]. None of our meningiomas were multiple. Meningiomas were present in 9–13% in each of the analyzed groups except in fraction II (sudden deaths caused by known tumors), where meningiomas were not present and were not expected to be present. The mean age of our four meningioma cases in fraction I (sudden unexpected deaths caused by unknown tumors), was 68 years, closely to the mean age of 70 years in a material of meningiomas found incidentally at autopsy [19].

It has been stated that suicide occurs more frequently in patients with serious medical illnesses than in the general population [20–24], and it is felt by many that it is not uncommon for a person with far advanced cancer to commit suicide. The prevalence of cancer among suicides has been enlightened in quite a few reports, and figures ranging from 8 to 234 per 1,000 have been reported (for refs. see [25]). Most of these reports, however, do not present age-specific data, and reliable conclusions thus can not be made safely. The lack of a reliable cancer prevalence rate may represent an additional problem. A study from Connecticut (USA) [25] suggests that male cancer patients are at greater risk for suicide than the general male population, while an overrepresentation of suicide among female cancer patients was not confirmed. A study from Finland [26] estimated higher risks for both male and female cancer patients to commit suicide, the relative risks were found to be 1.3 and 1.9, respectively. In a recent study from Sweden [23], it was found that the suicide rate among cancer patients was “of the same magnitude” as that in the general population, amounting to about 22 cases per year in Sweden. Only suicides where a cancer diagnosis was assigned on the death certificate were included in this material, but as cancer diagnoses are to be assigned on the death certificate only if the cancer has caused the death or is a main contributory factor, this method would be expected to yield only a fraction of the suicides with a cancer diagnosis. For example, in our material of 22 suicides, a cancer diagnosis was assigned on the death certificate in only ten cases. However, if extrapolated to the whole of Sweden (with a population of slightly more than 8 million), our own results would correspond to a total number of 25 suicides among cancer patients per year, i.e., our results are in good agreement with Bolund’s figures [23]. Still, there are findings which indicate that Bolund has underestimated the actual number, e.g., our figures are based solely on medicolegal cases, while the medicolegal fraction in Bolund’s material is only about 50%. Furthermore, she found only two suicides with undiagnosed cancer per year, while our figures would correspond to about

eight cases per year in Sweden, and the cancer fraction found by her amounted to 1.4% of all suicides, while we found that 2.1% of all suicides had cancer. On the other hand, we may also have underestimated the actual number of suicides among cancer patients; we have not detected cases of cured cancer, and we have recorded only medicolegal cases, while Bolund recorded just as many medicolegal as non-medicolegal cases.¹ Further, we may both suffer from a supposed under-registration of drug suicides in patients. All these findings indicate that the actual number is higher than any of us have reported.

In the present material, we found cancer in 2.2% of all investigated suicides, while we found only 1.0% cancer in non-suicidal deaths. It thus seems as though there is an over-representation of cancer in suicides, as suggested in several previous investigations, although questioned by others. A further analysis revealed that about one third of these 2.2% had no correlation to the suicide (fraction IV), giving a rate of "incidental" tumors in suicides of the same magnitude as in non-suicidal deaths. Two thirds of these 2.2% (fraction III) were, however, considered to be directly correlated to the suicide, thus forming an over-representation of tumor cases among suicides. On the other hand, the expected number of cancer cases among our 1,060 suicides was 27 according to the age-adjusted cancer prevalence rates for Sweden (P. Sparén, The Swedish National Board of Health and Welfare, personal communication), while only 22 were found. The possible over-representation of suicides among persons with cancer thus seems questionable and needs to be studied further.

References

1. Wahlin A, Olofsson B-O, Eriksson A, Backman C (1984) Myeloma-associated cardiac amyloidosis. *Acta Med Scand* 215:189–192
2. Jindrich EJ (1977) Splenectomy and sudden death. *J Forensic Sci* 22:610–613
3. Reay DT, Nakonechny D (1979) Sudden death and sepsis after splenectomy. *J Forensic Sci* 24:757–761
4. Schwartz PE, Sterioff S, Mucha P, Melton III LJ, Offord KP (1982) Postsplenectomy sepsis and mortality in adults. *JAMA* 248:2279–2283
5. Bauer FW, Robbins SL (1972) An autopsy study of cancer patients. I. Accuracy of the clinical diagnoses (1955 to 1965), Boston City Hospital. *JAMA* 221:1471–1474
6. Silverberg SG (1984) The autopsy and cancer. *Arch Pathol Lab Med* 108:476–478
7. Stenbäck F (1984) North-South differences in cancer incidence. Significance of autopsies. *Arctic Med Res* 38:37–42
8. Berge T, Lundberg S (1977) Cancer in Malmö 1958–1969. An autopsy study. *Acta Pathol Microbiol Scand [A] [Suppl]* 260
9. Hirvonen J, Rinne A (1981) Tumours and sudden death. *Forensic Sci Int* 18:31–39
10. Murphy GK (1977) Cancer and the coroner. *JAMA* 237:786–788
11. Huntington RW (1957) Primary intracranial neoplasms in a medicolegal autopsy service. *J Forensic Sci* 2:457–467
12. National Board of Health and Welfare (1987) The cancer registry. Cancer incidence in Sweden 1984. Allmänna Förlaget, Stockholm
13. Jenkins D, Fletcher SM, Hoole A (1982) Apparent suicide by carbon monoxide poisoning in a case of insulinoma. *Med Sci Law* 22:135–139

¹ According to the Swedish legislation unnatural deaths are always subjected to a police investigation, in most cases including a medicolegal autopsy.

14. Borzotta AP, Riddick L, Sadlack W, Chun B (1978) Sudden death from massive tumor embolization of chondrosarcoma. *J Bone Joint Surg* 60:561-563
15. DiMaio SM, DiMaio VJM, Kirkpatrick JB (1980) Sudden, unexpected deaths due to primary intracranial neoplasms. *Am J Forensic Med Pathol* 1:29-45
16. Keiding D, Gregersen M, Vesterby Charles A (1987) Primary intracranial tumours and angiomatous malformations in medico-legal autopsy service. *Ugeskr Laeger* 149:3002-3005
17. Huntington RW Jr, Cummings KL, Moe TI, O'Connell HV, Wybel R (1965) Discovery of fatal primary intracranial neoplasms at medicolegal autopsies. *Cancer* 18:117-127
18. Causes of death 1985 (1987) Official statistics of Sweden. National Central Bureau of Statistics, Stockholm
19. Wood MW, White RJ, Kernohan JW (1957) One hundred intracranial meningiomas found incidentally at necropsy. *J Neuropathol Exp Neurol* 16:337-340
20. Dubovsky SL (1978) Averting suicide in terminally ill patients. *Psychosomatics* 19:113-115
21. Abram HS, Moore GL, Westervelt FB (1971) Suicidal behavior in chronic dialysis patients. *Am J Psychiatry* 127:1199-1204
22. Whitlock FA (1978) Suicide, cancer and depression. *Br J Psychiatry* 132:269-274
23. Bolund C (1985) Suicide and cancer: I. Demographic and social characteristics of cancer patients who committed suicide in Sweden, 1973-1976. *J Psychosoc Oncol* 3:17-30
24. Bolund C (1985) Suicide and cancer: II. Medical and care factors in suicides by cancer patients in Sweden, 1973-1976. *J Psychosoc Oncol* 3:31-52
25. Fox BH, Stanek III EJ, Boyd SC, Flannery JT (1982) Suicide rates among cancer patients in Connecticut. *J Chron Dis* 35:89-100
26. Louhivuori KA, Hakama M (1979) Risk of suicide among cancer patients. *Am J Epidemiol* 109:59-65

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