

Causes of death in a hospitalized geriatric population: an autopsy study of 3000 patients

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Abstract. Macroscopic and histological studies of 3000 consecutive autopsies (43.9% of the registered deaths) were performed by the same pathologist in a geriatric institution over a period of 20 years. Bronchopneumonia (42.9%), malignant neoplasms – mainly of the gastrointestinal tract and its annexae and the lungs (28.1%) – pulmonary thrombo-embolism (21.2%) and acute myocardial infarction (19.6%), were the most prevalent fatal conditions observed. Next, in decreasing order were: urinary tract infection (12.3%), acute cerebrovascular disease (6.5%), internal haemorrhage (5.5%), and congestive cardiac failure (3.3%). Some “rare” causes of death noted included trauma, metabolic disease, acute asphyxia from foreign body obstruction of the upper respiratory tract and degenerative neurological diseases. Some potentially treatable disorders which led to death were unsuspected clinically: for example, acute pyelonephritis (87%), pulmonary thrombo-embolism (74%), acute myocardial infarction (74%) and active pulmonary tuberculosis (61%). With advancing age there is an increased frequency of multiple pathological processes in a given subject and interactions play an important role in morbidity and mortality. We observed that two or more co-existing conditions often determine the fatal event. We also emphasize the relevance of post-mortem examination to prevention of disease and to therapeutic medicine in a hospitalized geriatric setting.

Key words: Death – Geriatrics – Multiple pathology – Autopsy – Clinico-anatomical discrepancies

Introduction

Throughout the world, the population continues to age, a phenomenon which has given birth to the specialty of geriatrics. In Geneva, from which this study origi-

nates, some 30% of the population is within the geriatric age group.

Mortality statistics are often based on clinical diagnoses unconfirmed by autopsy studies. These data may not reflect a true picture of the conditions related to, or resulting in, death. This paper describes a 20-year study during which the author personally performed 3000 consecutive geriatric autopsies. This report may be of value to all concerned with health care issues related to the aged.

Materials and methods

The study is based on 3000 consecutive autopsies (1758 females and 1242 males; mean age 80.3 years; age range from 62 to 102 years, including 9 centenarians) performed by the author from January 1972 to March 1992, from a total of 6841 registered deaths in the Geneva Geriatric Institutions (the University Geriatric Hospital and the Centre for Continuous Care), during this period. Examination of the central nervous system was performed separately in 2911 cases by neuropathologists (see Acknowledgements); these results are only briefly described in the present study. In general, the results of the present report are correlated neither with sex nor age cross-sections. The underlying antecedent disease from which the patient suffered was included if it was considered as one of the main contributory factors related to the direct cause of death.

In all cases, after a review of the clinical and radiological files, a complete post-mortem was performed and the organs were examined macroscopically and studied histologically by light microscopy. Criteria for defining an infectious process were based on the macroscopic and histological findings as revealed by special stains (Gram, Ziehl-Neelsen, periodic acid-Schiff, Grocott and immunohistochemical techniques). The concept of septicaemia was based on ante-mortem bacteriological results and/or macroscopic and histological findings. Only in

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some cases was it possible to make valid post-mortem cultures.

In its demographic studies the World Health Organization (WHO) endorses the concept of the "direct cause of death" as the condition leading directly to death, and that of the "underlying cause of death" the disease, injury or circumstance which initiated the train of morbid events (Manual of the International Statistical Classification of Diseases, Injuries, and Causes of Death, 1977); the present study applies these concepts.

Results

The events to which direct causes of death could be attributed are presented by order of decreasing frequency in Table 1.

Acute infection was the most frequently observed direct cause of death (Table 1). The lungs were most often affected, commonly by bronchopneumonia (80% of subjects with a terminal acute infectious disease). In 1039 subjects (79.4%) bronchopneumonia was associated with aspiration of gastric contents or of material from the mouth and pharynx. In 49 cases (1.6%) massive acute aspiration of acid gastric contents resulted in destruction of lung tissue. In other cases of fatal bronchopneumonia, there was often a history of chronic or acute pulmonary stasis or of chronic obstructive pulmonary

disease (46% of the latter presented with terminal bronchopneumonia). In 8 cases, histology was compatible with viral pneumonia; 9 subjects featured suppurative pulmonary aspergillosis; 2 subjects manifested diffuse pulmonary candidiasis.

Active tuberculosis (originating from old reactivated lesions) was the source of pulmonary infection in 45 cases (1.5%): caseous tuberculous pneumonia, 14 cases (31.2%); fibrocaceous tuberculosis with cavitation, 19 cases (42.2%) and diffuse miliary tuberculosis, 12 cases (26.7%).

The urinary tract was the second major site of fatal acute infection, mainly purulent or necrotic cystitis (369 cases or 12.3%) which in 184 cases (50%) was associated with acute pyelonephritis (87% of the latter were diagnosed only at autopsy). Urinary tract infection was observed most often in relation to an indwelling urinary catheter. Four cases of genito-urinary fibrocaceous tuberculosis and 1 case of diffuse bilateral renal candidiasis were discovered.

Acute diffuse peritonitis was seen in 123 subjects (4.1%), very often secondary to either acute mesenteric ischaemia or to tumour invasion. In 46 cases (37.5%) recent perforation of acute colonic diverticulitis was noted; however, this corresponds to only 5.3% of the 876 cases of colonic diverticulosis observed. One case of bile peritonitis and 1 case of barium peritonitis, both secondary to perforation of duodenal ulcers discovered at autopsy, led to fatal ileus.

Septicaemia was the cause of death in 90 cases (3%); 25 (27.8%) also featured acute infectious valvular endocarditis and 14 (15.5%) acute infectious myocarditis. The main organisms identified were *Klebsiella pneumoniae*, *Escherichia coli*, *Staphylococcus aureus*, *Proteus vulgaris* and *Pseudomonas aeruginosa* (often forming a mixed flora) which varied in decreasing order from 20% to 11% of the cases. Other causal organisms were *Listeria monocytogenes* (2 cases), *Aspergillus fumigatus* (2 cases) and *Candida albicans* (1 case). In 18% of the cases the aetiology was not discerned.

Acute infection of the gallbladder and biliary tract was uncommon. Of the 548 cases of cholelithiasis, only 23 cases (4.2%, or 0.8% of autopsies) of acute phlegmonous cholecystitis and 16 cases (2.9%, or 0.5% of autopsies) of suppurative cholangitis were the source of a fatal outcome.

Meningitis was observed in 19 cases (0.6%) of which 3 were chronic tuberculous. In 7 cases, acute encephalitis was associated with meningitis including one tuberculous, one viral (herpes simplex I), one fungal with associated suppurative pulmonary dissemination (*A. fumigatus*). A case of *L. monocytogenes* meningitis developed in association with recurrent invasive meningioma and meningitis in 2 cases of septicaemia related respectively to *Staph. aureus* and to a mixed flora of *E. coli* and *Strep. faecalis*. The aetiology of the remaining case was unknown.

The principal malignant neoplasms observed were: carcinomas of the gastro-intestinal tract (23.3%), its annexae (pancreas, liver, gallbladder; 10.5%), lung (17.2%), urinary tract (10%) and lymphomas and mye-

Table 1. Frequency of conditions to which the direct cause of death could be attributed; based on 3000 autopsies

Prevalent fatal conditions	Number of cases	% of cases
Infections	1635	54.6
Malignant neoplasms	843	28.1
Pulmonary thrombo-embolism	635	21.2
Acute myocardial infarction	588	19.6
Uncommon fatal conditions		
Acute cerebrovascular diseases	194	06.5
Acute pulmonary oedema	173	05.8
Internal haemorrhage	166	05.5
Congestive cardiac failure	99	03.3
Acute intestinal ischaemia	92	03.1
Cirrhosis	60	02.0
Drug hypersensitivity reaction	49	01.6
Terminal renal failure	39	01.3
Auto-immune diseases	35	01.2
"Rare" fatal conditions		
Pneumothorax	22	00.7
Cachexia alone	15	00.5
Trauma	14	00.5
Foreign body obstruction of upper airways	14	00.5
Disseminated intravascular coagulation	13	00.4
Metabolic diseases	10	00.3
Degenerative neurological diseases	7	00.2
Total	4703 ^a	156.9 ^a

^a The total number of cases (4703) is greater than the total number of autopsies (3000) due to an association of diseases or events to which the direct cause of death could be attributed

loproliferative disorders (8.3%). In 34 cases (1.1% of autopsies) the neoplasm was a primary tumour of the central nervous system. Death due to visceral dissemination of cutaneous malignant melanoma was observed in 7 of the 12 autopsied cases (58.8%).

The most frequent malignant tumour seen in females was breast carcinoma (8%) and, in males, carcinoma of the prostate (21.3%). A systematical histological examination was made of prostatic tissue (comprising a complete transverse medial section parallel to, and including, the prostatic urethra). One hundred and sixteen (44%) of all prostatic carcinomas (264) were diagnosed only at autopsy; 11 (9.5%) had metastases (regional lymph nodes 8 cases, several lymph node areas 5 cases, spine and ribs 3 cases, brain 1 case). Two hundred and twenty-three of the prostatic carcinomas (84.7%) showed transcapsular invasion and/or intravascular penetration with metastases; the remainder were non-invasive microcarcinomas.

Multiple malignancies were noted in 252 cases of which 214 (122 males, 92 females) had two malignant processes and 38 cases (22 males, 16 females) had three or more malignant processes. In 57 cases (33 males, 24 females; 22.6%) one or more of the tumours was discovered at autopsy; in 10 cases (7 males, 3 females) these had not been diagnosed clinically.

Acute myocardial infarction was observed in 588 subjects (360 females, 228 males; 19.6%); 434 cases (74.1%) had not been diagnosed ante-mortem. Only 119 coronary thromboses (55 fresh and 64 old thrombi) were noted. Very mild coronary atherosclerosis was observed in 13 cases, whereas the remainder showed moderate to severe stenotic coronary atherosclerosis; 2 cases showed metastatic tumour compression of a coronary artery (Mac Gee 1991).

Death was ascribed to terminal congestive cardiac failure in 99 cases (3.3%) on macroscopic and histological examination; 25 cases were associated with hypertension, 12 cases with cardiac amyloidosis and 9 cases with cor pulmonale.

Massive emboli were found in the main pulmonary trunk and/or branches in 653 cases (21.2% of the subjects); 471 cases (74.1%) were diagnosed only at autopsy. Associated parenchymal infarctions were noted in 423 cases (66.7% of pulmonary thrombo-emboli). In 28 cases the thrombo-emboli localized in the main pulmonary trunk were adherent to fibrous plaques.

Acute cerebrovascular disease (cerebral infarction or haemorrhage) was observed in 194 subjects representing 6.5% of the total number of brains (2911) examined. In 58 cases (30%), this was associated with hypertension and, in 22 cases (11.4%), atrial fibrillation with left auricular thrombosis. Thirty-three cases (17%) revealed co-existing acute myocardial infarction, 35 cases (18%) massive or multiple segmentary pulmonary thrombo-embolism, and 88 cases (45.4%) also showed marked bronchopneumonia and/or sepsis.

Acute pulmonary oedema (with or without associated general anasarca), in the absence of recent myocardial infarction, was noted in 173 subjects (5.8%).

Internal haemorrhage was the cause of death in 166

subjects (5.5%). The sites were: gastrointestinal tract, 93 cases (3.1%); pleural and/or peritoneal serosae, 36 cases (1.2%); aortic atherosclerotic or dissecting aneurysm, 20 cases (0.7%, of which 12 were clinically undiagnosed), haemopericardium, 17 cases (0.6%, of which 15 cases were diagnosed only at necropsy), where 11 cases related to a ruptured myocardial infarct, 5 cases to ruptured aortic aneurysm and 1 case to extensive neoplastic involvement of the epicardium (Mac Gee 1991). One case of massive internal haemorrhage secondary to traumatic rupture of the thoracic aorta and one case of massive digestive haemorrhage through transmural gastric erosion from a voluminous haemorrhagic cyst of the body of the pancreas were discovered. Multiple sites of simultaneous bleeding secondary to prophylactic anticoagulation were seen in 19 subjects, whereas haemorrhage related to malignant tumour invasion was observed in 20 subjects (11% and 12% of massive internal haemorrhage respectively). Three cases of acute bilateral massive adrenal haemorrhage complicating anticoagulant therapy and one case of bilateral haemorrhagic adrenal infarction related to carcinomatous thrombosis of the central vein were also discovered.

Acute intestinal ischaemia was seen in 92 subjects (3.1%); its aetiology was diverse: occlusive thrombo-embolism (27 cases, of which 24 were discovered at necropsy), acute non-thrombo-embolic ischaemic lesions (55 cases, of which 50 were discovered at necropsy), peritoneal bands or adhesions, volvulus or tumour vascular compression (10 cases).

Cirrhosis and chronic liver disease (excluding cardiac cirrhosis) were considered the direct cause of death in only 60 cases (2% of autopsies) among the 154 cases (5.1%) observed; the remainder were devoid of anatomical or clinical signs of acute liver failure. The aetiological forms of cirrhosis were: associated with alcohol intake (129 cases), viral (9 cases), primary biliary disease (3 cases), bile duct obstruction (3 cases), drug-induced (2 cases), haemochromatosis (3 cases) and cryptogenic (3 cases). Severe portal fibrosis was seen in a case of schistosomiasis (*S. mansoni*; Berthoud et al. 1974) and also in a case of massive chronic hepatic alveolar echinococcosis. There was neoplastic transformation, generally multifocal, to hepatocellular carcinoma in 32 cases (20%). In 74 cases (48.1%) cirrhosis had not been clinically diagnosed.

Fatal drug hypersensitivity reaction was observed in 49 subjects (1.6%); namely, acute myocarditis, 18 cases (0.6%); acute hepatitis, 11 cases (0.4%); acute pseudo-membranous enterocolitis, 13 cases (0.4%); acute interstitial nephritis with tubular necrosis, 3 cases (0.1%); anaphylactic shock, 3 cases (0.1%); and severe haemolytic anaemia, 1 case (0.03%).

Terminal renal failure was noted in 39 subjects (1.3%): severe nephroangiosclerosis without a history of diabetes, 14 cases; diabetic nephroangiosclerosis, 7 cases; chronic interstitial nephritis in relation to phenacetin intoxication, 5 cases; chronic pyelonephritis of undetermined aetiology, 5 cases; chronic pyelonephritis associated with Thorotrast (colloidal suspension of thorium dioxide), 2 cases; diffuse amyloidosis, 1 case; chron-

Table 2. Association of eight selected conditions each of which had been considered as a possible main cause of death

Associated condition	Principal condition							
	Broncho-pneumonia (929 cases)	Urinary tract infection (220 cases)	Extensive neoplastic dissemination (373 cases)	Acute myocardial infarction (495 cases)	Pulmonary thrombo-embolism (454 cases)	Acute cerebrovascular disease (128 cases)	Acute intestinal ischaemia (57 cases)	Cirrhosis and chronic liver disease (35 cases)
Bronchopneumonia	—	73 (33.3%)	313 (84%)	96 (19.4%)	82 (18%)	50 (39%)	34 (59.5%)	15 (42.9%)
Urinary tract infection	73 (7.9%)	—	37 (9.9%)	28 (5.7%)	6 (1.3%)	7 (5.5%)	5 (8.8%)	0
Extensive neoplastic dissemination	313 (33.7%)	37 (16.8%)	—	72 (14.5%)	106 (23.4%)	10 (7.8%)	23 (40.3%)	2 (5.7%) ^a
Acute myocardial infarction	96 (10.3%)	28 (12.7%)	72 (19.3%)	—	60 (13.2%)	33 (25.8%)	32 (56.2%)	4 (11.4%)
Pulmonary thrombo-embolism	82 (8.8%)	6 (2.7%)	106 (28.4%)	60 (12%)	—	35 (27.3%)	29 (50.8%)	2 (5.7%)
Acute cerebrovascular disease	50 (5.4%)	7 (3.2%)	10 (2.7%)	33 (6.7%)	35 (7.7%)	—	6 (10.5%)	1 (2.7%)
Acute intestinal ischaemia	34 (3.6%)	5 (2.3%)	23 (6.2%)	32 (6.5%)	29 (6.4%)	6 (4.7%)	—	5 (14.3%)
Cirrhosis and chronic liver disease	15 (1.6%)	0	2 (0.5%) ^a	4 (0.8%)	2 (0.4%)	1 (0.8%)	5 (8.8%)	—

^a Excluding the 32 cases of hepatocellular carcinoma in association with cirrhosis

ic membranous glomerulonephritis, 1 case; necrotizing angitis (Wegener's granulomatosis), 1 case; systemic periarteritis nodosa, 1 case; proliferative glomerulonephritis associated with systemic lupus erythematosus, 1 case; bilateral adult polycystic kidneys, 1 case.

Progressive auto-immune diseases such as primary hypothyroidism (11 cases), rheumatoid arthritis (8 cases), Sjögren's syndrome (3 cases), Wegener's granulomatosis (3 cases), systemic scleroderma (3 cases), systemic lupus erythematosus (2 cases), pituitary dependent Cushing's disease (2 cases), systemic periarteritis nodosa (1 case), dermatomyositis (1 case) and primary hypoparathyroidism (1 case) were amongst the rare diseases to which death could be ascribed (35 cases, 1.2%), and in their terminal stage were generally associated with bronchopneumonia (34.5%), myocardial infarction (25%), pulmonary thrombo-embolism (18.9%) and infection (12.5%). In 2 cases, death was attributed to myxoedematous coma.

The following direct causes of death classified as "rare" have been summarized in Table 1: spontaneous or traumatic pneumothorax, 22 cases (0.7%); marked cachexia alone (less than 40 kg, 15 subjects (0.5%); trauma, 14 subjects (0.5%; including 2 cases of suicide); acute asphyxia following foreign body obstruction of the larynx and trachea, 14 patients (0.5%). Disseminated intravascular coagulation led to death in 13 patients (0.4%); 8 cases were related to neoplasms [liver cell carcinoma (2); adenocarcinoma of the lung (2); adenocarcinoma of the prostate (2), one of which was associated with concurrent chronic lymphocytic leukaemia and colonic adenocarcinoma; cystadenocarcinoma of the ovaries (1); Hodgkin's lymphoma with associated adenocarcinoma of the colon (1)]; 3 cases to myocardial infarction associated with sepsis, and 2 cases to necrotizing pancreatitis. Metabolic disorders were seen in 10 cases (0.3%): diabetic coma, 7 cases; morbid obesity, 3 cases (180 kg, 150 kg and 140 kg). Degenerative disease of the central nervous system had been diagnosed clinically and/or anatomically in 538 cases: Alzheimer's disease (382; Michel et al. 1991); Parkinson's disease (132); amyotrophic lateral sclerosis (13); multiple sclerosis (3); Huntington's chorea (2); syringomyelia (2); Pick's disease (1); cerebral palsy (1); Creutzfeldt-Jacob disease (2). The direct cause of death stemmed mainly from aspiration pneumonia; in only 7 cases was the neurological disease considered the principal direct cause of death.

In the present series the "oldest of the old" comprised a group of 9 centenarians ranging from 100 to 102 years of age with the following distribution: 100 years (4 females, 1 male), 101 years (2 females), 102 years (2 females). The main causes of death paralleled that of the 3000 subjects, namely, bronchopneumonia, 4 cases (44%); pulmonary thrombo-embolism, 2 cases (22%); acute myocardial infarction, 1 case (11%); septicaemia, 1 case (11%) and extreme cachexia (female, 101 years, 26 kg, 150 cm) associated with Hodgkin's lymphoma discovered at autopsy, 1 case (11%).

In 16 of the 3000 autopsies (0.5%) an anatomical explanation of the direct cause of death was not established. In several, the pathological lesions of at least

Table 3. Frequency of some clinically undiagnosed conditions to which the cause of death could be attributed; based on a total of 3000 autopsies

	Number of autopsied cases ^a	Number of cases clinically undiagnosed ^b
Pulmonary thrombo-embolism	635 (21.2%)	471 (74.1%)
Acute myocardial infarction	588 (19.6%)	434 (74.1%)
Acute pyelonephritis	184 (6.1%)	160 (87.0%)
Cirrhosis	154 (5.1%)	74 (48.1%)
Septicaemia	90 (3%)	49 (54.3%)
Acute intestinal ischaemia	92 (3.1%)	80 (87.0%)
Tuberculosis excluding lymph node alone)	47 (1.6%)	31 (66.7%)
Perforated acute colonic diverticulitis	47 (1.6%)	37 (78.7%)
Acute myocarditis	32 (1.1%)	32 (100%)
Acute infectious endocarditis	25 (0.8%)	23 (91.7%)
Ruptured aortic aneurysm	24 (0.8%)	14 (58.8%)
Acute phlegmonous cholecystitis	23 (0.8%)	19 (83.3%)
Haemopericardium (tamponade)	17 (0.6%)	10 (58.8%)
Suppurative cholangitis	16 (0.5%)	13 (81.3%)
Acute pseudomembranous enterocolitis	15 (0.5%)	13 (87.0%)
Massive adrenal haemorrhage	4 (0.13%)	4 (100%)
Wegener's granulomatosis	3 (0.1%)	3 (100%)
Systemic periarteritis nodosa	1 (0.03%)	1 (100%)

^a The percentages indicate the percentage of total autopsies

^b The percentages indicate the percentages for each given pathology

two co-existing conditions could possibly explain death. This is shown in Table 2, which emphasizes the paired association of eight diseases frequently observed.

In certain cases the main disease was diagnosed only at autopsy; the most frequent examples are listed in Table 3.

Discussion

Three findings are worthy of emphasis. The principle causes of death are represented by respiratory and urinary tract infections, generally observed in patients restricted to bed-rest.

Bronchopneumonia, which ranks first (42.9%), was frequently associated with aspiration of gastric or oral contents which in 79.4% of cases elicited a parenchymal granulomatous reaction. Extensive terminal bronchopneumonia often accompanied other potentially fatal disorders such as degenerative diseases of the central nervous system, disseminated neoplasia, chronic obstructive pulmonary disease, acute cerebrovascular disease, cirrhosis, acute myocardial infarction and pulmonary thrombo-embolism. Viral and fungal pneumonia were rare causes of death.

Urinary tract infection, generally in relation to an indwelling urinary catheter, was the second most prevalent fatal infectious disease (12.3%), especially purulent

or necrotic cystitis. In 50% of the cases this was also associated with acute pyelonephritis.

Our observations corroborate the findings of several studies with regard to the prominence of acute infections in determining the direct cause of death in elderly patients (Bruyère et al. 1990; Gloth and Burton 1990; Gross et al. 1988; Ishii et al. 1980; Kohn 1982; Ueda et al. 1990) which, in our series, is the most frequent condition noted (54.6%).

In second position as direct cause of death are cardiovascular disorders (33.3%), excluding pulmonary thrombo-embolism. This finding differs from some autopsy studies in which cardiovascular diseases were the dominant direct cause of death in the geriatric subjects (Jonsson and Hallgrímsson 1983; Kohn 1982; Ueda et al. 1990). In the present series, moderate to severe stenotic coronary and aortic atherosclerosis were observed in 91.7% and 90.9% of the autopsies respectively. These vascular changes led to death from the following conditions: acute myocardial infarction (19.6%); acute cerebrovascular disease (6.5%); congestive cardiac failure (3%), of which only 12% were associated with cardiac amyloidosis (Bustos et al. 1993); acute intestinal ischaemia (2.7%) and ruptured aortic aneurysms (0.8%). Notably, of the 588 cases of acute myocardial infarction, only 11 cases (1.9%) of transmural rupture were observed.

In our group of 9 centenarians there was only minor deviation from the pattern observed in the entire series of 3000 subjects, bronchopneumonia being the main direct fatal condition in nearly half (44%) of these very old people. Death from ischaemic heart disease was noted in only 1 subject (11%) and pulmonary thrombo-embolism occurred in 2 subjects (22%).

Our data differ to some extent from a review of several studies concerning the causes of death in very old people (older than 90 years) which revealed four main conditions with varying frequency patterns for each study: ischaemic heart disease, cerebrovascular disease, malignant neoplasm and bronchopneumonia (Howell 1963; Ishii et al. 1980; Jonsson and Hallgrímsson 1983; Kohn 1982). Certain studies listed either "atheromatosis" or "general arteriosclerosis" as the cause of death (Howell 1963; Ishii et al. 1980); these may be considered as an "underlying cause" but not the "direct cause" of death.

The autopsy establishes not only the immediate cause of death (incorrectly stated on death certificates in about 25% of cases; Nielsen et al. 1991), but also verifies the major underlying disease (misstated in about 33% of cases; Nielsen et al. 1991). We observed a high percentage of ante-mortem failure to diagnose potentially treatable conditions such as acute myocardial infarction (74.1%) and pulmonary thrombo-embolism (74.1%). This finding has been established in other studies (Battle et al. 1987; Bayer et al. 1986; Cameron and McGoogan 1981a, b; Freiman et al. 1965; Gross et al. 1988; Karwinski and Svendsen 1989; Poli et al. 1993; Rossman et al. 1974).

Pyelonephritis, acute intestinal ischaemia and septicaemia also appeared to be underdiagnosed in this popu-

lation: approximately seven eighths of the cases of pyelonephritis and a little more than one half of the cases of septicaemia were not diagnosed clinically. We also emphasize the importance of reactivated tuberculosis and its failure to be diagnosed clinically in the elderly (66.7% in this series), as well as the risk of transmission incurred by the environmental population (Mac Gee 1989; Michel et al. 1992). Such discrepancies in clinical and autopsy findings have been ascribed to such factors as: misleading laboratory tests, atypical or delayed clinical symptoms, unrecognized diseases, inattention to suggestive symptomatology, multiple causes of a disorder and other underlying conditions (Battle et al. 1987; Bayer et al. 1986; Gloth and Burton 1990; Gross et al. 1988; Karwinski and Svendsen 1989; Mac Gee 1989, 1991; Michel et al. 1992; Poli et al. 1993; Zarling et al. 1983). To those factors we also add the patient's refusal for evaluation or treatment, dementia and the clinical policy to adopt a palliative attitude of assuring comfort in settings of advanced or chronic diseases. These discrepancies between the clinical diagnoses and those obtained at post-mortem emphasize the value of the necropsy as the final medical act in patient's care and medical audit (Cameron 1988; Paterson et al. 1992).

We observed two, three or more associated conditions in a number of cases, each of which could have been a possible cause of death. The pathologist is then left with an arbitrary decision about the documented cause. Examples are provided in Table 2.

The problem of diverse pathology and associated diseases is fundamental to geriatrics. This has been addressed by a committee of the WHO which emphasizes that the number of conditions to which death can be attributed increases with advancing age, and furthermore, that the "underlying cause of death" is not necessarily the disease leading directly to death (WHO, in press). Other studies have also demonstrated the possibility of either polymorbidity or multiple causes of death, especially in elderly subjects (Goodman et al. 1982; Howell 1963; Israel et al. 1986; McKeown 1965; Michel et al. 1991; Poli et al. 1993; Rossman et al. 1974).

Conclusion

Although we do not assume that our hospitalized population is representative of the entire elderly population, post-mortem examinations in geriatric institutions provide data which are of interest to medical practice providing evidence of the relevance of post-mortem examination in the prevention of disease (or conditions) and to therapeutics in a hospitalized geriatric setting.

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References

- Battle RM, Pathak D, Humble CG, Key CR, Vanatta PR, Hill RB, Anderson RE (1987) Factors influencing discrepancies between premortem and postmortem diagnoses. *JAMA* 258:339–344
- Bayer AJ, Chadha JS, Farag RR, Pathy MSJ (1986) Changing presentation of myocardial infarction with increasing old age. *J Am Geriatr Soc* 34:263–266
- Berthoud S, Cox JN, Thiebaud G, Bouzakoura C (1974) Liver schistosomiasis and primary biliary cirrhosis. A clinico-pathological study. *Virchows Arch [A]* 364:285–296
- Bruyère A, Mac Gee W, Rapin CH (1990) Cancer et personnes âgées. Complications et analyse des causes de décès confirmées par autopsie. *Méd Hyg* 48:3202–3206
- Bustos D, Perrenoud JJ, Michel JP, Grab B, Mac Gee W (1993) Diagnostic post-mortem de l'amyloïdose cardiaque du vieillard. Corrélation anatomoclinique. *Arch Mal Coeur* 86:315–319
- Cameron HM (1988) Future of the hospital autopsy (editorial). *Br J Hosp Med* 40:335
- Cameron HM, McGoogan E (1981a) A prospective study of 1152 hospital autopsies. I. Inaccuracies in death certification. *J Pathol* 133:273–283
- Cameron HM, McGoogan E (1981b) A prospective study of 1152 hospital autopsies. II. Analysis of inaccuracies in clinical diagnoses and their significance. *J Pathol* 133:285–300
- Freiman DG, Suyemoto J, Wessler S (1965) Frequency of pulmonary thromboembolism in man. *N Engl J Med* 272:1278–1280
- Gloth FM, Burton JR (1990) Autopsies and death certificates in the chronic care setting. *J Am Geriatr Soc* 38:151–155
- Goodman RA, Manton KG, Nolan TF Jr, Bregman DJ, Hinman AR (1982) Mortality data analysis using a multiple-cause approach. *JAMA* 247:793–796
- Gross JS, Neufeld RR, Libow LS, Gerber I, Rodstein M (1988) Autopsy study of the elderly institutionalized patient. Review of 234 autopsies. *Arch Intern Med* 148:173–176
- Howell TH (1963) Multiple pathology in nonagenarians. *Geriatrics* 12:899–902
- Ishii T, Hosoda Y, Maeda K (1980) Cause of death in the extreme aged. A pathologic survey of 5106 elderly persons 80 years old and over. *Age Ageing* 9:81–89
- Israel RA, Rosenberg HM, Curtin LR (1986) Analytical potential for multiple cause-of-death data. *Am J Epidemiol* 124:161–179
- Jonsson A, Hallgrímsson J (1983) Comparative disease patterns in the elderly and the very old: a retrospective autopsy study. *Age Ageing* 12:111–117
- Karwinski B, Svendsen E (1989) Comparison of clinical and post-mortem diagnosis of pulmonary embolism. *J Clin Pathol* 42:135–139
- Kohn RR (1982) Cause of death in very old people. *JAMA* 247:2793–2797
- Mac Gee W (1989) The frequency of unsuspected tuberculosis found post-mortem in a geriatric population. *Z Gerontol* 22:311–314
- Mac Gee W (1991) Metastatic and invasive tumours involving the heart in a geriatric population: a necropsy study. *Virchows Arch [A]* 419:183–189
- Manual of the International Statistical Classification of Diseases, Injuries, and Causes of Death (1977) Ninth revision conference (1975, vol. 1). WHO, Geneva, pp 699–713
- McKeown F (1965) Pathology of the aged. Butterworths, London

- Michel JP, Bruchez M, Constantinidis J, Bouras C, Grab B, Mac Gee W (1991) Polymorbidité cardiovasculaire en fonction de l'état psycho-organique. Série de 904 confrontations pathologiques et neuropathologiques. *Encephale* 17:61–66
- Michel JP, Arroyo V, Mac Gee W (1992) Confrontacion clinico-anatomopatologica. *Rev Esp Geriatr Gerontol* 27:301–304
- Nielsen GP, Björnsson J, Jonasson JG (1991) The accuracy of death certificates. Implications for health statistics. *Virchows Arch [A]* 419:143–146
- Paterson DA, Dorovitch MI, Farquhar DL, Cameron HM, Currie CT, Smith RG, MacLennan WJ (1992) Prospective study of necropsy audit of geriatric inpatient deaths. *J Clin Pathol* 45:575–578
- Poli L, Pich A, Zanolchi M, Fonte G, Bo M, Fabris F (1993) Autopsy and multiple pathology in the elderly. *Gerontology* 39:55–63
- Rossmann I, Rodstein M, Bornstein A (1974) Undiagnosed diseases in an aging population. *Arch Intern Med* 133:366–369
- Ueda K, Hasuo Y, Ohmura T, Kiyohara Y, Kawano H, Kato I, Shinkawa A, Iwamoto H, Nakayama K, Omae T, Fujishima M (1990) Causes of death in the elderly and their changing pattern in Hisayama, a Japanese community. Results from a long-term and autopsy-based study. *J Am Geriatr Soc* 38:1332–1338
- WHO (in press) Meeting of Heads of WHO Collaborating Centres for the Classification of Diseases. Notes from period February 1985–January 1986, annex 5. Possible changes in mortality statistics. WHO/DES/ICD/86.11:12–15
- Zarling EJ, Sexton H, Milnor P (1983) Failure to diagnose acute myocardial infarction. The clinicopathologic experience at a large community hospital. *JAMA* 250:1177–1181