

ORIGINAL ARTICLE

Analysis of the sensitivity of death certificates in 440 hospital deaths: a comparison with necropsy findings

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Background: There is current heightened public interest in issues surrounding death certification and necropsy. The present study was initiated to determine the accuracy of death certification in providing a correct diagnosis in a series of adult deaths occurring in hospital, all of which were followed by a necropsy.

Method: We examined a series of 440 consecutive adult hospital necropsies performed at Addenbrooke's Hospital, without prior knowledge of the cause of death on the death certificate. The major causes of death at necropsy were subdivided on the basis of organ systems and subsequently compared with the cause of death stated on the death certificate.

Results: There were 448 stated causes of death on the death certificates, compared with 508 causes recorded at necropsy. The overall sensitivity of the death certificate in predicting an individual cause of death was 0.47, with sensitivities ranging from 0.90 in the neurological system to 0.28 in the cardiovascular system, and the sensitivity for all malignant causes of death was 0.65. No significant overall differences were noted in respiratory, gastrointestinal, malignant, and "other" systems when comparing causes of death on the death certificate with those at necropsy.

Conclusions: There is a substantial discrepancy between the diagnosis given on death certificates compared with that at hospital necropsy. This paper discusses the importance of clinicopathological concordance and emphasises the importance of the necropsy in death certification.

An accurate and verifiable system for the recording of causes of death is an essential prerequisite for meaningful collection of epidemiological data, and also should ideally safeguard against illegal practice on the part of individual practitioners. Cause of death is defined as the "disease or injury" that initiated the train of events leading directly to death. Despite recent advances in diagnostic technology, especially in radiology, necropsy is still regarded as the gold standard for the determination of cause of death.¹ Previous studies have consistently shown a pronounced divergence between the clinician's view of the cause of death, as recorded on the death certificate, and the eventual findings of a postmortem examination.^{2–5} Such studies emphasise the continuing importance and relevance of the necropsy in monitoring clinical performance, auditing diagnostic accuracy, and providing educational feedback to the doctors who attended the patient in their last illness.

"Necropsy is still regarded as the gold standard for the determination of cause of death"

We have elected to categorise each of the immediate and underlying causes of death given on the death certificate and compare them to those found at necropsy. We also attempt to analyse the diagnostic accuracy of the diagnosis given on the death certificate as a major cause of death by comparing it with its respective diagnosis at necropsy to establish a baseline for clinical performance and future audit.

METHODS

Data from consecutive adult hospital necropsies performed between January 1999 and August 2000 were obtained retrospectively from hospital files and a computer based registry at Addenbrooke's Hospital, Cambridge, UK. Information was obtained from the postmortem report and the corresponding causes of death given by hospital clinicians on the death certificate were reviewed without prior knowledge of the cause of

death information on the certificate. The necropsies were performed in a standard manner without special techniques. Tissue was submitted for histological examination where deemed appropriate for cases with consent.

Causes of death at necropsy were defined by the pathologist and these were divided into major organ systems with a category for systemic disease. A separate category of malignancy was assessed, with cases drawn from the previously stated organ systems.

The causes of death on the death certificate and at necropsy were compared and tabulated according to whether the clinical (death certificate) diagnosis was:

- True positive: a correct match of clinical and necropsy cause of death.
- False negative: clinically unknown cause of death disclosed by necropsy (underdiagnosis).
- False positive: clinically presumed disease not found at necropsy (overdiagnosis).

Sensitivity was calculated as the proportion of true positives divided by the sum of true positive and false negative diagnoses, and positive predictive value (PPV) as the number of true positives divided by true positives and false positives, respectively.⁶ We specifically charted individual causes of death where more than three cases of any cause were documented, although the overall sensitivity and PPV have taken into account all causes. Within the malignant category, specific information on the overdiagnosed category was gained retrospectively by studying the necropsy report itself. We evaluated the proportion of cases for which tissue was obtained for histology, how often this was formally reported, and the proportion of cases to which the histology was confirmatory of clinical or necropsy findings.

Differences between causes of death for each system on the death certificate and at necropsy were evaluated using the χ^2 test, with a probability of less than 0.05 being considered as significant.

Table 1 Major causes of death in terms of true positive, false positive, and false negative diagnoses in cases of more than three major causes

System	Disease	Correct clinical diagnosis (true positive)	Clinical underdiagnosis (false negative)	Clinical overdiagnosis (false positive)
Cardiovascular	Ischaemic heart disease	39	76	19
	Hypertensive heart disease	3	29	5
	Valvular heart disease	2	10	1
Respiratory	Bronchopneumonia	57	52	42
	Pulmonary embolus	5	17	15
	Malignancy	12	3	3
	Other pneumonia	6	5	17
	Obstructive airway disease	4	10	9
	Pulmonary fibrosis	3	1	0
Gastrointestinal	Malignancy	7	7	6
	Peptic ulcer	1	6	4
	Pancreatitis	0	1	0
	Cirrhosis	11	6	2
	Ischaemia	2	3	0
	Diverticulitis	3	4	0
	Colitis	1	1	2
	GI haemorrhage (unknown cause)	0	1	5
Genitourinary	Malignancy	5	5	5
	Infection	2	4	6
	Renal failure	2	0	14
Neurological	Infarct	24	1	23
	Haemorrhage	14	1	1
Others	Malignancy	14	7	6
	Iatrogenic	8	3	0
	Septicaemia	0	0	14

GI, gastrointestinal.

RESULTS

In the months between January 1999 and August 2000, 2657 deaths were certified within Addenbrooke's Hospital. Of these, 861 resulted in necropsy and just over half were hospital cases (471 necropsies). The hospital necropsies accounted for 55% of all those performed and 21% of all hospital deaths (excluding the coroner's cases).

Of the 471 hospital necropsies, data were reviewed for 440 cases (93%), with the remainder excluded because of a lack of complete information. The male : female ratio was 1.1 : 1, with the mean age at necropsy being 78.2 years and a range of 28 to 100 years. In many cases, more than one cause of death was diagnosed, with 508 found at necropsy compared with 448 on the death certificate. Table 1 lists the major individual causes of death in cases of more than three causes and table 2 details the sensitivity and PPVs of the individual organ systems in predicting the accurate cause of death. Table 3 shows total causes of death on the certificate and at necropsy for organ systems, with a separate category for malignancy.

The overall sensitivity and PPV of the death certificate, for any individual cause, were 0.47 and 0.54, respectively.

Cardiovascular system

The overall clinical diagnosis of cause of death in this system was the most inaccurate, with significant divergence between

diagnoses on the death certificate and those at necropsy. The overall sensitivity (0.28) was low, with significantly more cardiovascular deaths noted at necropsy compared with the death certificate ($p < 0.001$). Data show that the major cardiovascular causes of death have low sensitivities as a result of significant underdiagnosis (table 1).

Respiratory system

The greatest overall numbers of deaths were present in this system, with no significant difference when comparing numbers on the death certificate with those at necropsy ($p > 0.05$). The sensitivity of all respiratory causes on the death certificate was 0.51, with bronchopneumonia as the most common cause; however, individual variations show high sensitivities and PPVs for malignancy (0.80), with lower sensitivities for pulmonary embolus (0.23) and obstructive airway disease (0.29).

Gastrointestinal system

The gastrointestinal system shows the widest range of diagnoses with no difference noted for causes given on the death certificate and at necropsy ($p > 0.05$). The highest individual sensitivity is seen with cirrhosis (0.65); however, the low overall sensitivity (0.44) is caused by the higher numbers of false negative diagnoses in peptic ulcer, malignancy, and diverticulitis.

Table 2 Sensitivity and positive predictive values of individual organ systems in predicting the accurate cause of death

System	Correct clinical diagnosis (true positive)	Clinical underdiagnosis (false negative)	Clinical overdiagnosis (false positive)	Sensitivity	Positive predictive value
Cardiovascular	46	119	25	0.28	0.65
Respiratory	91	89	86	0.51	0.51
Gastrointestinal	26	33	23	0.44	0.53
Genitourinary	9	9	25	0.5	0.26
Neurological	43	5	27	0.9	0.61
Others	25	13	22	0.66	0.53
Total	240	268	208	0.47	0.54
Malignancy	41	22	20	0.65	0.67

Table 3 Causes of death for each system at necropsy and on the death certificate with corresponding p values

System	Cause on death certificate (%)	Cause at necropsy (%)	p Value (χ^2)
Respiratory	177 (40)	180 (35)	>0.05
Cardiovascular	71 (16)	165 (32)	<0.001
Neurological	70 (15)	48 (9)	<0.001
Gastrointestinal	49 (11)	59 (12)	>0.05
Others	47 (10)	38 (8)	>0.05
Genitourinary	34 (8)	18 (4)	<0.001
Total	448	508	
Malignancy	61 (14)	63 (12)	>0.05

Genitourinary system

Relatively more diagnoses were made in this system on the death certificate compared with necropsy ($p < 0.001$). The lowest PPV in the study was noted here (0.26) because of an overall high false positive rate in the three major causes.

Neurological system

The highest overall sensitivity attained for causes of death was in the neurological system. The common individual diagnoses of infarct and intracerebral haemorrhage show sensitivities of 0.96 and 0.93, respectively; however, PPV is lower in infarct (0.51) than in haemorrhage (0.93) as a result of more false positive diagnoses. Significantly higher proportions of neurological causes of death are also present on the death certificate compared with necropsy ($p < 0.001$).

"Others" system

The overall high sensitivity in this system (0.66) reflects predominantly concordant diagnoses, especially in iatrogenic and malignant causes (0.73 and 0.66, respectively). No significant differences in causes of death were present at necropsy compared with death certificates ($p > 0.05$).

Malignancy

The separate category of malignancy showed no difference in numbers of diagnoses between death certificate and necropsy ($p > 0.05$). Malignancies of the respiratory tract show the highest overall sensitivity (0.80). Breakdown of the false positive diagnoses (overdiagnosis) of malignancy shows that eight of the 20 tumours given as the cause of death on the death certificate (40%) were not present in the subsequent necropsy. Of the five colonic carcinomas, three were confirmed present, one excised with no recurrence, and one not present at all. Two of the three lung malignancies were present and the other was myeloma. Of the four "unknown" primary tumours, three could not be substantiated after necropsy and in the fourth a lung malignancy was present. Two lymphomas, two bladder carcinomas, and one prostate carcinoma given as the cause of death on the death certificate were present but not the real cause of death at necropsy. One pancreatic carcinoma noted on the death certificate was not present, and of the two ovarian malignancies, one was benign and the other not apparent at necropsy.

Histology

Tissue was submitted for histology in 263 cases (60%) and reported in 101 (23%). In 98 of these cases, the reported histology confirmed the macroscopic findings; however, not all of these were related to the cause of death—for example, neuropathological examination of the brain revealing Alzheimer's disease in a patient who died as a result of myocardial infarction.

DISCUSSION

We have attempted to classify causes of death on the death certificate and at necropsy by calculating the sensitivity and

PPV of the certificate in providing accurate diagnoses. Our study has shown an overall sensitivity (0.47) within limits of previously recorded findings.¹⁻⁵ The low sensitivity of cardiovascular causes of death is in keeping with other studies showing that underlying cardiac disease is rarely recorded on the death certificate,⁷ and we have demonstrated a sensitivity in the malignant disease category comparable with other published data.²⁻⁸ We have also shown a correct primary site to be established in a higher proportion (84%) of malignant cases, compared with other reports.⁸ We have shown agreement in the cause of death to be likely in a neurological diagnosis and the diagnosis of respiratory malignancy, possibly because of early presentation or a more clear cut clinical scenario.

The fact that our study is retrospective and is in the setting of the non-coronal necropsy has meant that some histology was not directly related to the cause of death, and may have been taken for confirmation of other findings. The high rate of concordance of histological and pathological findings in 23% of our reported cases suggests that many of these diagnoses are justified, although data have shown a relatively high incidence of discrepancy between macroscopic and histological diagnoses.⁹

The percentage of necropsies in our centre (33%) falls within the limits recommended by Royal College of Pathologists' guidelines,¹⁰ despite the fact that most necropsies in the UK are now performed for the coroner.¹¹ At the same time, our study and others show consistent discrepancies between antemortem and postmortem diagnoses. Many authors believe that the necropsy and subsequent audit is the only valid means by which these inaccuracies can be remedied,^{2,12} because necropsy may confirm or refute clinical diagnoses as the final cause of death, with rates of up to 75% for previously undisclosed and clinically important findings.¹³ In previous studies, up to 23% of certificates have recorded only the mode of dying, with 55% incorrectly coded using the criteria of the International Classification of Diseases (ICD-IX) when used to classify mortality statistics.⁷ In studies of multiple causes of death, up to 54% were found to be inaccurate, with 79% of undiagnosed causes of death considered treatable,¹⁴ and 25–75% of death certificates recording more than one cause of death.^{7,15}

"The relevance of these discrepancies at a population level is that they may also significantly alter mortality data, with subsequent inaccuracies in epidemiological statistics hiding potential associations between risk exposure and possible outcome"

There are several reasons for the discordance between our data and those of other reports. We have incorporated more than one cause of death for each patient where present on both the death certificate and at necropsy, whereas many previous studies take into account only one. Other studies have also included competing causes of death in their definition of error, whereas we believe that separate disease processes, each

Take home messages

- The overall sensitivity of the death certificate in predicting an individual cause of death was 0.47, with sensitivities ranging from 0.90 in the neurological system to 0.28 in the cardiovascular system, and the sensitivity for all malignant causes of death was 0.65
- No significant overall differences were noted in respiratory, gastrointestinal, malignant, and "other" systems when comparing causes of death on the death certificate with those at necropsy
- There is a substantial discrepancy between the diagnosis given on death certificates compared with that at hospital necropsy
- Thus, the declining rate of hospital "request" necropsies is a worrying and regrettable trend with important implications for mortality statistics, clinical audit, and clinical education

with an important impact, may have been disallowed. The very nature of the hospital necropsy is such that only the more difficult clinical cases are chosen and our data are derived from a tertiary referral centre where the most challenging cases will be managed. These may be situations where the clinical picture may not have been fully conclusive or where multiple disease processes are present, with difficulty in deciding the ultimate cause of death. Unfortunately, there is a widely acknowledged universal decline in the rate of necropsies,¹⁶ especially in the elderly, where there is a potentially higher discrepancy rate and therefore higher rate of undiagnosed conditions.¹⁷ The inclusion of an elderly inpatient population in our data will therefore have influenced these results because the clinical presentation may often be atypical, with the real cause of death being difficult to elicit.

The discordance between this and other studies can also be partially explained by the limited clinical information the pathologist may possess at the time of the necropsy. This may be the result of a lack of meaningful communication between the clinician and pathologist, either before or at the conclusion of the necropsy. Further discrepancies may develop because of the constraints of death certification, where only those factors directly causing death are recorded by the clinician, so that not all the diseases of an individual are recorded. It follows from this that a lack of clinical information at the time of the necropsy, especially the timing and presence of multiple pathology, may make it difficult to decide which of these should be included within the real cause of death. Alternatively, in complex cases the notes may be voluminous and poorly sequenced, and without discussion of these cases between clinician and pathologist it is possible that the important issues may not be highlighted. The fact that a complex cause of death may be surmised in a two part form suggests inadequacies within the death certificate itself, and others have previously suggested that it should include diseases present at the time of death, rather than conditions leading directly to death, and that an underlying cause of death could be listed as "pending" until the clinicians have seen the results of the necropsy before completion of the certificate.¹⁸

The relevance of these discrepancies at a population level is that they may also significantly alter mortality data, with subsequent inaccuracies in epidemiological statistics hiding

potential associations between risk exposure and possible outcome. Suggestions for improvements in data have been the immediate audit of data by the attending staff, completion of workshops by certifying doctors, and addenda to certificates to incorporate new findings.¹⁸⁻²⁰ We also suggest that attendance at the necropsy by clinicians would further facilitate this process.

In conclusion, we have shown that inaccuracies are still common in the completion of the death certificate in the current hospital setting. It follows from this that the declining rate of hospital "request" necropsies is a worrying and regrettable trend with important implications for mortality statistics, clinical audit, and clinical education. The encouragement of meaningful communication between the clinician and the pathologist may help to redress this balance and also aid accurate recording of the cause of death.

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