Published in final edited form as:

J Surg Res. 2011 May 1; 167(1): 121–124. doi:10.1016/j.jss.2009.07.009.

Autopsy after Traumatic Death—A Shifting Paradigm

Timothy D Light, MD, Nora A Royer, MD, Joseph Zabell, BA, Mark B Le, M BS, Timothy A Thomsen, MD, FACS, Gerald P Kealey, MD, FACS, Michel A Alpen, RN MS, and Marcus B Nashelsky, MD

Research performed at University of Iowa Carver College of Medicine

Abstract

Objective—The role of autopsy in evaluating missed injury after traumatic death is well established and discussed in the literature. The frequency of incidental findings in trauma patients has not been reported. We believe that incidental findings are under recognized and reported by trauma surgeons.

Design—Prospective, descriptive, cohort study.

Setting—Level 1 trauma center in a rural state.

Patients—Four hundred ninety-six deaths over a 4-year period were identified from the trauma registry. Two hundred four complete autopsies were available for review.

Interventions—One thousand eighteen traumatic diagnoses were identified from two hundred four autopsies and corresponding medical records by trauma surgeons blinded to patient identity. The surgeons recorded missed diagnoses, incidental diagnoses identified at autopsy, and diagnoses known at the time of death confirmed by autopsy.

Measurements and Main Results—The surgeons had a kappa score of 0.82-0.84. Forty-two patients (21% of patients) had 68 severe missed injuries; sixty-seven patients (33% of patients) had 94 minor missed injuries. Twenty-eight patients (14%) had significant incidental findings including premature atherosclerosis, multiple endocrine neoplasia, tuberculosis, and others.

Conclusions—The autopsy after traumatic death is more than a mechanism of quality control and teaching. A high proportion of patients will have incidental findings important to family members and have of public health importance. Systems need to be developed to review autopsy results with attention to identifying and communicating incidental findings. Given the incidence of significant missed injuries and incidental findings, the autopsy continues to have an important role in health care.

Keywords

trauma; autopsy; incidental finding; missed injury; death

© 2009 Elsevier Inc. All rights reserved.

Corresponding author: Timothy D Light MD, University of Iowa Carver College of Medicine, Dept of Surgery, 200 Hawkins Dr, Iowa City, IA 52242.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

There are no conflicts of interest to report.

Portions of this work were presented in poster and abstract form at the 2008 SCCM Annual Meeting

Introduction

Autopsy has long been used to help clarify the cause of death and the pathological processes leading to death. It is an integral part of efforts to improve medical knowledge and enhance the quality of patient care. Its role in trauma system education and improvement is widely debated.^{1,2}

Most trauma autopsy studies focus on missed injuries and their impact on outcome. In the literature, the percentage of missed injuries discovered at autopsy after traumatic death ranges from 11-68%.^{3,4} The most widely cited standardized classification scheme for clinical/autopsy discrepancies was first used in 1983 and came to be known as the Goldman criteria⁵. Essentially all reported clinico-pathological studies utilize the Goldman criteria or a modification. According to this scheme, “major” diagnoses are the primary autopsy-derived cause or causes of death and related underlying disease or injury processes. “Minor” diagnoses are also autopsy-derived and consist of other conditions which, if recognized and treated, would not have prevented the death. Discrepancies between “major” autopsy diagnoses and clinical diagnoses (“missed” diagnoses) are categorized as Class 1 or Class 2. Class 1 discrepancies are those in which the autopsy diagnosis, if known before death, would have likely altered the treatment plan and possibly resulted in prolonged survival or recovery of the patient. Class 3 discrepancies are “minor” diagnoses, which, if known before death, would probably not have changed the outcome of the patient. Class 4 discrepancies are incidental autopsy findings unrelated to cause of death (Table 1).

While there is a body of literature regarding incidental findings on radiologic studies done for trauma,⁶ there are no reported data on the rate of incidentally discovered conditions at autopsy for trauma patients.

The preliminary autopsy report is usually completed within a few days after the death, and it easily identifies missed injuries. The findings and the rapidity of the communication make the preliminary autopsy report very useful in morbidity and mortality conferences and other quality review efforts.^{7,8} In contradistinction, many of the incidental autopsy findings are reported in the final report several weeks after the death -- long after the discussion about missed injuries and process improvement has ceased.

We undertook this study to determine the rate of incidental findings at autopsy in trauma patients and compare them to missed injuries.

Materials and Methods

This project was exempt from approval by the institutional review board because the subjects were all deceased. We used best practices to ensure confidentiality and data security. The trauma registry at a Level 1 trauma center was queried for deaths from January 1, 2002 through May 31, 2006.

Iowa has had an integrated, statewide trauma system since 1997. All hospitals in the state participate in the trauma system; there are pre-existing transfer arrangements between all hospitals and transport systems. The University of Iowa Hospitals and Clinics is one of two Level 1 trauma centers in the state. All traumatic deaths in Iowa are mandated to be reported to the county Medical Examiner, who has the authority to order an autopsy if it will assist in the death investigation. A forensic pathologist is on staff at the University of Iowa Hospitals and Clinics who is available to perform autopsies at the Medical Examiner's request. In this series, there were no family consent autopsies.

Trained personnel, blinded to the autopsy findings, abstracted injuries known at the time of death from medical records. Three attending trauma surgeons, blinded to patient identity, reviewed the abstracted medical record and the corresponding autopsy report to identify injuries not known antemortem and discovered at autopsy, known antemortem injuries confirmed by autopsy, and incidental diagnoses revealed by autopsy. Each surgeon independently assigned a modified Goldman score to each finding (Table 1).

Incidental findings were categorized into infectious, premature atherosclerosis (males before age 40 or females before age 50), neoplasm, and other. Other data such as cause of death, date of death, length of stay, mechanism of injury, age, gender, and completeness of autopsy were also abstracted.

Data were collected in Microsoft Access 2003, and analyzed in SAS 9.1. All analyses were performed in consultation with biostatisticians.

Results

From January 1, 2002 to May 31, 2006, there were 10,937 trauma patients with an average Injury Severity Score (ISS) of 11.1 (median=11, SD=10.1). There were 496 deaths during the study period, with an average of ISS 28.6 (median=26, SD=13.6). Two hundred twenty-nine were autopsied, for an overall autopsy rate of 46%. Two hundred four autopsy reports were available for review.

Sixty-five percent of the deceased were male. The average age was 59 years (SD = 25, median = 66). The overwhelming majority of deaths were accidents; most of these were caused by blunt injury of the head and/or torso from motor vehicle collisions or falls (74%).

Autopsied patients who were younger, had a lower admission Glasgow Coma Scale score (GCS), died earlier in the hospital course, and had more intentional injury (Table 2). By multivariate regression analysis, patients likely to be autopsied died after 2004, were admitted by the trauma team (instead of subspecialists), had shorter lengths of stay, were younger, and had penetrating trauma.

The inter-rater reliability between the reading surgeons was over 0.82, reflecting a very high agreement. Class 3 missed injuries were common (33% of autopsied deaths) and consisted mostly of rib fractures and face injuries. Class 1 and 2 injuries were rarer (21% of autopsied deaths) and consisted of traumatic brain injury, spine fractures, and skull fractures in moribund patients—none of these patients were candidates for neurosurgical intervention (Table 3).

There were twenty eight patients with important incidental findings (14% of autopsied deaths) (Table 4). In this group there were two infectious cases: pulmonary tuberculosis, and schistosomiasis. There was a 4% rate of severe premature atherosclerosis. This included a 21-year-old male with a 75% left anterior descending artery stenosis. There were 13 incidental neoplasms. Most were deemed important because of concern for familial tendencies -- i.e. a 90 year old male with incidental prostate adenocarcinoma was not included in this list. These included patients with multiple endocrine neoplasia syndromes (MEN), gastro-intestinal stromal tumors (GIST), and thyroid neoplasms. There were four cases in the other category: a patient with Ehlers-Danlos syndrome, a patient with hypertrophic cardiomyopathy, a patient with coarctation of the aorta, and a young patient with a likely hypercoagulable disorder - the patient had evidence of acute and chronic deep venous thromboses and pulmonary emboli at autopsy performed on hospital day two.

Discussion

The rate of incidental findings is comparable to the rate of significant missed injuries. These incidentally noted conditions in deceased trauma patients have implications for the health of the patient's family members and community. This rate (14 %) is concordant with the 10-40% rate described in the radiology literature^{9,10,11} but has not previously been reported in the trauma/surgical critical care literature. This finding should encourage trauma surgeons to widen their view of the utility and role of autopsy after traumatic death. Incidental findings are as common—and probably of more clinical importance—than missed injuries in traumatic death.

Tuberculosis is a reportable disease with significant public health implications. While schistosomiasis is not a reportable disease, it is very contagious and has significant morbidity. Atherosclerosis is the leading cause of death in the US. A family history of premature atherosclerosis is a leading risk factor for heart attack and stroke. Family members of patients with hypertrophic cardiomyopathy, hypercoagulable states, and MEN syndromes need to be evaluated and counseled about further testing.

The incidental radiographic finding is relatively easy to handle and to communicate with the patient and family.¹² There are several reasons why important incidental diagnoses found on autopsies after traumatic death are not communicated to surviving family members. The trauma autopsy is often done for forensic reasons or quality control reasons to identify missed injuries.^{13,14} The trauma surgeon might not recognize the incidental finding as important -- by definition, it did not contribute to the cause of death. The incidental finding may be beyond the surgeon's area of expertise and interest, thereby offering little incentive for followup for general medical education and practice improvement. There may not be a relationship with a family member to inform them of the incidental finding. In this series, there were no family consent autopsies - i.e. the Medical Examiner mandated each autopsy as part of the death investigation, so the surgeon did not obtain consent from the family and did not develop a relationship with them. In Medical Examiner mandated autopsies, the trauma surgeon might not feel the responsibility to 'close the loop' and fully followup and explain the findings to family members.

Finally, the incidental findings are often described in the final report, which is finalized at some interval of time after the death (3-4 weeks at our institution), after the focus of the trauma team has moved on to the next series of clinical challenges.

Autopsies, whether ordered by the Medical Examiner to assist in the death investigation, or requested from the family by the treating physician, are valuable tools. The results should be followed up as is done with any other diagnostic test or procedure. Autopsies validate clinical diagnoses, refine clinical diagnoses, and reveal new, unexpected diagnoses. The spectrum of case specific autopsy information contributes to ongoing clinician education and improvement. Equally important, family members are entitled to complete communication about the care and diagnostic evaluation of their relative, including the postmortem examination.

A system needs to be in place to ensure that critical autopsy findings are identified and communicated to the patient's next of kin as well as appropriate public health authorities. Knowledgeable professionals must provide guidance for screening and testing of surviving family members when indicated. Just as trauma systems extend themselves into prevention and education, we need to close the loop at the end of the life cycle as well.

Conclusion

Important incidental findings have gone unrecognized in trauma autopsies. The rate of important incidental findings rivals that of missed injuries. The autopsy is not just a tool for quality control and medico-legal certainty; it can identify conditions that may be important to the surviving family and have public health implications. The autopsy should be viewed not just as the coda on a heroic attempt to save a life tragically cut short by traumatic injury, but the opportunity to start the healing process by communicating autopsy results with the affected surviving family and community.

Acknowledgments

Special thanks to Miriam Zimmerman, PhD for statistical assistance.

This work was supported in part by NIH Training Grant HL007485-28 (JZ), and by University of Iowa Carver College of Medicine Summer Research Scholarship (MBL)

References

1. Ong AW, Cohn SM, Cohn KA, Jaramillo DH, Parbhu R, McKenney MG, Barquist ES, Bell MD. Unexpected findings in trauma patients dying in the intensive care unit: results of 153 consecutive autopsies. *Journal of the American College of Surgeons*. 2002; 194(4):401–406. [PubMed: 11949744]
2. Forsythe RM, Livingston DH, Lavery RF, Mosenthal AC, Hauser CJ. Autopsies in Trauma Do Not Add to Peer Review or Quality Assurance. *Journal of Trauma*. 2002; 53(2):321–325. [PubMed: 12169941]
3. Sharma BR, Gupta M, Harish D, Virender Pal Singh. Missed diagnoses in trauma patients vis-à-vis significance of autopsy. *Injury*. 2005; 36(8):976–983. [PubMed: 16005004]
4. Stothert JC, Gbaanador GBM, Herndon DN. The Role of Autopsy in Death Resulting from Trauma. *Journal of Trauma*. 1990; 30(8):1021–1026. [PubMed: 2388303]
5. Goldman L, Sayson R, Robbins S, Cohn LH, Bettmann M, Weisberg M. The value of autopsy in three medical eras. *N Engl J Med*. 1983; 308:1000–5. [PubMed: 6835306]
6. Eskandary H, Sabba M, Khajehpour F, Eskandari M. Incidental findings in brain computed tomography scans of 3000 head trauma patients. *Surg Neurol*. Jun; 2005 63(6):550–3. [PubMed: 15936382]
7. Marx WH, Simon HM, Jumbelic M, Sposato E, Nieman G. Severity of Injury is Underestimated in the Absence of Autopsy Verification. *Journal of Trauma*. 2004; 57:46–50. [PubMed: 15284547]
8. Martin BT, Fallon WF, Palmieri PA, Thomas ER, Breedlove L. Autopsy Data in the Peer Review Process Improves Outcomes Analysis. *Journal of Trauma*. 2007; 62:69–73. [PubMed: 17215735]
9. Lanctin HP, Futter NG. Renal cell carcinoma: incidental detection. *Can J Surg*. Dec; 1990 33(6): 488–90. [PubMed: 2253127]
10. Gluecker TM, Johnson CD, Wilson LA, Maccarty RL, Welch TJ, Vanness DJ, Ahlquist DA. Extracolonic findings at CT colonography: evaluation of prevalence and cost in a screening population. *Gastroenterology*. Apr; 2003 124(4):911–6.
11. Osman MM, Cohade C, Fishman EK, Wahl RL. Clinically significant incidental findings on the unenhanced CT portion of PEG/CT studies: frequency in 250 patients. *J Nucl Med*. Aug; 2005 46(8):1352–5. [PubMed: 16085594]
12. Green DE, Woodward PJ. The management of indeterminate incidental findings detected at abdominal CT. *Semin Ultrasound CT MR*. Feb; 2005 26(1):2–13. [PubMed: 15771259]
13. Sharma BR, Gupta M, Bangar S, Pal Singh V. Forensic considerations of missed diagnoses in trauma deaths. *Forensic and Legal Medicine*. 2007; 14:195–202. [PubMed: 16914359]
14. Shojania KG, Burton EC, McDonald KM, Goldman L. Overestimation of clinical diagnostic performance caused by low necropsy rates. *Qual. Saf. Health Care*. 2005; 14:408–413. [PubMed: 16326784]

Table 1

Modified Goldman Classification

Class	Description
Class 1:	Major missed diagnosis, which if identified, would have changed outcome
Class 2:	Major missed diagnosis, which if identified, would not have changed outcome
Class 3:	Minor missed diagnosis, which if identified, would not have changed outcome
Class 4:	Incidental Finding, which was unknown at the time of death and unrelated to the trauma

Table 2

Demographics of Deceased Patients

Variable	Autopsy	Not Autopsied	P-Value
Age mean (SD, median)	45 years (25, 47)	69 years (21,76)	<0.001
LOS (median)	1 day	4 days	<0.001
GCS (SD, median)	5.2 (4.5,3.0)	7.7 (5.1,6.5)	<0.01
Mechanism - Blunt -- Burn -- Penetrating	78% 12% 10%	83% 8% 4%	0.004
Sex (Male)	63%	62%	0.17
Alcohol or substance use	37%	19%	<0.001

Table 3

Missed Injuries

Goldman Class	Number of injuries Number of patients *	Injury Description	Injury Count
I	1 injury, 1 patient	Aortic Dissection	1
II	67 injuries, 41 patients	Traumatic Brain Injury	16
		Spine Fracture or cord injury	10
		Skull Fracture	7
		Pulmonary Embolus	5
		Pneumonia	4
III	94 injuries, 67 patients	Sternal and Rib Fractures	37
		Head/Neck/Face soft tissue	8
		Liver Laceration	8
		Pulmonary Embolus	8
		Pneumonia	5

Only the five most common Class II and Class III injury descriptions are listed.

* Some patients had more than one missed injury.

Table 4

Incidental Findings

Finding	Number of Patients
Neoplasms	12
Premature Coronary Artery Disease	7
Possible MEN Variants	3
Infectious Disease	2
Others	4