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Do autopsies still matter? The influence of autopsy data on final injury severity score calculations

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ABSTRACT

Background: Despite a proven record of identifying injuries missed during clinical evaluation, the effect of autopsy on injury severity score (ISS) calculation is unknown. We hypothesized that autopsy data would alter final ISS and improve the accuracy of outcome data analyses.

Materials and methods: All trauma deaths from January 2010 through June 2014 were reviewed. Trauma registrars calculated Abbreviated Injury Scale and ISS from clinical documentation alone. The most detailed available autopsy report then was reviewed, and AIS/ISS recalculated. Predictors of ISS change were identified using multivariate logistic regression.

Results: Seven hundred thirty-nine deaths occurred, of which 682 (92.3%) underwent autopsy (31% view-only, 3% with preliminary report, and 66% with full report). Patients undergoing full autopsy had a lower median age (39 versus 74 years, $P < 0.01$), a higher rate of penetrating injury (41.7% versus 0%, $P < 0.01$), and a higher emergency department mortality rate (30.8% versus 0%, $P < 0.01$) than those receiving view-only autopsy. Incorporating autopsy findings increased mean ISS (21.3 to 29.6, $P < 0.001$) and the percentage of patients with ISS $\geq$ 25 (49.9% to 69.2%, $P < 0.001$). Multivariate analysis identified length of stay, death in the emergency department, full rather than view-only autopsy, and presenting heart rate as variables associated with ISS increase.

Conclusions: Autopsy data significantly increased ISS values for trauma deaths. This effect was greatest in patients who died early in their course. Targeting this group, rather than all trauma patients, for full autopsy may improve risk-adjustment accuracy while minimizing costs.

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Introduction

The autopsy examination, once the gold standard for definitive diagnosis, has seen its rate of use decline by almost 60% since the early 1970s.[1] Although the literature supports the notion that autopsies still identify missed injuries despite marked technological improvements in diagnostic capabilities, debate continues about the clinical relevance of such findings.[2-4] Multiple groups have reported failing to identify actionable errors after introducing autopsy data into their trauma performance improvement processes.[5,6] In light of such findings and costs exceeding $1250 per autopsy, some have suggested autopsy simply is not cost-effective in trauma process improvement.[7] However, large studies of autopsy data are rare, and the role for autopsy data in improving risk adjustment remains unclear.

The injury severity score (ISS) is a validated tool used by the trauma community to quantify, in an objective and comparable way, the overall severity of each patient's traumatic injuries. To calculate ISS, each traumatic injury is assigned an Abbreviated Injury Scale (AIS) score for the corresponding regions of the body (head, face, chest, abdomen, extremities—including pelvis—and external); the sum of the squares of the three highest AIS scores is the ISS.[8] Accurate calculation of AIS scores and the ISS relies on the identification of the entirety of a patient's injuries. Typically, this occurs through a retrospective review of the medical record by trained registry staff. This heavy reliance on the medical record, however, exposes ISS calculation to the risk of undocumented injury that might have been missed during trauma evaluations before death.[9] As AIS and ISS become important components of risk-adjusted benchmarking, erroneous scoring could negatively impact institutional remuneration, should the widespread implementation of value-based payments occur.[10]

Our study aimed to investigate the role that an autopsy examination may play in determining or altering ISS calculations. We hypothesized that the addition of autopsy data would significantly increase ISS and AIS scores. We further postulated that clinically relevant predictors of ISS change following the inclusion of autopsy data exist, and that these predictors could assist providers in identifying those cases that would most benefit from the addition of autopsy data.

Materials and methods

Study population

Patient data were collected retrospectively for all patients evaluated by the trauma service at the University of Cincinnati Medical Center, a verified level I trauma center, from January 1, 2010, through June 30, 2014, and who died during their index admission. The primary outcome of this study was change in AIS/ISS following autopsy. The secondary objective of this study was to identify variables that served as predictors of ISS change. This study was approved by the University of Cincinnati's Institutional Review Board and performed with the assistance of the Hamilton County Coroner's office.

Patient characteristics

Patient characteristics and demographic information collected from our institutional trauma registry included age, race, mechanism of injury, motive of injury, date and time of arrival, initial emergency department (ED) vital signs to include systolic blood pressure, pulse, respiratory rate, and Glasgow Coma Scale, diagnoses as documented in the medical record, and, where applicable, time of death and autopsy status. Race was divided into black, Hispanic, white, or other. Mechanism of injury was characterized as penetrating trauma, asphyxiation, or thermal burn. Motive of injury was separated into accidental, self-inflicted, assault, or unknown, with assault patients in this study being identified as homicide victims.

Autopsy categorization

Autopsies were described as view-only, preliminary, and full. View-only examinations were performed at the discretion of the country coroner medical staff. These entail an external viewing of the body with injuries and causes of death identified with guidance from the hospital record. Preliminary reports included an abbreviated listing of injuries found at the time of internal and external examination performed by the coroner medical staff. Full reports included a detailed listing of the internal and external examination findings, nonassociated trauma findings, organ descriptions and weights, as well as toxicology results.

Outcomes

A senior institutional registrar calculated each study patient's preautopsy and postautopsy AIS/ISS. To determine preautopsy scores, the registrar reviewed the totality of the clinical documentation from the patient's admission while blinded to autopsy data. Postautopsy calculation differed only in its inclusion of the most detailed autopsy report available. Injuries identified during autopsy, which were not diagnosed in the clinical record, were added to the deceased patient's injury list, while diagnoses that specifically excluded autopsy were removed. New postautopsy scores were calculated from this modified listing of injuries.

To ensure accurate chart abstraction, each registrar completes an audit of all other registrars monthly. For each peer, an auditing registrar selects a previously coded chart and reviews it, blind to the prior coding, using a 30-point validation tool. The trauma information coordinator reviews the subsequent report for discrepancies in coding; if any are identified, the trauma information coordinator, along with senior performance improvement and registry staff, determines the appropriate coding and educates registrars on the correct protocol going forward. Each registrar's errors are recorded and reported as an accuracy rate. Approximately 50 charts are audited each month by this method—roughly 11% of the new additions to the registry.

Data analysis

Preautopsy and postautopsy AIS/ISS were compared to each other; where appropriate, t-test and chi-squared test were

used to identify differences between the two groups. To investigate the relationship between autopsy data and change in ISS, univariate and multivariate logistic regressions were performed using SAS, version 9.4 (SAS Institute, Cary, NC). Multivariate logistic regression was calculated using a forward stepwise procedure. Significance throughout was determined at a $P \leq 0.05$.

Results

Demographics

A query of our trauma database returned a total of 15,138 trauma encounters and 739 deaths during the 54-month study period. Ninety-two percent of patients who died underwent some form of autopsy, with two-thirds receiving a full autopsy (Fig. 1).

Demographics and characteristics of the 682 patients who received a view-only or full autopsy are shown in Table 1. Patients who received a full autopsy were younger (median age 39 versus 74 years, $P < 0.01$), were more frequently nonwhite (39.3% versus 5.6%, $P < 0.01$), had a higher rate of penetrating injury (41.7% versus 0%, $P < 0.01$) and assault (30.8% versus 0%, $P < 0.01$), and had a higher rate of death in the ED (60.7% versus 22.0%, $P < 0.01$) than patients who underwent a view-only autopsy.

Preautopsy and postautopsy AIS and ISS

With the addition of autopsy data, AIS scores significantly increased for each body region (Table 2). Accordingly, mean ISS increased from 21.3 to 29.6, a 38.9% increase, whereas median ISS grew from 25 (interquartile range [IQR] 9-29) to 26 (IQR 22-35) (Table 3). ISS increased in 328 patients (48.1%), whereas it decreased in three patients (0.4%). The percentage of patients with ISS less than nine fell from 19% to 4% after the inclusion of autopsy data, whereas those with an ISS of 25 or greater went from 49% to 69%. The most commonly missed injuries following blunt and penetrating mechanisms are listed in Table 4.

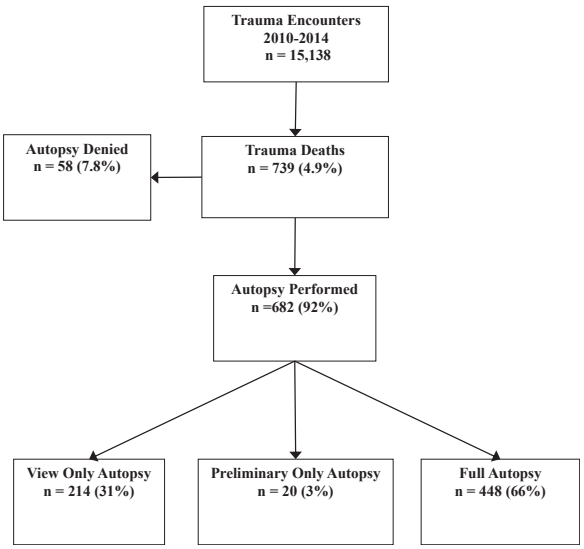

Fig. 1 – Inclusion criteria algorithm for autopsy analysis.

Table 1 – Demographics of autopsy cohort ($n = 682$).

Age (years)*	51 (29-74)
Male gender	507 (74.4%)
Race, nonwhite	209 (30.6%)
Penetrating injury	193 (28.3%)
Assault motive	142 (20.9%)
ICU LOS (days)*	1 (0-2)
Hospital LOS (days)*	1 (1-3)
ED as place of death	213 (31.3%)
Patients with ISS change after autopsy	330 (48.5%)

ICU = intensive care unit; LOS = length of stay; ED = emergency department; ISS = injury severity score.
*Median (IQR).

Predictors of ISS increase following autopsy

Using univariate logarithmic regression, we identified multiple significant predictors of ISS increase following autopsy (Table 5). The strongest predictors in univariate analysis were penetrating injury and obtaining full instead of view-only autopsy. Multivariate logarithmic regression identified the ED as place of death (OR 3.24) and having full-autopsy data available (OR 2.70) as independent predictors of ISS increase with the inclusion of autopsy data (Table 5). The initial patient pulse (OR 0.99) and duration of hospital length of stay (OR 0.95) were found to be protective against an increase in ISS values when autopsy data were available.

Discussion

In the present study, we investigated the effect of autopsy on determination of ISS values following death from trauma. We

Table 2 – Abbreviated Injury Scale before and after autopsy ($n = 682$).

AIS body region	Preautopsy	Postautopsy	P
Head	2.2 ± 2.3	2.7 ± 2.3*	<0.0001
Face	0.3 ± 0.7	0.4 ± 0.8*	<0.0001
Neck	0.1 ± 0.5	0.2 ± 0.7*	<0.0001
Chest	1.1 ± 1.6	1.9 ± 2.0*	<0.0001
Abdomen	0.4 ± 1.2	0.9 ± 1.5*	<0.0001
Arm	0.3 ± 0.7	0.3 ± 0.8*	<0.0001
Leg	0.4 ± 1.1	0.6 ± 1.2*	<0.0001
External	0.7 ± 0.9	0.9 ± 0.8*	<0.0001
Cervical spine	0.3 ± 1.0	0.4 ± 1.1*	<0.0001
Thoracic spine	0.2 ± 0.6	0.2 ± 0.8*	<0.0001
Lumbar spine	0.2 ± 0.6	0.2 ± 0.6	0.002

Values in means ± standard deviations.
*Higher value between means.

Table 3 – Injury severity scores preautopsy and postautopsy data ($n = 682$).

Injury severity score values	Preautopsy	Postautopsy	P
Total ISS*	21.3 ± 15.5	29.6 ± 16.1	<0.0001
ISS < 9	147 (19.9%)	30 (4.1%)	<0.0001
ISS 9-15	118 (16.0%)	75 (10.2%)	
ISS 16-24	105 (14.2%)	123 (16.6%)	
ISS ≥ 25	369 (49.9%)	511 (69.2%)	

*Means ± standard deviations.

Table 4 – Most frequently identified missed injuries by mechanism.

Blunt	Penetrating
Pneumothorax/hemothorax	Pneumothorax/hemothorax
Pulmonary contusion	Pulmonary laceration
Hepatic laceration	Penetrating cardiac injury
Vertebral fracture	Bowel injury
Subarachnoid hemorrhage	Hepatic laceration
Pelvic fracture	Penetrating injury to cerebrum/cerebellum
Splenic laceration	Aortic injury

reviewed 739 deaths with an autopsy rate of 92%. We found that the inclusion of autopsy data led to a 38.9% relative increase in average ISS. Based on our findings, we conclude that autopsy studies are essential for accurate determination of ISS after trauma.

Since 1972, when the Joint Commission abandoned the autopsy as a benchmark for quality care, the overall autopsy rate has plummeted from 19.3% to 8.5% of all deaths in 2007.[1] The proportion of autopsies done for "external causes," such as trauma, rose from 19% to 50% during this period—although this total includes legally mandated forensic autopsies for suspected murders or suicides.[1] Although the overall decline in autopsy has been ascribed to many etiologies from improved diagnostics to concerns about liability for a missed diagnosis,[11] it most likely stems from cost. Reports on cost vary in the range of $1250-$2500 per autopsy, and the procedure is rarely covered by payers.[7,12,13] In their study of trauma deaths in the state of Utah in 2005, Esposito's group estimated that a 100% autopsy rate for all US trauma deaths that year would have cost $354 million.[7] When these costs are passed on to next-of-kin or taxpayer-funded coroners, a more deliberate, restrictive autopsy policy seems a natural response.

Previous series have examined the potential role for autopsy after death from trauma. In their study of 134 deaths from 1994 to 1998, Marx *et al.* found consideration of autopsy data led to a 15% increase in ISS, which primarily was driven by those patients who died before reaching an intensive care unit.[14] Similarly, Martin *et al.* found a 23% increase in ISS for all subjects, with a 30% increase in ISS for prehospital and early deaths.[15] Others, however, have not found that autopsy data aid performance improvement efforts. Shojania *et al.* found that missed diagnoses rates have declined over time, suggesting that improvements in imaging technology slowly diminish the utility of autopsy in this capacity.[3] In their 2002 single-center study of trauma and burn patients, Ong *et al.* noted only 4 of 153 autopsies detected missed injuries that a reviewing panel of surgeons felt might have changed management and prevented death if identified antemortem.[2] Similarly, Forsythe *et al.* reviewed 263 fatalities at their center and, despite an 82% autopsy rate, could not identify any missed injuries felt to have altered survival.[5] Of note, over 90% of prehospital and ED deaths in this study were found to have multiple lethal injuries—suggesting a large cohort of patients whose injury pattern was far more severe than their antemortem workup might have suggested. In addition, Esposito *et al.* reported a study of all trauma-related deaths in Utah in 2005. With a 55% autopsy rate, they found autopsy increased cause of death specificity in 91% of patients; however, only 1%-2% of autopsied cases were felt to have unveiled injuries that might have improved survival.[7]

Our data indicate that autopsies have a significant ability to identify additional severe injuries. The percentage of severely injured patients (ISS ≥ 25) increased by 40% with the inclusion of autopsy data, whereas the percentage with mild injury scoring (ISS < 9) fell by over 80%.[8] Although its role in performance improvement remains a matter of debate, autopsy data appear crucial to quantify anatomical injury accurately, especially in patients who die before completion of a basic workup. Improving the accuracy of ISS values can impact crucial tools for trauma center evaluation in other ways. Inclusion in the Trauma Quality Improvement Program database requires a patient to have a single-region AIS score ≥ 3, corresponding to an ISS value ≥ 9.[16] In this study, 117 patients crossed that threshold after consideration of autopsy data. Along with our regression data, this suggests that many patients who die early are being excluded incorrectly from data sets such as Trauma Quality Improvement Program because of their clinical, preautopsy ISS; such inaccuracies may help explain discrepancies in ISS and other measures of patient complexity.[17]

In our multivariate analysis, we found that increased presenting heart rate and hospital length of stay were protective for ISS change, whereas death in the ED and full, rather than view-only, autopsy greatly increased the odds of ISS change. Late deaths are protective against increasing ISS in spite of autopsy data likely because, as length of admission increases, the amount of clinical data increases as well. As this information is added to the medical record, it becomes less likely autopsy will find previously undocumented injuries. In this light, increasing pulse rate likely protects against increasing ISS with autopsy because patients with a pulse survive for further diagnostic workup. In our study, patients who arrived pulseless to the ED had a median increase in ISS of 20 (IQR 9-33) following addition of autopsy data; in contrast, those who arrived with heart rate at or over 100 beats per minute (bpm) had a median ISS change of 0 (IQR 0-1). Of the pulseless group, only 4.8% survived to undergo cross-sectional imaging, whereas 73.3% of patients with a pulse rate over 100 bpm underwent CT scan ($P < 0.01$). In light of these findings, we suggest that pursuing full autopsies for early deaths

Table 5 — Predictors of injury severity score increase after autopsy ($n = 328$).

Predictors	Univariate OR (CI)	P	Multivariate OR (CI)	P
Age (years)	0.97 (0.96-0.98)	<0.001		
Female gender	0.88 (0.64-1.23)	0.458		
African American race	3.69 (2.59-5.26)	<0.001		
Penetrating injury	22.92 (5.26-99.94)	<0.001		
Initial pulse	0.98 (0.98-0.99)	<0.001	0.99 (0.99-1.00)	0.008
Initial systolic BP	0.99 (0.98-0.99)	<0.001		
Initial GCS	0.89 (0.86-0.93)	<0.001		
Hospital LOS	0.85 (0.80-0.89)	<0.001	0.95 (0.90-0.99)	0.03
ED as place of death	3.24 (1.44-7.30)	0.005	3.24 (1.06-9.89)	<0.001
ICU as place of death	0.24 (0.11-0.51)	<0.001		
Radiographic imaging performed	0.15 (0.11-0.21)	<0.001		
Full autopsy versus view only	5.75 (3.94-8.40)	<0.001	2.70 (1.66-4.37)	<0.001

OR, odds ratio; CI, confidence interval; BP, blood pressure; GCS, Glasgow Coma Scale; LOS, length of stay; ED, emergency department; AIS, Abbreviated Injury Scale; CS, cervical spine; TS, thoracic spine; LS, lumbar spine; Ext, external.

(especially those occurring in the ED), rather than a high overall autopsy rate, best optimizes the balance between autopsy cost and accurate severity scoring.

Our study has multiple limitations. Although the catchment area of the University of Cincinnati Trauma Center is large, with a diversity of rural and urban areas, this does not exclude bias inherent in any single-center study. One specific bias may be seen in our high autopsy rate, which likely benefited from a coroner's office that performed autopsies on the majority of trauma cases. Similarly, documented interrater and intrarater reliability for injury extraction and AIS/ISS calculation were not available. However, multiple institutional processes were in place to determine extraction and coding accuracy by the entire registrar team, in a blinded fashion, with predefined corrective measures for any identified discrepancies. Our study also was not designed to investigate the utility of ISS as a standardization metric in trauma research; ISS was initially designed for blunt injury only, does not correlate directly with survival, and does not account for either multiple injuries within the same body region or comorbidities.[18,19] The inability to accurately determine ISS without additional costly studies that pose no benefit to patient outcome may represent yet another shortcoming of the heavy reliance on ISS. Finally, the population presented is primarily young and male, with a significant proportion having a penetrating injury from assault. Extrapolation to other populations with different injury mechanisms and patterns may not produce similar findings.

Conclusions

We report the relationship of available autopsy data to alterations in the calculation of AIS and ISS in trauma patients. We found that autopsy data not only increased mean ISS by 38.9% but also allowed for the reclassification of 20.8% of our autopsied cohort to a "severe" ISS of 25 or greater. Furthermore, we found that those patients most likely to benefit from autopsy die early in their course. In a growing climate of benchmarking, our findings advocate for an important, continued role for full autopsy, specifically in those patients so severely injured that they die on presentation or early in their hospital course.

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Disclosures

The authors report no proprietary or commercial interest in any product mentioned or concept discussed in this article.

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