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Accuracy and validity of determined cause of death and manner of death following forensic autopsy prosection

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ABSTRACT

Aims The purpose of this study is to evaluate the accuracy and validity of the determination of cause of death (COD) and manner of death (MOD) at the completion of the forensic autopsy prosection.

Methods We analysed 952 autopsy cases conducted from 2019 to 2020 and compared every patient's COD, other significant contributing factors to death (OSC), and MOD after prosection to their COD, OSC and MOD after completion of the final autopsy report.

Results We found that 83% of cases (790 patients) did not have an unexpected change and 17% of cases (162 patients) exhibited a true change in their final diagnosis; the relationship between age and changes in COD and MOD was significant.

Conclusions Our findings indicate that in the majority of forensic autopsy cases, medical professionals can reasonably complete death certification after the autopsy prosection. In addition to improving the accuracy of COD and MOD, advances in this field will enhance timely decedent affairs management, timely investigations of crimes and timely closure to families who have lost loved ones. We recommend implementing combined interventional education and consultation with expert pathologists, and a well-followed structured method of death classification as the best course of practice.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Currently, death certificates are routinely inaccurate, often contain multiple errors and can require months to complete. This study needed to be done to evaluate the accuracy of death certifications when a standardised approach is adhered to in combination with extensive experience and training in death certification.

WHAT THIS STUDY ADDS

⇒ As a result of this study, we now know that in the majority of autopsy cases, the death certification remains unchanged between the completion of the autopsy prosection and the completion of the final autopsy report when a standardised approach is adhered to in combination with extensive experience and training in death certification.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Our findings indicate that in the majority of forensic autopsy cases, medical professionals can reasonably complete death certification after the autopsy prosection. This change of practice enhances timely decedent affairs management, timely investigations of crimes and timely closure to those who have lost loved ones.

INTRODUCTION

Death certificates are frequently inaccurate. In some studies, over 85% of death certificates have more than one error.[1] This has far-reaching repercussions in closure for families and loved ones, insurance benefits claims and assisting law enforcement investigations, which involve accidental deaths or homicide cases. The populations experiencing the greatest percentage of change in death certificates have been women, as well as younger and older age groups.[2] Death certificates are inaccurate due to premature cause of death (COD) findings, undertraining of physicians, variable medical practices, time constraints, fatigue, unfamiliarity with the deceased and perceived unimportance of death certificates.[1–8] After receiving results of hospital autopsies, changes in the COD have been seen in 61% of patient cases.[2] The high percentage of changes in COD after receiving hospital autopsy findings are in part due to a lack of adequate educational training of medical students and non-pathology residents in death certification. One study found that over three quarters of residents in the USA had received no formal training in principles of death certification.[1] Additionally, medical examiners and coroners have their own unique and different practices across jurisdictions which undoubtedly lead to inconsistencies in classifying CODs.[3] Physician teams may also be simply overworked without enough time to thoughtfully and accurately classify COD, especially when equipped with inadequate training and/or insufficient knowledge regarding death certification in potentially unknown patients.[4]

We sought to explore whether death certificates can be finalised after forensic autopsy prosection (autopsy dissection) or if death certification is best delayed until completion of the final autopsy report, which can take up to 3 months or longer to complete. Our study addresses gaps in current knowledge by having cases conducted by a single pathologist who is also a board-certified forensic pathologist and neuropathologist with over 22 years of experience. Having a single medical professional with extensive experience and death

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Table 1 Unexpected versus expected change classification

Unexpected (true) change	Expected change
Prosection result pending toxicology and final result is unrelated to toxicology	Prosection result pending toxicology and final result is related to toxicology
Prosection result pending histology/ neuropathology and final result is related to toxicology	Prosection result pending histology/ neuropathology and final result reveals expected histology/neuropathology findings
Prosection result pending medical records review or investigation and final result is not due to natural disease	Prosection result pending medical records review or investigation and final result is due to natural disease
Final result differs from Prosection result in any way relating to COD, OSC and/ or MOD	

COD, cause of death; MOD, manner of death; OSC, other system disease.

certification training limits variation in practice and lack of standardised approach in death certification of cases. These facets of our research along with the use of original medical records allows us to evaluate the importance of certifying death certificates immediately after prosection as well as identify factors that lead to expected and unexpected changes after the final autopsy report is completed.

METHODS

Data were collected from a private autopsy practice with a single pathologist to avoid variable death certification practices. We initially reviewed 1005 case records, which were conducted from 2019 to 2020 in multiple Northern California counties. Fifty-three case records were excluded from the study because they were conducted by another pathologist or were solely medical records review cases.

Among the 952 cases included, we analysed age, sex, ethnicity, COD, other significant contributing (OSC) and manner of death (MOD). Prosection COD, prosection OSC and prosection MOD were compared with final COD, final OSC and final MOD which included toxicology and histology reports for every case record. After the autopsy prosection, the COD, OSC, MOD were determined and provided with a reasonable degree of medical certainty based on the prevailing forensic scenario and gross autopsy findings. When the COD could not be determined with a reasonable degree of medical certainty, the COD and MOD were determined as 'pending'. The reason for classifying a case as 'pending' was specified as follows: 'pending toxicology,' 'pending histology,' 'pending neuropathology,' 'pending investigation' and 'pending medical records review.' We noted whether a case was initially classified as 'pending' and if any changes were made in the COD, OSC and/or MOD from prosection to the final autopsy report. If any change was noted, a reason for the change was identified and determined whether it constituted an expected or unexpected change as enumerated in table 1.

For biostatistical analysis, the COD and OSC were abstracted after consultation with a biostatistician. The primary pathologist was not included in case records abstraction to avoid confirmation bias and other potential biases. During case review, another pathologist independently reviewed the cases for quality control and inconsistencies. For the purposes of statistical analyses, we created six COD classification categories as follows: heart and/or lung disease (HLD), other system diseases (OSD), trauma, infections, overdose and/or toxicities (OT) and neoplasm. Ethnicity was categorised into either Asian, Black, Hispanic, white or other. All fetal deaths were designated as having 0 years of age.

We used the Monte Carlo estimate of Fisher's exact test to examine associations between change in the final diagnosis and prosection COD, OSC and MOD. The Monte Carlo estimate was used because the exact test was slow to converge for large tables. The t-test was used to test for differences in age between those who had a change in the final diagnosis compared with those who did not. Summary statistics are reported as percentages. A $p<0.05$ was considered statistically significant. All analyses were conducted by using SAS(r) software V.9.4 for Windows(r) (SAS Institute).

Table 2 Prosection versus final COD frequency

COD	Prosection frequency	Final frequency	Prosection per cent	Final per cent
Heart and/or lung disease	329	369	34.56	38.76
Pending	261	0	27.42	0.00
Trauma	218	226	22.9	23.74
Other system diseases	61	83	6.41	8.72
Overdose and/or toxicities	37	209	3.89	21.95
Infection	23	35	2.42	3.68
Neoplasm	17	18	1.79	1.89
Other	6	12	0.63	1.26

COD, cause of death.

Table 3 Prosection versus final OSC frequency

OSC	Prosection frequency	Final frequency	Prosection per cent	Final per cent
None	297	372	31.20	39.08
Pending	262	0	27.52	0.00
Other system diseases	184	306	19.33	32.14
Heart and/or lung disease	165	197	17.33	20.69
Trauma	30	32	3.15	3.36
Overdose and/or toxicities	8	34	0.84	3.57
Other	4	6	0.42	0.63
Neoplasm	2	3	0.21	0.32
Infection	0	2	0.00	0.21

OSC, other significant contributing.

RESULTS

The 952 forensic autopsies performed included 269 women and 683 men. Ethnicity consisted of 1.4% Asian, 3.8% Black, 9.4% Hispanic, 81.4% white and 4.1% were of other ethnicities. Across all cases, the minimum age of death was 0 years and maximum age of death was 98 years. Median age of death was 60 years and mean age of death was approximately 57.8 years with an SD of 18.4.

Table 4 Prosection versus final MOD frequency

MOD	Prosection frequency	Final frequency	Prosection per cent	Final per cent
Natural	460	487	48.32	51.16
Pending	265	0	27.84	0.00
Accident	118	342	12.39	35.92
Suicide	72	81	7.56	8.51
Homicide	36	39	3.78	4.1
Undetermined	1	3	0.11	0.32

MOD, manner of death.

Table 5 Relationship between cases with a change and age

Change	# of cases	Mean age	SD	SE	Minimum age	Maximum age
Yes	380	52.87	17.07	0.88	0.00	89
No	572	61.05	18.46	0.77	0.17	98

The abstracted prosection and final COD, OSC and MOD are shown on tables 2–4, respectively.

Out of the 952 cases analysed, 380 cases (39.9%) had a change from prosection to final diagnosis. The average age of death of cases that had a change was 52.9 years compared with 61.1 years as shown in table 5 ($p<0.001$). Of the 380 total cases that had a change, 162 cases exhibited an unexpected (true) change (17% of the total number of cases). We found that 15% of females had an unexpected change compared with 18% of men, although this was not statistically significant ($p=0.16$). There was not a statistically significant difference among ethnicities ($p=0.70$).

The reasons for the 162 cases with unexpected changes are listed in table 6. We classified these reasons as follows: 'positive toxicology', 'negative toxicology', 'positive histology', 'investigation' and 'negative laboratory results'. The most common causes for an unexpected change were due to unexpected toxicology results (table 6). Biostatistical analysis showed that outside of pending cases, the prosection COD associated with the highest likelihood for an unexpected change was HLD (18%). Similarly, the MOD associated with the highest rate of unexpected changes were originally classified as Natural deaths (26%). None of the cases with changes in COD were either suspicious cases or homicides.

DISCUSSION

39.9% of our total number of autopsy cases exhibited a change from prosection to final diagnosis. The average age of death of decedents that had any change were 8.2 years younger than those who did not. We suspect that this difference may be due to the tendency that older decedents are more likely to die from ageing-related natural causes which are more likely to be determined at the end of the autopsy prosection by gross autopsy findings, while younger decedents are more likely to die from non-natural causes like drug-overdose which are more likely to be determined after the autopsy prosection by additional laboratory studies like toxicology reports.

Seventeen per cent of our total number of cases exhibited an unexpected (true) change between prosection and final COD, OSC and MOD. Twenty-three per cent of our total number of cases exhibited an expected change between prosection and final COD, OSC and MOD. Conversely, the average age of decedents with unexpected change were 8.6 years older than the average age of those who exhibited an expected change from prosection to final diagnosis. This is likely due to the increased number of unexpected positive toxicology results in older and elderly patients, whose COD was obvious at the end of the autopsy prosection based on the gross autopsy findings; however, toxicological analyses of the blood revealed unexpected presence of toxic drugs and combinations of toxic drugs, which either caused death or contributed to death. Results show that gender and ethnicity were not statistically significant factors contributing to unexpected change in cases.

Table 6 Reasons for change for 162 unexpected (true) change cases

Reason for change	Frequency	Per cent
Positive toxicology	92	56.79
Negative toxicology	44	27.16
Positive histology	22	13.58
Investigation	3	1.85
Negative labs	1	0.62

Limitations

One major limitation of the study is the lack of ethnic diversity among our study population. We were unable to find correlation between ethnicity and changes in final autopsy, a trend that may be a relevant factor and should be studied further. Our study population was majority male and we were unable to observe a correlation between gender and changes in final autopsy found in other studies.[2] The proportion of deaths in our study population caused by HLD, trauma, OSD, OT, infection and neoplasm differs from the general population. Additionally, the cases for our study all came from one database, one general geographical location (Northern California) and respective autopsies were completed by one expert forensic pathologist. Although having cases conducted by a single pathologist eliminated the possibility of interobserver variability, the possibility of intraobserver variability exists. It should also be recognised that medicolegal autopsy practices vary in different countries such as the UK and other parts of the world. Therefore, this study should be replicated with necessary adjustments to the sample population and use cases from multiple medical professionals with extensive experience and death certification training along with uniform practice and standardised approach in death certification of cases to yield stronger results.

CONCLUSION

Our findings indicate that in the majority of forensic autopsy cases, medical professionals can reasonably complete death certification after the autopsy prosection. We observed that death certification after forensic autopsy prosection was unchanged in a majority (83%) of cases between the completion of the autopsy prosection, and the completion of the final autopsy report. We also observed that the age of decedent correlated with the likelihood that an expected or unexpected change would occur between the two events. However, we did not see this correlation with gender or different ethnicities. We understand that this study only examined cases performed by a single experienced forensic pathologist. Therefore, future studies should be performed to determine if experienced forensic pathologists have lower rates of unexpected changes and implicit biases, and thus positively impact their ability to provide accurate death certifications after forensic autopsy prosections.

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REFERENCES

1 Schuppener LM, Olson K, Brooks EG. Death certification: errors and interventions. *Clin Med Res* 2020;18:21–6.
2 Alfsen GC, Mæhlen J. The value of autopsies for determining the cause of death. *Tidsskr Nor Laegeforen* 2012;132:147–51.
3 Shapiro-Mendoza CK, Parks SE, Brustrom J, *et al*. Variations in cause-of-death determination for sudden unexpected infant deaths. *Pediatrics* 2017;140:e20170087.
4 Pritt BS, Hardin NJ, Richmond JA, *et al*. Death certification errors at an academic institution. *Arch Pathol Lab Med* 2005;129:1476–9.
5 Kircher T, Nelson J, Burdo H. The autopsy as a measure of accuracy of the death certificate. *N Engl J Med* 1985;313:1263–9.
6 Myers KA, Farquhar DR. Improving the accuracy of death certification. *CMAJ* 1998;158:1317–23.
7 McGivern L, Shulman L, Carney JK, *et al*. Death certification errors and the effect on mortality statistics. *Public Health Rep* 2017;132:669–75.
8 Brooks EG, Reed KD. Principles and pitfalls: a guide to death certification. *Clin Med Res* 2015;13:74–82.